A regional study of the East Jordan valley, with special relation to the problems of soil and water utilization

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A REGIONAL STUDY OF THE EAST JORDAN VALLEY, WITH SPECIAL RELATION TO THE PROBLEMS OF SOIL AND WATER UTILIZATION.

Volume 1 : TEXT

BY

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A Thesis Submitted for the Degree of Doctor of Philosophy in the University of Durham ,

June 1969.

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Problems concerned with the utilization of soil and water are world-wide in scope, but are particularly distinctive in arid zones where high temperatures and dryness can create soil salinity, soil alkalinity, and deficits in the water balance of plants. As a part of the semi-arid zone, the Eastern Jordan Valley suffers from such problems, which are reflected in crop yields and output, and hence in real incomes.

During the last twenty years the impetus for the agricultural development in the area has largely come from successive waves of Palestinian settlers. These new immigrants have brought about revolutionary changes in the Agricultural Geography of the region. The increasing pressure of population on natural resources is the most important factor which has led to the search for additional utilization of available irrigation water. Execution of the East Ghor Irrigation Project in the nineteen sixties has aimed at transforming the economic and social life of the inhabitants of the valley. Thus, the present decade represents a transitional period leading to the proper development in the valley.

The water resources of the area are discussed, with particular attention being paid to their qualities and quantities, their problems and potentials. The characteristics and distribution of the various soil types are analysed, and particular attention has been given to soil management problems, i.e. salinity, alkalinity and erosion, especially where these problems integrate with the problems of water use. The transformation of the land use pattern and management practices during the last ten years is considered in relation to the capability of lands in the valley, and the new problems which have arisen from recent development are discussed. These considerations lead to an assessment of past and present land evaluation in the study area, and suggest lines for future research and development.

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PREFACE

My research on the East Jordan Valley was started in September 1965. Part of the time was spent in carrying out research into the present land use system in all its aspects, part of the time was spent in distributing questionnaires and part was spent working with officials in the various Government Departments. Unfortunately, these research activities were curtailed in June 1967; following the outbreak of Arab-Israeli hostilities, the Jordan Valley became a military cease fire area and since that time it has become impossible for any surveyor, researcher, or civilian to work in it. Fortunately, however, the programme of field work had already been substantially completed. The military situation has made it impossible for any return visit for the purpose of rechecking the data already acquired.

It is hoped that the records of the area which I collected before the turmoil will help in the reorganisation and rehabilitation of the area when the military situation improves. These records relate to climate, hydrogeology, hydrology, soils, land classification and past and present land use. The data which are recorded in the present thesis have been gained by applying new techniques, mathematically equations and the whole range of geographical method in order to construct the first work of geographical synthesis which has been written about the area. My concern has been with the relations between natural resources on the one hand and past and present land use on the other. It is hoped that the results I here present may be of

benefit to the Government of Jordan and to the planners who may control future development policy for the valley.

I would take this opportunity of recording my thanks and appreciation to Professor W.B. Fisher who accepted me as a research student in his department. I also would like to acknowledge the sincere interest, constructive attitude, and unfailing patience and guidance of my supervisor, Dr. K. Atkinson. My thanks also go to the University of Jordan who provided a study grant. I would wish to record my appreciation and thanks for the assistance rendered and facilities provided by the following authorities and organisations :-

The Jordan Government:- The various administrative officials and specialist officers of the Ministry of Agriculture; the Jordan Development Board; the Natural Resources Authority; the Agricultural Research Stations at Deir Alla and Jubeiha; the Department of Forests; the Water Office of the East Ghor Canal Authority, Deir Alla; the Meteorological Office; the Department of Lands and Surveys; the Department of Statistics; the Jordan River and Tributaries Regional Corporation; and the Marketing Offices at Amman and Northern Shuneh.

The German Geological Mission, Amman.

The Municipal village councils of the Jordan Valley and the Manager of Karameh Refugee Camp.

The Co-operative Societies of the Jordan Valley. The University of Durham, the Geography Department, the members of the staff, technicians and research fellows who helped and encouraged me in the preparation of this work.

INTRODUCTION.

Problems concerned with the utilization of soil and water are world wide phenomena, particularly in arid zones where high temperatures and dryness can create soil salinity, soil alkalinity and deficits in the water balance for plants. As a part of the semi-arid zone, the Jordan Valley suffers from these problems. Although the northern part of the valley has more favourable environmental conditions than the southern part of the valley this is only partly explained by prevailing climatic conditions. The difference between them is also an expression of the geological history of the valley which gives the southern part remnants of a former saline Jordanian Lake. Thus, soil parent materials and groundwaters in the south are naturally more saline than those in the north. This differential is enhanced by evapo-transpiration conditions and is reflected in crop yields and output, and hence in real incomes.

The study area is the Eastern Jordan Valley (figs.O.1 and O.2) which comprises the eastern part of the rift valley lying between Lake Tiberias (- 212 m.) in the north and the Dead Sea (- 398 m.) in the south. The study area is approximately a hundred kilometres long, varying in width from 2 to 8 kms., and has a total area of some 605 sq.kms. The River Jordan in the west, the River Yarmouk in the north and the Dead Sea in the south form convenient natural boundaries. The eastern limit is taken as the minus 200 metres contour line which runs along the foot of the eastern escarpment. Generally the valley floor consists of terraces; the upper terrace is known as the "Ghor" and the present flood plain of River Jordan as the "Zor". In general, the Ghor slopes towards the river at the rate of 1.5 to 3 percent, and also from north to south at approximately the same rate. Usually the lower portion of the Ghor has been extensively eroded to give bad land topography between the Ghor and Zor; this area is known as the "Katar".

Eleven perennial streams flow into the Jordan River across the valley. The largest tributary, the Yarmouk River, joins the River Jordan about 8 kms. south of Lake Tiberias, and the international boundary between Syria and Jordan follows the course of this stream. The second main tributary is the River Zarqa which reaches the River Jordan at Damia Bridge.

The land use history of the valley is very varied. From historical times up to the first quarter of the twentieth century it was used as pasture land for the stock of nomadic tribes. In the second quarter of the present century the Government of Jordan took the first steps towards land settlement and sedentary agriculture, particularly on the alluvial fans of the side wadis where it was possible to acquire irrigation water. During the last twenty years the impetus for the agricultural development has largely come from successive waves of Palestinian refugees who have settled in the valley. These new immigrants have brought about revolutionary changes in the Agricultural Geography of the region. Land has come to be cropped every year, new lands were brought into production, and new crops were introduced in the cropping system. The growing pressure of population on land was accompanied by an expansion in the acreage of cash crops, which in turn led to a growing pressure on the waters of the River Jordan and its tributaries. Since the erratic discharge of the unregulated side wadis could not meet the increasing irrigation needs of the new crops, attention has lately been centred on possibilities of using water from underground sources and from the international River Jordan network. In particular, of course, the East Ghor Irrigation Project has been designed to alleviate the growing pressure of population on the resources of the valley.

This study is aimed primarily at examining the potentialities of the natural resources of the valley in the face of increasing pressures for their use. During the early part of the field work it soon became apparent that the valley suffered from problems of soil and water utilization. Soil salinity, alkalinity and erosion thus provide a main theme of this thesis, as well as the practical conservation measures necessary in the future. The second main theme aims at studying the water resources of the valley:- the qualities and quantities, the problems and potentials.

Another aim has been to examine the Eastern Ghor Irrigation Project in its transformation of the economic and social life of the inhabitants of the valley. Emphasis has been placed on the extent of the success so far realized, and stress is laid on the new problems which have resulted from the innovations introduced by the project. Finally, the thesis will attempt to suggest lines of future development in the valley in the light of past and present land evaluation on the one hand, and in the light of water potential on the other.

With the exception of the Master Plan Report (1955)[1] of Baker and Harza, little attention has been given to problems of soil and water utilization. The Baker and Harza appraisal deals systematically with soil and water, but does not integrate them into a regional geographic context. Previous studies have been no more than bare factual reports compiled by Government Authorities, with little reference to the wider causes and consequences of the problems of soil and water utilization. Detailed investigation has only been carried out by either geologists or economists.

Previous studies have been found to be very incomplete and patchy for the purposes of this study. Much additional data has been collected in the field and accordingly the present research can be regarded as the first comprehensive geographical study of the Eastern Jordan Valley. In particular field work was necessary on account of the very scanty and limited statistical information available. This was even more serious in the study area as the valley, for administrative and statistical purposes, is divided between the Ajlun and Belqa Districts. Another difficulty is that the survey carried out by the Department of Statistics (1960)[2] did not include all of the Eastern Jordan Valley but only the project area prior to the construction of the East Ghor Canal. Therefore, it is difficult to compare its findings with those of the UNRWA. (1953)[3] report which covered the whole Jordan Valley. Another problem was that the economic feasibility study of the Jordan Valley by the Harza Company (1962)[4] only included general recommendations for development without distinguishing between the very different parts of the valley. The German Geologic Mission carried out the geological survey in 1964[5] for parts of the southern valley and a soil survey in 1965[6] for the Deir Alla area. These two surveys are useful, but again are only partial in their coverage of the present study area.

The published material on the Eastern Jordan Valley was thus only marginally helpful in preparing this thesis. In addition to clear gaps in official and semi-official material, striking discrepancies have also been discovered in available data. This has particularly been the case in figures for river discharge, crop acreage and yield, water balance statistics and statistics dealing in marketing and population. Given this situation, the importance of the primary field work is clearly demonstrated.

Field work was carried out between September 1965 and May 1967. It involved the collection of data from government authorities, research stations, and extension and water offices in the valley. Water samples were collected from the River Jordan and its tributaries and from wells, and the results of the analyses have been helpful in showing water quality in the valley. Following the work by Baker and Harza, the results of soil analyses have been used to subdivide the soil of the valley into reconnaissance soil units which can be shown on the map. Personal communications and interviews with land engineers working in the valley were helpful in showing changings in land capability due to changing cropping patterns. Four administrative or cadastral villages were selected in order to analyse the present cropping pattern. Field maps of scale of 1 : 10,000 were used for this purpose and land use maps prepared. Sample farms of irrigated and non-irrigated management systems were selected from a variety of land classes and representative farm budgets were prepared. The possibilities of gaining accurate information on crop yield and crop sales by interview are greater in Jordan than in many other countries as agricultural incomes are not taxed, each farmer paying a land tax and a per capita tax on animals owned. As a means of checking the data farm income was also calculated from its components as indicated on the farm questionnaires. In addition some 150 inhabitants of the valley were chosen at random and interviewed. Questions were asked to cover the whole range of domestic, social and agricultural activities.

The thesis is divided into three sections. The first, comprising Chapters I - III, is concerned with water. The emphasis in the first chapter is placed on the effect of climate and its numerous elements, with particular attention being paid to its effects on the soils, on the water balance and on the irrigation and diversion requirements of the crops of the valley. The second chapter, containing hydrogeology, deals with the rock outcrops and their correlation with the different soil associations and different aquifers; it elucidates the distribution of groundwater quality within the aquifers and the natural recharge of the aquifers. The third chapter of hydrology deals with the problems of water resource, especially discharge and potential.

The second section, containing Chapters IV - VII, is concerned with soil. The emphasis in the fourth chapter is placed on the factors of soil formation - climate, geomorphology, and vegetation - and their important influences on soil. The fifth chapter discusses soil categories in the valley and the soils are grouped into five associations based on the factor of parent material. Each association includes soil series with different characteristics. With topography and drainage, the soils play a paramount role in dividing the lands of the valley into different land classes, ranging from Class 1 to Class VI. Chapter VI discusses these land classes dealing particularly with their capability. The second section is ended by the seventh chapter dealing with soil and conservation problems; problems of salinity and erosion are discussed in detail and explanations given of their effects on the economy of the valley in general and on agriculture in particular. Controlling measures for conservation are suggested in such a way that planners and farmers can benefit from them.

The third section, containing Chapters VIII - X, is concerned with land use. The eighth chapter indicates the historical land use divided into two stages; the first one deals with land use pre 1950, the second between 1950 and 1960. The ninth chapter indicates the present land use which was developed since 1960. In this chapter, emphasis is placed on the present cropping patterns, agricultural yields and their problems, livestock, farm economy, and development proposals. The final chapter deals with management aspects of present land use such as irrigation, landownership, marketing, population and settlement. These aspects discuss the results of development so far undertaken in the valley, such as irrigation schemes and methods, land reform and size of land ownership, marketing, communications, population and its distribution, and the present and future status of settlement.

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CHAPTER I.

CLIMATE

The climate of the Jordan Valley is determined by two factors, its position at a distance of 100 km. from both the Mediterranean Sea and the Eastern and Southern Deserts, and the enclosure of this deep depression on either side by steep fault scarps rising more than 1000 metres above its floor. This position in the transitional zone between the sea in the west and the desert in the south east, has made it a climatic zone of contact where their opposing forces meet. There is a very striking difference between the western and eastern sides of the valley, for on the east the influence of the sea predominates and on the west the influence of the desert.

Pressure and Wind.

Summer:- In summer, Jordan lies just to the south of a low pressure axis that extends from the Gulf of Oman through the Tigris-Euphrates valley to the island of Cyprus, and between this low and a high pressure centre that lies over Egypt and adjacent desert portions of Africa and Saudi Arabia.[1] The summer low of Cyprus maintains a separate existence, being divided from the main monsoonal low by a shallow isobaric col situated over north west Syria.[2]

From early June until mid-September, the weather of the valley is dominated by winds which are of eastern origin, but which may, blow from the north, or even the west. These winds are the "tail-end" of the monsoons which sweep across the Indian Ocean towards the low-pressure area which develops over the Indian sub-continent in summer time. After dropping their rain, they continue their anticlockwise course westwards, and in the eastern part of the Mediterranean turn southwards and eventually eastwards again, joined with the winds tending to move northeast from the Egyptian high. No rain is brought by these summer winds due to the very dry air imported from Egypt and the Sahara. Throughout the summer months skies are almost always clear, humidity is relatively low, and rainfall is nil.

Winter:- As summer comes to an end the force of this great wind cycle weakens and bursts of air intrude from the Mediterranean; by the end of September the area is largely under the influence of the westerly wind belt which begins to shift southward shortly after the autumnal equinox.

In winter, the Eastern Mediterranean is a region of relatively low pressure, across which a succession of depressions passes from west to east. It is flanked from the north by a high pressure system of Eurasia, which extends to the Balkans and Turkey, and on the south by a high-pressure system over north Africa. The higher the pressure gradients, the stronger the winds emerging from anticyclones and depression centres.

Atlantic depressions arrive via Spain, or northwest Africa, and rejuvenated by contact with the sea, often continue via the Mediterranean as far as Armenia or Iran. More frequently, however, low-pressure systems develop within the Mediterranean area itself, which, with its contrasts of sea and land, warm plain and cold mountain, favours the growth of atmospheric disturbances. Depressions are rejuvenated, especially in places where warm Mediterranean water is enclosed within encircling land which in winter had rather higher pressures. Such saucers of low pressure are formed over the Gulf of Alboran and the Gulf of Sidra.

Depressions tend to follow a sea track.[3] From northern Italy, they frequently pass down the Adriatic into the Ionian Sea. Here the track divides, under the influence of the land mass of Asia Minor. Many depressions continue eastwards into the Levant and Iraq, while others move northwards into the Aegean and Black Seas, reaching the Caspian. A second route lies in the south of the Mediterranean basin. In this case an uninterrupted sea track brings rain to the Levant, and depressions often reach the Persian Gulf.

The onmoving depressions of the winter cause a change of wind directions in the area.[4] As long as a depression is over the central Mediterranean sea and Greece and anticyclone over the Levant, winds blow at first from the northeast and east, and later from the southeast; they issue anticlockwise from the anticyclone and strive toward the depression. After a day or more, the depression reaches the eastern basin of the Mediterranean and often stays for a while over Cyprus. Winds over Levant then change their direction and come from the sea in the southwest. As the depression moves eastward, winds veer to the west and northwest and, finally, again to the northeast.

Air masses of different qualities are sucked into the depression. With the eastward displacement of the depression centre, they meet and create "fronts" giving rise to disturbances which produce a kind of weather similar to that of the cyclonic belt of cool temperate latitudes. The intensity of the depression depends upon the degree of contrast in temperature and humidity of the varied air-masses that form them. In good years the depressions sometimes succeed each other quite steadily once a week, bringing three days of heavy rain followed by four of fine weather. Rain may occur with a wind from any part of the west, but it is usually strongest when the wind is southwesterly.

The European high pressure, however, extends thin fingers along the Mediterranean peninsulas and from time to time these may join up with the high pressure over the Sahara and thus block the passage of the depressions, sometimes for as long as a whole month.[(5)] When this happens the results in Jordan may well be disastrous. The harm may not be too great if it should happen later in the year when the crop roots are well established, but it is particularly unfortunate if the start of the rains are delayed until much after the first of December, or if the first rains come early and are then followed by a period of drought to kill the young crops which the early rains have started. During these interruptions the winds are from the east.

A remarkable feature in the distribution of pressure is caused by the Jordan Valley, where actual pressure is abnormally high both in winter and in summer. Table 1.1

(App.1) shows the mean monthly of atmospheric pressure at Jericho (- 376 m.) over a period of 1964-1965. From these figures, it can be seen that highest pressures occur in winter (1053.4 mb.) followed by 1051 mb. in spring, 1046.6 mb. in autumn and 1040.9 in summer. The means in January and July are 1055.4 and 1038 mb. respectively, compared with 1016.4 and 1004.2 mb. at Aqaba, in addition to 929.3 and 923.4 mb. at Jerusalem. The absolute maximum recorded at Jericho in July 1964 was 1071.2 mb. compared with 1037.7 mb. at Jerusalem. These high figures are, of course, the direct result of the depth of the valley below sea-level. They are not strictly comparable with those of the pressure systems described above, and the general circulation of the winds is therefore not affected.

In the valley, lands are sheltered from easterly and westerly winds, and only when winds blow from the north are they felt on the ground; because of the "funnelling" effect of the rift.

The under-currents are often distinct from the prevailing upper wind. The under-current in winter generally blows down the valley from the north, and in summer up the Ghor from the Arabeh from the south.

Table 1.2 (App.1) shows frequency of wind direction in the valley. From percentages of total observations, it can be noted that, in winter, north and northwest upper winds prevail round the Dead Sea. Farther north, easterly winds are most numerous at Tiberias, but calm conditions are prevalent. In summer, the prevalent upper wind at Tiberias is westerly; at

Jericho northerly or north easterly, and near the Dead Sea northerly and southerly (fig. 1.1).

Analysis of wind velocity at Deir Alla and Jericho, over a period of 1964-1966 (Table 1.3 (App.1)), reveals that the maximum wind velocity occurs in both winter and summer. While wind velocity ranges between 10 and 17 kms./hour during winter at Deir Alla, it ranges between 5 and 9 kms. during summer (fig.1.2). Paradoxically, it ranges between 7 and 8 kms., 12 and 13 kms. during winter and summer respectively, at Jericho. Generally, velocity is higher in the southern valley than in the northern valley. Accordingly, it can be expected that excessive evaporation takes place in the southern valley particularly in summer when the maximum of both temperature and wind velocity occur simultaneously in this season. This phenomena should be put into consideration on using irrigation water.

Local winds:- In the absence of other strong winds, horizontal air movements are in summer restricted to breezes. The fall in the barometric pressure brought on as a result of the considerable warming of the air of the entire Jordan Valley, induces a stream of cool air from the Mediterranean towards the valley. The air rising from the Mediterranean to the hills of Jerusalem and Hebron, 800-1,000 m. in altitude, cools by 6-8^{o}C, and then in its descent to the Dead Sea it warms by about 12-14^{o}C. Since the difference in altitude between the hills of Jerusalem and the valley is 1,200 m., the adiabatic heating is manifest on summer afternoons on the valley. The greater the distance between the valley and the Mediterranean, the later is the western wind in reaching the valley. In the northern part of the valley, the western wind arrives early, whereas in the southern part, it arrives about sunset. The distance between Lake Tiberias and the Mediterranean is 50 km. and the western wind reaches the lake in the summer between noon and 2 p.m. This wind is not a laminary wind of an uniform and continuous flow of air, but is gusty , the gusts attaining 30-50 km. per hour. The foregoing Katabatic wind generally lasts till 10 or 11 p.m.

Plantations suffer from such a strong and continuous wind during successive months from April till October, particularly if their leaves are hypersensitive, as are those of the banana plantations. The citrus plantations suffer greatly from this wind as well. The farms along the entire Jordan Valley, from Yarmouk river to the Dead Sea, need strong wind-breaks for the protection of the plantations.

The Dead Sea is large enough to develop the familiar sea-breeze especially at its northern and southern ends. It is worthwhile distinguishing a midday minimum of temperature between the morning maximum (under the summer sun) and the afternoon maximum (under the Mediterranean sea breeze). This midday minimum is the result of the Dead Sea breeze which has a cool damp steady current. Northwards the Dead Sea breeze of summer days certainly blows up the valley as far as Fassayil , about 25 km. from the north end of the lake.[6]

Along the western and west-southern shores of Tiberias lake, blow in the summer in the forenoon and at dawn local winds which are less developed here than in the Dead Sea.

At night and at sunrise blows a south-easterly to south-south-westerly land wind in the southern part of Tiberias lake, from the surface of the valley toward the surface of the lake. In the morning and forenoon hours blows a northerly to north-easterly wind, sometimes more easterly, along the south-western shore of the lake. This wind arises from the water surface of the lake to the land. In the southern part of the lake it blows more from the north and in the western part from the east.(7) The wind from the water, which blows in the summer in the morning and forenoon, is cool, humid and refreshing in the hot valley.

The Sirocco:- During the transitional seasons, that is any time from the beginning of April until mid-June and any time from mid-September to about the end of October, there occur periods of about three days to a week during which there develop easterly, southeasterly, or even southerly winds blowing in front of depressions as they pass eastward and bring with them desert conditions to the whole of Jordan. These winds are known as "Siroccos" from the Arabic word "Sharqiyyeh" meaning an east wind; they are sometimes also known as the Khamsin or Simoom or Shlouq. These winds of the transitional seasons are not to be confused with the east winds which develop on the dry days during the rainy season. This winter wind, known as the cold Sirocco,(8) is distinct from the usually much weaker southeast hot Sirocco of spring and autumn. The relative humidity of the air is equally low during both the Siroccos.

The main feature of a Sirocco wind is heat, dryness and haziness, suggesting the idea of a continental tropical air-mass. It is a fact that the maximum temperature recorded in a Sirocco wind greatly exceeds the normal maximum temperature attained in the spring. The hazy or dusty character can be attributed to the fact that in the spring the Mediterranean areas are still relatively cold when compared with the lower latitudes, and tropical air moving northward cools down from below, which makes the lapse-rate within the lower layers more stable, and so restricts the upward diffusion of suspended dust.(9)

The cold air behind the cold front of a Khamsin depression is generally of the same nature as the normal Mediterranean air masses prevailing in the spring. The passage of the front is accompanied by a sudden drop of temperature of the order of - 7°C to - 1°C., and sudden increase of relative humidity to about 80 percent. The Siroccos of the spring transitional season are frequently rather stronger than those of autumn, but at both seasons they produce abnormally high temperatures.

These winds are more intense in their effects in the valley, where the air is warmed still further by its descent over the plateau edge. They are of greatest danger to the horticultural crops during blossom and fruit setting and to cereal crops during heading and between the end of the milky-ripe and the end of the yellow-ripe stages of ripening.(10) The effect of the Dead Sea on sirocco days is obvious; observation shows that in most cases the sirocco is not felt on the north shore of the Dead Sea so prominently as other parts in the valley.

Temperature.

The Jordan Valley has tropically hot summers and warm winters, because of its location below sea level and its protection by mountains from the cooling westerly winds. The amount of insolation is higher than the neighbouring regions due to the clearness of its sky, the depth of its floor, the height of its borders, and the dryness of its air. The high values of insolation are felt prominently since the sun's rays falling on the valley and the slopes of its both eastern and western escarpments are so restricted in their reflection that they remain a longer period in the valley. Furthermore, the dry atmosphere of the valley depletes by absorption less of the solar radiation than a humid atmosphere in the other regions. Hence, the total heat-summation averages for the May-October period (computed above 10°C) are about 1093°C. higher for the valley than for the coastal plain.(11)

The amount of insolation reaching the southern valley is more than that of the northern. The reason of this difference resides first and foremost in the difference between cloud coverage for the two sections. Table 1.4 (App.1) shows cloud amounts over a period of 1964-1965. Whereas the average annual cloud amount at Northern Shuneh is 2.7 oktas, it is 2.3 oktas at Deir Alla, and 1.9 oktas at Southern Shuneh (fig.1.3). Generally, the northern valley has on average 2.2 oktas, while this amount becomes 2 oktas in the southern valley. Neuman's explanation to the relationship between insolation and cloud amount shows that, under average conditions, each tenth of the sky obscured by clouds is responsible for a reduction by 5 to 6% of the insolation which would reach the surface from a cloudless sky.[12] Converting Neuman's equation to oktas, the result would be each $\frac{1}{8}$ of the sky obscured by clouds is responsible for a reduction by 6.3 to 7.5% of the insolation. Estimating the cloud coverage over Southern Shuneh as just about 0.4 less than Deir Alla, and that of Deir Alla as just about 0.4 less than Northern Shuneh, the calculations thus lead to an insolation rate 2.5 - 3% at Southern Shuneh higher than for Deir Alla, and 5 - 6% higher than for Northern Shuneh.

The number of days on which cloud is recorded varies from year to year and from month to another within the one year. Table 1.5 (App.1) shows number of overcast and clear sky days at seven stations over two years (1964-1965). From these figures, it can be concluded that clear sky days represent 87 percent of the total days of the year. Moreover, all of summer days are distinguished with clear sky days (100 percent). Although winter of the Mediterranean region is usually distinguished with high values of either cloud amounts or the number of cloud days, winter of the valley has overcast days less than 50 percent of the year (46.3 percent). It is noteworthy that the number of clear sky days are more in the southern than in the northern valley. These facts elucidate the importance of clear sky days in inducing the high values of insolation and their effect on rising of temperatures.

The length of daytime hours is another factor which determinesthe value of insolation. The monthly percent of daytime hours for latitude 32°N in the valley, shows that July has the longest days (9.77%). Moreover, the period from May to August inclusive has long daytime hours (38.28%), whereas winter months have the shortest daytime hours (30.29%) (Table 1.6a, App.1).

The value of insolation is influenced by the duration of sunshine also. The longer is the period of sunshine, the higher will be the value of insolation. Table 1.6b (App.1) shows mean duration of sunshine at Deir Alla and Jericho over six years (1961-1966). It can be seen that this mean is 9.4 hours at Jericho, ranging between 12.9 hours in July and 6.2 hours in January. On the other hand, Deir Alla has a mean of 9 hours, ranging between 12.9 hours in July and 5.8 in January. Consequently, it can be expected that this period is too sufficient to the needs of the plants. Suffice it to say that the light and heat of the sun are important factors in shortening the growth period by the early ripe of the crops. This fact emphasises the point that the crops of the valley arrive at the markets early before the arrival of crops of the other regions. Therefore, not only have they been protected from the competition of the other crops, but they also gain high profits as a result of the high prices.

The seasonal temperature regime can be divided into three main periods. In high summer from mid June to late September, mean temperatures are uniformely high and show little variation. Following this period from October to January, a very marked drop in temperatures of 5°C on average, per month is seen. Finally the cycle is completed from January to June by a slow rise in mean monthly temperatures of 3°C until the high and persistent mid summer temperatures are reached. (Table 1.7 (App.1)).

The mean monthly temperatures indicate very small differences in certain parts of the valley (fig.1.4). Though the temperatures in the northern part are slightly lower than those in the south, these differences are very small. That is quite clear when comparing the temperature record of the station Wadi Jurum which has the lowest mean monthly temperatures in the valley, and the station of Dead Sea North which is considered as one of the hottest spots. Their mean monthly temperatures differ by 1.3°C and their mean annual temperatures differ by 1.1°C only, whereas the difference between the northern and southern stations of the valley is not more than 0.3°C on average.

As these mean monthly and annual temperatures give a somewhat misleading impression of actual conditions, it is preferable to refer to average maxima and minima of temperature (fig 1.5). In winter, the valley has a most enjoyable and healthy warm weather. Jericho and Southern Shuneh are the winter resorts of Jordan.

Table 1.8 (App.1) shows mean maximum and minimum temperatures at six stations over six years (1961-1966). In winter (January), the mean maximum temperatures range between 19°C at Northern Shuneh and 20.3°C at Dead Sea North. Mean minimum temperatures are high when compared with those of the neighbouring mountainous region. Although they range between

8 and 11^{o}C, the lowest absolute temperatures range between - 5^{o}C at Wadi Jurum and 3.7^{o}C at Southern Shuneh. It is to be noted that Wadi Jurum station had been forementioned as the lowest station in mean monthly and annual temperatures. Undoubtedly, its location in the northern valley borders, in addition to its relatively higher elevation, are contributory factors. The drop in absolute temperature of January is caused by wind blowing from the north along the narrow trough bringing sudden cold from the snows of Hermon mountains even as far south as the Dead Sea.

In summer, the valley is too hot, but the heat is dry and therefore more bearable than that of the coast. In July, the mean maximum temperatures vary from 37^{o}C at Wadi Jurum to 39^{o}C at Jericho, whereas the mean minimum temperatures vary from 22.2^{o}C at Deir Alla to 25.1^{o}C at Southern Shuneh. The lowest absolute temperature in the northern valley is 16^{o}C at Northern Shuneh while it is 20^{o}C at Dead Sea North. The highest absolute temperatures range between 42.5^{o}C at Wadi Jurum and 46^{o}C at Jericho.

It is noteworthy that the increase in temperatures from the north to the south is due to the fact that the northern valley is more elevated than the southern part. In addition, it is nearer to the Mediterranean whom effect is stronger via the natural gap of Esdraelon valley.

Diurnal range of temperature:-

This is usually greater in summer than winter, and in south than north of the valley. The mean daily range of temperature at Tiberias amounts to a yearly average of 11.6^{o}C;

at Jericho, it amounts to 13.3°C. On the other hand, this range rises in the months of July-August to 13.3°C; at Tiberias, 15.5°C; at Deir Alla, and 15.6°C at Jericho. In the Dead Sea region, there is a considerable difference between the two ends of the sea. The night minima are much lower at the southern end, so that the daily ranges are greater there, sometimes in the ratio of 1½ : 1.

Comparing the daily range of the valley with the adjacent regions, the daily range increases so rapidly from the coast to the east that the southern part of the valley shows in its climate many features characteristic of a desert. Of course the modification of the Mediterranean is the dominant factor, and the difference of the mean daily range from one zone to another is due to the result of the battle between the desert and the sea effects.

Certain extraordinary fluctuations in temperature have been recorded. Prevailing winter winds are sometimes interrupted by winds of continental origin which may bring a severe drop in temperature at any period through the winter months. The exceptionally cold years may affect seriously the tropical crops in the valley; this has happened with bananas and tomatoes during winters 1950/51, 1956/57,* 1963/64 at Jericho and Northern Shuneh.

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* It was noticed that water consumption in January, February, and March 1957 is less than the figures for the same months of the preceding year. This is probably due to the abnormally low temperatures that occurred in January 1957, resulting in the killing of a great portion of the leaves.

On the other hand, Sirocco winds play an important role in the sudden rise of temperature. Considerable areas of crops fail totally in these years when either the cold or hot Sirocco blows across the valley.

Relative Humidity.

Moving from the coast of the Mediterranean to the east, there is a general lowering of the average relative humidity. In the coastal plain, the relative humidity varies comparatively little between January, with about 70% to June with 60%. In the western hills of Jordan, the corresponding figures are 70% and 50%. In the Jordan Valley, the relative humidity varies from 70% in the winter to less than 50% in June, while on the eastern hills, the variation is from about 75% in winter to 35% in June (fig.1.6). Although the resemblance is clear between the figures of winter, the variation of figures in summer is caused by the difference of the location of these regions from the Mediterranean. (Table 1.9 (App.1)).

There is a gradual decrease in the annual, monthly and diurnal averages of relative humidity from the north to the south throughout the valley. Table 1.10 (App.1) shows mean monthly of relative humidity at six stations over six years (1961-1966). It can be concluded that January has the highest percentage, because it is the month of rains' peak. Paradoxically, June is the month of lowest percentage as a result of the winds direction, i.e., the prevailing winds are southerly, south easterly and north easterly. There is a considerable correlation between the low humidity in May-June and the blowing of hot Sirocco across the valley. It is notable that October is distinguished with low humidity when compared with the relatively high humidity during the months before and after it. This fact elucidates again the role of north, north easterly, and south easterly prevailing winds during October. Generally, mean annual relative humidity in the northern valley amounts to 57%, decreasing to 53% in the southern valley. The cause of the abundance of humidity in the north rather than in the south is that the north is nearer to the Mediterranean, in addition to its higher elevation.

There is a large diurnal variation of relative humidity, partly due to temperature changes and partly to land and sea breezes. The daily range, from a maximum in the early morning about 8 a.m. to a minimum shortly after noon, may amount to as much as 10 percent in winter and 20 percent in summer.

At Deir Alla station, during the years 1961-1965, the average relative humidity at 8.a.m. and 8 p.m. is approximately 70% during the winter season and 50% during the summer. At 2 p.m., it is about 58% in winter and 35% in summer. At Southern Shuneh, the figures are respectively, 68% during the winter, 46% during the summer and 53% in winter, 33% in summer. Jericho has the lowest humidity in the valley where, at 2 p.m., it is about 50% in winter and 30% in summer. On account of the intense irrigation in the northern valley and some patches of the south, the foregoing figures cannot be regarded as truly representative for the region. The waters in canals, and the plants themselves increase the local percentage of relative humidity.

Dew.

Regional distribution:- Comparing the maps of rain and dew distribution in the region, it may be seen that the Negeb is the poorest in rainfall and richest in dew. The hill regions, on the other hand, have the largest rainfall, but a smaller dew formation than the Negeb. There is a coincidence between a small rainfall and a small dew formation in the Jordan Valley.

Dew is formed when water vapour condenses on cold bodies. Air, when descending from the western hills to the Jordan Valley, generally lowers the relative humidity and reduces the cooling by giving up heat.(14) We can thus conclude that on the windward-side of mountains, where the air coming from Mediterranean rises, conditions favour the cooling and condensing of water vapours in the air; whereas on the lee-side of mountains, where the air descends, there are no such conditions for condensation. This interpretation may be used also in the explanation of the valley's lack of precipitation.

In the valley, there is a decrease in dew from the north to the south. In the years 1943-47, according to Duvdevani,(15) the amount of the yearly dew precipitation, measured by means of the Duvdevani dew gauge, varied from 13.6 mm. in Degania A, to 10.6 mm. in Beit Alpha, to 4.7 mm. in Jericho (Table 1.11a, App.1). The number of dew nights decreases also, it is 171, 156, 115 respectively. The zone of Beisan-Wadi Ziglab is distinctive on account of its relatively high order in dew formation. The phenomenon is explained by the fact that the air passing throughout Jezreel Valley gap in its way to the valley is flowing more horizontally than the precipitated air descending from the western escarpment in other parts of the valley. The influence of irrigation also in this zone is important in dewfall, especially in the dry months.

Since dew formation is dependent on the rate of cooling, it is important to know that the daily range of the soil temperatures in the valley amounts to about 25^{o}C. in summer. It should be stressed that on the surface the maximum temperature is at noon, and the minimum toward the end of the night, but inside the soil, the maximum and minimum temperatures are retarded.(16)

Table 1.11b (App.1) shows half-yearly and yearly totals of dew for the rainy and dry seasons in the valley over the years 1963-1965. As the forementioned table, it can be seen a gradual decrease in the amount of the yearly dew precipitation and the number of dew nights from the north to the south of the valley. It is notable that the valley differs from other neighbouring regions concerning the distribution of dew according to the time of the year. In the valley, the totals of dew nights and amounts during the rainy winter season are more than during the dry summer season. At Northern Shuneh, the number of dew nights from April to September is 38 nights with 2.7 mm. of dew amount; from October to March, it is 127 nights with 13.1 mm. At Wadi Fari'a station, the number from April to September is 13 nights with 0.6 mm., while it is from October to March about 124 nights with 9.8 mm. Undoubtedly, the lower humidity in summer than in winter is a considerable factor.

The topographical setting is an important factor in the problem of dew formation in the valley. The under-currents of the air in the valley in summer have been always coming from the hot south, as already noted; these currents co-operate with the descending western air to obliterate the humidity. Although the other deserts substitute their dryness with the dew, we have found a strong coincidence between the hot dry valley summers and the scarcity of dew amount. This means that the growth of summer plants cannot depend on the poor dew of the southern valley; and unless they are irrigated they will not succeed.

Effect of dew on plants:- Dew is a major factor in the water balance of the vegetation of the valley, a subtropical zone with a rainless summer. Although the amount of dew is small in summer, it is so frequent in the northern part that it occurs during 50% of the nights. Therefore, the dew potential is more drastic in the north than in the south.

In all the measurements undertaken by Duvdevani, growth was always markedly greater for plants receiving dew than for those not receiving it. Moreover, it seems that dew formation has a significant effect on the survival of corn leaves when the plants are grown without irrigation. This result emphasises the fact that dew can contribute a very considerable amount of moisture in those periods in which there is no precipitation. Consequently, dew may contribute to the growth of plants during the dry summer months in the northern valley. On the other hand, this contribution is restricted in the southern section.

Precipitation.

The annual mean precipitation lies in the northern valley between 200 and 400 mm; in the southern valley between 100 and 200 mm.

The precipitation totals indicate mean annual totals between 134 and 406 mm. (fig.1.7).

A consideration of the minimum and maximum totals indicates that the maximum annual totals can be 320 percent of the minimum values.

Field observations on the vegetation pattern in the Eastern Jordan Valley give a strong impression of increasing aridity from the north to the south. The driest station at King Husein Bridge some 347 m. below sea level, receives only 67 percent less precipitation than Adasiyeh, the station with the highest precipitation at 180 m. below sea level; on average, King Husein Bridge has between only 3 - 66 percent less precipitation than other stations. The altitudinal range, over

TABLE 1.1 Mean, maximum, and minimum annual rainfall in the valley.

Station	Elevation Metres	Approximate Location Latitude	Years of Records	Period of Records	Mean annual rainfall (mm)	Maximum annual rainfall (mm)	Minimum annual rainfall (mm)
Adasiyeh	-180	32° 39'	15	1951-1967	406	518	272
Baqoura	-200	32° 38'	16	1951-1967	388	528	150
Northern Shuneh (W.Arab)	-197	32° 37'	16	1951-1967	391	515	218
Wadi Ziglab	-190	32° 31'	16	1951-1967	357	492	210
Wadi Jurum	-180	32° 26'	16	1951-1967	349	460	198
Wadi Kufrinja	-200	32° 16'	16	1951-1967	285	385	130
Deir Alla - N.R.A.	-180	32° 12'	16	1951-1967	291	432	118
Ghor Fari'a	-240	32° 08'	15	1952-1967	220	322	32
Southern Shuneh (Shunet Nimrin)	-230	31° 54'	13	1954-1967	175	299	41
King Husein Bridge	-347	31° 52'	14	1953-1967	134	236	45
Jericho	-250	31° 51'	36	1923-1967	138	333	48
Kufrein	-200	31° 51'	20	1947-1967	178	345	59

Source:- Met.Dept. and various.

160 m. within a distance of about 90 km., undoubtedly is a contributory factor; altitude-precipitation relationships appear in Fig.1.8. On the other hand, in autumn ,the northern part of the valley moves first from the dry subtropical into the wet belt; and in spring, it shifts last back into the subtropical zone. Consequently, the rainy season is likely to begin in the north a few days earlier than in the south, and to end a few days later. In addition, the northern valley is nearer to the usual track of depressions, where pressure gradients become steeper. Hence, air masses move more quickly, rise at a steeper angle, are better cooled, and gain in relative humidity.

The contrast between cold and warm air is stronger at the north rather than at the south as a result of the Mediterranean modification.[17] Consequently, the cold front will be meagre at the south, and rainfall quantity will decrease from the north to the south along the cold front. This decrease is also partly due to the southwestern origin of some of the winds affecting the southern area as they blow from Egypt and the desert, rather than across the whole length of the Mediterranean, these winds have been able to absorb moisture over only a short distance of water.

The topographical setting contributes in the decrease of the precipitation towards the south of the valley. While the Samarian hills are lower than the Judean hills, the latter interposing a tremendous barrier between Mediterranean and the southern valley. On the other hand, the winter storms pass through the Esdraelon gap easily to the northern valley.

However, the valley lies in the rain shadow, the effect of this rain shadow can be seen everywhere in the valley; it becomes more obvious when comparing the valley with the adjacent regions. While the mean annual rainfall is 400 mm. in the coastal plain, it is 800 mm. in the western hills, 200 mm. in the valley, and 600 mm. in the eastern hills. This is due to the cooling of the winds as they rise over the western hills, dropping some of their moisture; on the eastern side of the valley they are again cooled in rising and deposit their remaining moisture on the eastern hills. Therefore, the valley is drier than the hill country on either side of it. In addition, its rains begin later and end earlier than the rains of the hills and the coast.(18)

The following tables show the mean monthly rainfall for the northern and southern parts of the valley.

The rainfall of the valley is concentrated in the months of October to May (figs.1.9 and 1.10). Analysis of the monthly records of the stations in these two tables shows that on average December is the wettest month in the northern valley with 24.9 percent of the total precipitation, followed by January (22.4 percent) and February (15.8 percent) respectively. On the other hand, January is the wettest month in the southern valley with 28.8 percent of the total precipitation, followed by December (23.1 percent) and March (16.9 percent) respectively. Although precipitation falls during eight of the calendar months, the four months of December to March inclusive provide more than 78 percent of the total precipitation in the northern valley, while they provide

TABLE 1.2 Mean monthly rainfall of the northern valley (mm.)

Station	Period of records	Years of records	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total annual
Adasiyeh	1951-1967	15	11.6	48.0	107.2	85.7	75.8	53.8	17.0	6.6	405.7
Baqoura	1951-1967	16	14.7	48.0	96.0	82.2	64.0	55.6	18.1	8.9	387.5
Northern Shuneh (Wadi Arab)	1951-1967	16	30.7	46.5	84.8	91.5	53.9	61.2	9.8	12.6	391
Wadi Ziglab	1951-1967	16	23.7	37.2	82.0	88.5	53.5	56.0	11.3	5.1	357.3
Wadi Jurum	1951-1967	16	20.7	42.6	81.2	87.8	45.0	55.8	9.9	5.5	348.5
Wadi Kufrinja	1951-1967	16	14.9	30.2	78.5	65.6	36.7	46.4	8.8	3.4	284.5
Deir Alla	1951-1967	16	7.8	29.2	74.6	69.0	42.8	54.6	9.0	3.6	290.6
Average			16.4	42.6	90.9	82.3	58.2	54.8	13.7	6.9	365.8

Source:- Met.Dept. and various.

TABLE 1.3. Mean monthly rainfall of the southern valley (mm.)

Station	Period of records	Years of records	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total annual
Ghor Fari'a	1952-1967	15	3.2	25.7	52.9	62.8	26.7	42.0	5.9	0.8	220
Wadi Auja	1954-1964	10	4.4	11.6	23.6	32.6	21.7	13	4.9	2.2	114
Shunet Nimrin (Southern Shuneh)	1954-1967	13	10.7	11.3	39.0	53.9	21.0	33.7	4.5	1.2	175.3
King Husein Bridge	1953-1967	14	8.0	9.6	33.3	39.4	15.6	20.7	7.0	0.4	134
Jericho	1923-1967	36	4.0	16.3	29.7	34.3	26.5	16.6	7.3	3.0	137.7
Wadi Kufrein (Kufrein)	1947-1967	20	9.4	11.0	42.5	55.1	18.0	34.7	6.5	0.5	177.7
Average			6.6	14.3	37.0	46.3	21.6	26.8	6.0	1.4	160.0

Source:- Met.Dept. and various.

some 83 percent in the southern valley. The four months October, November, April and May provide one fifth of the total average precipitation. The percentage of annual rainfall totals in each month is shown in the following table.

TABLE 1.4. The percentage of annual rainfall totals in each month in the valley.

Northern Valley					
Month	per.%	Month	per.%	Month	per.%
October	4.4	January	22.4	April	3.8
November	11.7	February	15.8	May	1.9
December	24.9	March	15.0		
Southern Valley					
	%		%		%
October	4.4	January	28.8	April	3.7
November	8.7	February	13.8	May	0.6
December	23.1	March	16.9		

An analysis of the average isomeric values for the months of rainy season in Jericho during the international standard period 1931-1960 emphasises the point that January is the peak of rainfall in the southern valley.

It is important to distinguish two patterns of rainfall, the coastal plain pattern, with the peak of the rain in December, and the mountain pattern with the peak in January. Whereas the northern valley has the first pattern, the southern has the second one. The coastal pattern favours large quantities of rain in the beginning of the season because of the thermal convection, and because of the large amounts of heat and water vapour which are absorbed by air masses that travel over the warm Mediterranean during this part of the year. Both these factors are relatively absent during the rest of the season, and therefore the orographic factor appears more pronounced then.(19)

The "first rains", the "main rains", and the "late rains" are the three phases of the local rainy period. The first or "former" rains take place in October and November; the main rains in December, January and February; the late or "latter" rains in March and April. The first rains in the valley contribute only 27 percent less precipitation than the late rains. On the other hand, the late rains are heavier than the first or early rains. This fact becomes more evident when comparing between the totals of maximum rainfall in 24 hours. The mean totals of early rains in October-November and late rains in March-April are shown in the following table for the period 1960/61-1966/67.

TABLE 1.5. The mean totals of early and late rains in the valley.

Station	Period of Records	Mean totals of maximum rainfall in 24 hours in early rains period.		Mean totals of maximum rainfall in 24 hours in late rains period.	
		Mean totals (mm)	Percent of the two periods totals	Mean totals (mm)	Percent of the two periods totals
Adasiyeh	1960-1967	24.2	40.7%	35.0	59.3%
Baqoura	"	27.4	42.3%	37.4	57.7%
Northern Shuneh (Wadi Arab)	"	26.0	48.1%	28.0	51.9%
Wadi Ziglab	"	22.5	46.8%	23.4	53.2%
Wadi Jurum	"	24.1	49.5%	24.5	50.5%
Wadi Kufrinja	"	20.7	54.5%	17.3	45.5%
Deir Alla N.R.A.	"	15.9	40.8%	23.0	59.2%
Ghor Fari'a	"	12.2	47.6%	13.4	52.4%
Shunet Nimrin (Southern Shuneh)	"	11.6	46.2%	13.5	53.8%
King Husein Bridge	"	13.9	56 %	10.9	44.0%
Jericho	"	12.6	58.4%	9.0	41.6%
Wadi Kufrein	"	9.4	40.1%	14.0	59.9%
Average		18.3	46.8%	20.8	53.2%

Source:- Met.Dept. and various.

It can be concluded that Baqoura station has the highest mean totals of maximum rainfall in 24 hours in both periods of early and late rains. Moreover, these values are higher towards the north of the valley. It is noteworthy that the early rain period receives some 7 percent less maximum precipitation than the late period. Exceptions to this rainfall distribution are not infrequent. There are very few stations having higher precipitation in the early rains period. In the rainy season itself, there are at times prolonged dry periods. The interval between main and late rains is especially long, and in some years the late rains do not occur at all. These last rains are critical to the maturing of crops, but if they are heavy as in the years 1958/59, 1960/61, damage from rust may be widespread.

Convectional rain is largely confined to the beginning and end of the rainy season, where the heaviest falls often occur at these periods. Ashbel has assumed that the Red Sea is the dominant factor in great floods formation;[20] it may be seen from his map of pressure and wind of the region during the flood of 1937 that a local low pressure is concentrated upon the northern part of the Red Sea. This explains the fact that over the region there is a conveyance of various kinds of air differing in temperature, humidity, and weight. Condensation on the line of convergence is facilitated by the cold northern air which forces upward the warm southern air. The rising southern air cools, reaches saturation point and even goes beyond it, as it rises to a considerable height of several kilometres. Since in these cases the ascent is effected with great force the precipitation of surplus water from the air occurs with unusual energy, in the form of cloudbursts which let fall immense quantities of water on small areas.

The flood which occurred on November 17-18, 1937 concentrated in the Dead Sea basin and caused the swelling of the Dead Sea. A very heavy flood occurred during the night of November 7-8, 1935 in the north of the Huleh valley. The maximum intensity recorded during 24 hours in Wadi Qilt near Jericho was 130 mm.(21) The flood which occurred in the valley at May 1934 destroyed a part of Tiberias city and raised the level of the lake water.

The number of days on which rain is recorded varies from year to year and from month to month. The number of raindays per year, shown in Table 1.12 (App.1), is an indication of the type and intensity of the precipitation. It can be seen that more than 86 percent of the station years within the northern valley have between 30-60 raindays per annum (fig.1.11). Whereas in the southern valley, more than 91 percent of the station years have between 10-40 raindays. No station within the valley receives more than 70 raindays per annum or fewer than 5 raindays.

The amount of rainfall on any rainday varies from 0.1mm to a maximum of 84 mm. Table 1.13 (App.1) shows annual maximum daily rainfall in the valley. From these figures, it can be seen that, in the northern valley, 80 percent of these days receive precipitation of between 20-60 mm. Fourteen percent of the raindays receive precipitation of more than 60 mm. in a 24 hour period. In the southern valley, 85 percent of these days receive precipitation between 0-40 mm. while 15 percent receive more than 40 mm. in a 24 hour period. Less than 6 percent of the observations in all of the valley show intensities of over 80 mm. per 24 hours.

While these figures show the maximum intensities to be expected within the valley, they give no indication of what might be considered average daily conditions. To remedy this omission the daily rainfall intensities for Northern Shuneh and Kufrein were analysed over a period from October 1961 to October 1967. This showed that precipitation occurred in general in a series of isolated storms, which seem to follow a general pattern. Precipitation commences with one day of low rainfall 1 mm. This is generally followed by 1-2 days of heavy rain with intensities of generally between 5 and 10 mm. per 24 hours, and finally by one day with low intensity rains. A period of drought then ensues until another storm follows (fig.1.12). It is noteworthy that not only has the northern valley more storms than the southern valley, but it has also longer periods of storms with peaks of heavy rains over 15 mm. per 24 hours.

An analysis of the raindays with rainfall intensities per 24 hours for the six years of observation (1961-1967) at seven stations reveals some interesting features (Table 1.14 (App.1)). In the northern valley, fifty percent of the total per number of raindays have less than 5 mm. of rain per 24 hours, and about 82 percent have less than 15 mm. per 24 hours. High rainfall intensities of over 25 mm. per 24 hours occur on less than 7 percent of the raindays. In the southern valley, sixty three percent of the raindays have precipitation totals of 0-5 mm., and more than 90 percent have less than 15 mm. These figures give added weight to the idea that erosion of the soil is restricted to the 18 percent of the raindays when intensities of over 15 mm. per 24 hours occur in the northern valley and to the 9 percent of the raindays when these intensities occur in the southern valley. Bearing in mind that on average there are approximately 42 raindays per annum in the northern valley and 28 raindays in the southern valley, this means that soil erosion takes place in any quantity on only 8 days and 3 days per year respectively. Furthermore, the valley is liable to the dangers of floods from the eastern side wadis coming from the plateau in which the soil erosion takes place on 10 days per year.(22)

Although precipitation intensities on the majority of the raindays are low, the percentage of the total rainfall occurring in any one intensity group is much more uniformly distributed (fig.1.13). Raindays with less than 15 mm. per a day, which make 82 percent of the total raindays in the northern valley and 90 percent in the southern valley, contribute only 48 and 62 percent of the total precipitation respectively. Whereas, raindays with more than 15 mm. per day (18 and 9 percent total raindays of the northern and southern valley respectively), make 52 percent of the total precipitation in the northern valley and 38 percent in the southern valley (Table 1.15 (App.1)). This fact emphasises the point that it is the rainfall of the short and relatively intense showers which dominates annual precipitation totals.

It may be noted that the torrential downpours of rainfall are observed over a limited period of the rainday. Fifty nine mm. in 35 minutes were recorded at Ma'oz, about 25 km. south of Lake Tiberias, on October 10th, 1957, and 38 mm. in 20 minutes at Tirat-Tsevi in 1944.(23) The consequences are serious; much rain is lost in runoff, some soil is carried away, and crops may be damaged.

Incidence of dry and wet years.

Lack of rain, as well as unseasonal heat and the resulting high evaporation rates, are factors of drought conditions. Dry years in the area are frequent. Often there are series of dry years, as in the five winters between autumn 1958 and spring 1963.

There is, however, no regularity in the incidence of ample rainfall and of dry years. In Jerusalem, where rainfall has been measured continuously since 1846, the periods 1854-1859, 1880-1898, 1917-1922, 1936-1939 and 1941-1945 had above-average rainfall, while between 1869 and 1873, or between 1924 and 1936, most years were those of drought.(24) 1950-51 was the driest winter ever recorded at Jerusalem up to the present. A nearly equally low amount was recorded in 1924-25, the next lowest year on record being 1869-70.

In the valley, the year 1959-60, saw the second worst, or at some stations the worst, drought on record.* Rainfall in this year, in the southern part of the valley, was less than half the average of all years since measurements began**; the northern valley fared slightly better receiving a higher absolute rainfall. Rainfall data of twelve stations for the period 1951-1967 (figs.1.14 and 1.15) show that the rainfall at northern valley stations ranges from six to eleven times over the average, and from five to ten times below it. Whereas, in the southern valley, it ranges from four to seven and from seven to ten respectively (Table 1.16 (App.1)). These fluctuations are more extreme from north of the valley to its south. For instance, the northern shore of the Dead Sea received 258 mm. in 1944/45, while the rainfall amount of the year 1946/47 was only 23.2 mm.

The seriousness of these fluctuations for rain-fed agriculture is clear. However, irrigated agriculture is also affected, partly because it depends in varying degrees on rainfall as a supplementary source of water, and more important - because the flow of water in the side wadis which

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* The northern stations recorded lowest rainfall in the year 1950/51. In the southern stations, however, 1959/60 was the most serious drought recorded.

** Rainfall records are available starting in 1937/38 for Baqoura; 1947/48 for Adasiyeh; 1950/51 for Northern Shuneh (W.Arab), Wadi Ziglab and the Deir Alla Irrigation Office; and 1952/53 for the Deir Alla Agricultural Research Station.

feed the irrigation canals also varies with the rainfall. Even the underground water from springs and wells fluctuates according to the fluctuation of rains.

The output of rainfed products fluctuated considerably from year to year depending upon weather conditions. In 1959-60 wheat output was only about 19 percent of 1953-54 production, sesame output was about 42 percent of 1953-54. This severe decline in output is due to the fact that the average rainfall of 1959-60 was a little less than half of 1953-54.[25] The high positive correlation between rainfall and wheat output is very clear; for every 1 mm. of rainfall in a season, there would normally be a resultant increase in wheat output of 1,916 tons; on the other hand, every 1 mm. of additional rainfall increases by 640 tons the sesame output.[26]

Evaporation and Water Balance.

The moisture available to plant growth, animal life and man is determined by the relationship between rainfall and evaporation. This can be expressed by the "rain factor",[27] i.e., annual precipitation (in mm.) of a place, divided by its mean annual temperature (in centigrade). In the northern valley, the rain factor attains more than 15 north of Wadi Ziglab, where its average at Northern Shuneh and Wadi Jurum is 17 and 15.5 respectively. In the part of the valley between Wadi Ziglab and Wadi Zarqa, the rain factor ranges between 10 and 15, where its average at Deir Alla and Wadi Ziglab is 12.2 and 15.3 respectively. The rain factor, in the southern valley, varies from 9.4 at Ghor Fari'a to 5.8 at Jericho (fig. 1.16).

The valley is distinct for its strong evaporation compared with other neighbouring regions. While the average yearly evaporation at Jericho is 2932 mm., it is 2100 mm. at Aqaba Gulf area,[28] 2082 mm. at Jerusalem, and 935 mm. at Jaffa.* Undoubtedly, highest temperatures, strong winds, and lowest humidity are the dominant factors in this case.

Table 1.17 (App.1) shows mean monthly and annual evaporation in the valley over ten years observation. It is notable that the evaporation rate increases towards the south of the valley. Whereas the average yearly evaporation amounts to 2377 mm. at Beisan, it amounts to 2932 mm. at Jericho. The mean monthly evaporation reveals that the strongest evaporation is concentrated over the period from May to October. Tables 1.18aand 1.18b show mean daily evaporation at two stations in the Western Jordan Valley and at eight stations in the valley over the years 1961-1965. It can be observed that daily evaporation in the northern valley ranges between 3 mm.in January and 10 mm. in June (fig.1.17). This range is higher in the southern valley

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* Jericho	has	9	year's	observations	over	the	years	1943-1951.
Jerusalem	"	10	"	"	"	"	"	1926-1938.
Aqaba	"	11	"	"	"	"	"	1929-1939.
Jaffa	"	5	"	"	"	"	"	1934-1938.

where it varies from 4.5 mm. in January to 16 mm. in June. On the other hand, evaporation exceeds 10 mm. per day in the months from May to October. It is noteworthy that there is a close coincidence between the highest evaporation and the lowest humidity during the period of late spring and early summer.

Fortunately for the valley, its rainfall is concentrated in the cool season, so that there is less evaporation upon reaching the ground than would be the case with summer rains. (Fig.1.16).

The relationship between evaporation and precipitation is so clear that we can divide the climatic cycle into three parts. Firstly, the early rain period in which evaporation amounts are more than precipitation; in this time, most of the agricultural soils will be bare, vegetation will be scarce also. It is assumed that any rain percolation is so shallow that there is no main decrease in evaporation rates even from the bare soils. Evaporation will be so dependent on the rain amounts that it cannot increase them. Secondly, the main rain period in which precipitation amounts increase evaporation. During this period, the soils will become gradually covered with vegetation and agriculture. The rain penetrating in the soil will moisten all the profile reducing the deficiency of soil moisture. Thirdly, the late rain and the dry period, during which the evaporation rates become more dependent on the water stored in the soil. It has been assumed that evaporation rates from the soil may be 10% of transpiration amount potential.[29]

As regard the water balance of the valley, it is necessary to note the important role played by evaporation in this tropical environment. Comparing the water balance of different parts of the valley (Huleh, Tiberias, and Dead Sea lakes), several interesting conclusions can be made: The annual total of gains which Lake Huleh and its swamps (formerly) have benefited by Jordan inflow, precipitation and runoff from their catchments, this total amounts to 655 mcm. (1942/43 - 1946/47),[30] while their losses from evaporation and evapotranspiration have been 60 mcm. Consequently, the balance was +595 mcm. The annual total gains of Lake Tiberias (1935/36 - 1946/47)[31] have been 760 mcm. whereas the losses by evaporation have been 270 mcm. Hence, the balance was +490 mcm. The annual total gains of the Dead Sea have been 1580 mcm. and the losses from evaporation have been the same figure;[32] this means that the balance is zero (Table 1.19 (App.1)).

The forementioned figures show that the water balance in the north of the valley is higher than that in the south; besides, there is a gradual decrease in the water balance from the north to the south. In winter, the water balance is higher than in summer, this fact is prominent at the Dead Sea which has changeable levels ranging of between positive levels from December to April, and negative levels from May to November.[33] In other words, the waters of the Dead Sea rise and fall around the mean level (-392 m.) as a consequence to the fluctuation of the water balance.

There is no equivalence between the gains and losses at the present time. The discharge of the Jordan river has decreased in the last few years,* therefore, the evaporation has become higher than the gains. Consequently, the water balance has been facing deficiency at present; this deficit will be continuous as long as the discharge of the river continues to decrease. The evaluation of the annual average decrease in the level of the Dead Sea, over the years 1960-1965 is some 34 cm., though Finbert[34] has assumed that the level decreased some 150 cm. in two years.

The levels of Lake Tiberias range between $\mp$ 1m.,[35] because of the variations in evaporation during summer and winter seasons. Generally speaking, the water balance in the valley as a whole, is low as a result of the high values of temperature and evaporation compared with the precipitation. Therefore, if the agriculture remained dependent on precipitation only, it would be liable to fail in any year. The best solution is to use irrigation from the water resources in the valley as a substitution to the deficiency of water balance.

The following table gives an information about water balance during winter crop season at Deir Alla for a period of 8 years (1952-59):-[36]

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* Israel and Jordan have withdrawn large amounts of waters from both Jordan and Yarmouk rivers in their irrigation projects.

TABLE 1.6. Water balance during winter crop season at Deir Alla - Jordan Valley.

Month	$\bar{P}$	ETP	$\frac{ETA}{ETP}$	$\bar{P}$ - ETP	ETA	Wst	Wst acc.	Average need of Irrigation
Nov.	44	96		-52				
Dec.	60	68	0.6	- 8	41	19		-
Jan.	59	56	0.8	3	45	14	33	-
Feb.	56	64	1.0	- 8	64	-8	25	-
March.	45	99	1.0	-54	99	-54		29
1-15 Apr.	9	64		-55	64	-55		55
	273	447		-174	313			84

Note:- $\bar{P}$ = Precipitation (in mm.)

ETP = Evapotranspiration Potential (in mm.)

ETA = " Actual (in mm.)

Wst = Water Storage total (in mm.)

Source:- FAO., A Study of agroclimatology in Semi-arid and Arid Zones of the Near East. Rome (1962).

It can be concluded that the ETP is high in the winter months, due to high winter temperatures (fig. 1.18). The area, however, has also considerable rainfall with a maximum in December-January. Although very little rain is stored, the water balance is not as bad during the winter crop season as in the southern part of the valley. The period of active growth ends as early as the end of March and we see that the ETP is balanced until the first part of March. This factor, combined with the fact that soil conditions are not very suitable, make regular dry farming impossible. Since it is impossible to obtain the data necessary to calculate the ETP for other locations in the valley, it will be interesting to make a tentative comparison between the southern and northern parts of the valley. The ETP in the north is on the whole lower than in the south. In the north, rainfall is high enough to give a small surplus of water in November; whereas, in the south, evaporation in November exceeds the amounts of rainfall. This may be a reason why seeding, in the south, takes place later than in the north.

The water storage, in the north, is concentrated in the period from December to February. Even in March, nearly all the ETP of that month could be covered by rain and the storage is left to be used during April and May. On the other hand, owing to very poor rainfall conditions in the south, there is a very small water storage which concentrates in January. Consequently, winter crop needs cannot be covered much later than middle of March.

Comparing the water balance in winter, during the active growth period, of Deir Alla as a representative of the Jordan valley, with Irbid, Amman and Mafraq, as representatives of the plateau and desert, it can be concluded that the water balance is the best in Irbid and Amman due to their position on the plateau having more precipitation and less evapotranspiration. They are followed by Deir Alla, which has a transitional condition and, finally, Mafraq is the worst, due to its position in the desert. (Table 1.20 (App.1)).

The comparison varies when taking the water balance during the whole of the year. (Table 1.21 (App.1)). Of course, Deir Alla is the worst of all stations due to the continuous evapotranspiration all round the year, as a result of the intense irrigation and the perennial agriculture. It is followed by Mafraq of a desert climate, while Irbid is the best of all, due to its highest precipitation.

In order to know the winter requirements for every irrigated crop, it must be remembered that every crop has a Consumptive Use Coefficient. According to the Blaney-Criddle method (fig.1.19), it was found that the Consumptive Use Coefficients for the crops cultivated at the valley range between 0.65 and 1.30 acre feet of water per acre.[37] (Table 1.22 (App.1)).

On the basis of these results, a determination of water requirements for the northern and southern valley can be made. First of all, the quantity of water consumed during evaporation is calculated and then, by subtraction of "effective rainfall", monthly irrigation requirements are obtained. It is notable that months with less than 25 mm. of rainfall should be considered as without an effective rainfall. This net consumptive requirement (consumptive use minus precipitation) of the crop when divided by the farm-irrigation efficiency* gives the seasonal amount of water required at the farm headgate for each acre of the crop. The value of irrigation requirements has to be multiplied by a constant of 1.5385 in order to obtain diversion requirements.(38)

Tables 1.23 (App.1) and 1.24 (App.1) show irrigation and diversion requirements for the valley. From these figures, it can be concluded that irrigation and diversion requirements for the southern valley are more than for the northern in all the values of K (Consumptive Use Coefficient). This is due to the high values of temperature and evaporation. Summer has higher requirements than winter in both zones of the valley. It is to be noted that the higher is the value of (K), the greater is the need of crops to the water. The crops of (K) 0.65 need 15 mm. in January and 140 mm. in July for irrigation; while they need 23 mm. in January and 215 mm. in July for diversion in the northern valley. On the other hand, the crops of (K) 1.30 in the southern valley need 111 mm. in January and 281 mm. in July

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* The irrigation efficiency is estimated at 65%, because some 35% of water is lost by surface-runoff and percolation.

for irrigation, while they need, 170 mm. in January and 432 mm. in July for diversion.

Conclusion.

From the forementioned climatic data of the valley, it seems so clear that the valley can be divided into two climatic zones, the Syrian Steppe type and the Arabian Desert type. The border between these two zones is not a line but a transitional strip located between Deir Alla north, and Ghor Fari'a south. Undoubtedly, the common climatic characteristics of these two zones are dominant in this strip. The Syrian Steppe type is confined to the northern part of the valley between Yarmouk river in the north and Zarqa river in the south. According to De Martonne index of aridity i.e., $I = \frac{P}{T + 10}$, it has an index of aridity of more than 5. For instance, I = 12 at Northern Shuneh. According to Koppen's climatic classification, it is BS. The Arabian Desert type is confined to the southern part of the valley between Zarqa river and the Dead Sea. It has an index of aridity of less than 5. For instance, I = 4 at Jericho. According to Koppen, it is BW.

This variation between the two zones has to be taken into consideration in any irrigation project in the valley.

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CHAPTER 2.

HYDROGEOLOGY.

The stratigraphy and structure of the rock formations of the Jordan Valley have a paramount importance in the study of soil and water utilization. Hydrogeological characteristics explain why the water resources of the valley have been used in the past since the Roman times. In addition, they indicate the role played by groundwater in supplying the present irrigation water and the potentiality of groundwater as a future resource for the area. Nature provides a gradation from highly permeable materials, which, if saturated, are very productive aquifers, to impermeable materials that yield practically no water. Not only does the classification of rock materials help in recognizing the sources of groundwater, but it helps also in revealing the origin of soil parent materials. For instance, the alluvium on the alluvial fans gives rise to a brown stony sherty soil, while the Lisan Marls produce a saline whitish grey soil.

Stratigraphy.

The Jordan Valley is very complex stratigraphically, sedimentologically and tectonically. Its floor is composed of lacustrine deposits whereas its escarpment is formed from marine sediments and terrestrial deposits. Since the valley structure is unstable, stratigraphy is very varied, and there are groups extending from Triassic to Quaternary periods. As will be seen, the very complex history during the latest geological periods has made lithological conditions of the Jordan Valley very variable. The complex stratigraphy with variable lithology is shown in the following tables 2.1 and 2.2.

Pattern of Geological Outcrop.

The pattern of geological outcrop in the Jordan Valley has been complicated locally by faulting and tectonic movements (figs. 2.1 - 2.7). However, the broad patterns of outcrop are relatively simple. Using the Geological maps prepared by A.M.Quennell, (1954), Baker and Harza, (1955),[1] D.J.Burdon, (1959),[2] the German Geological Mission, (1964),[3] and Hunting Services Company (1963), the following outcrops can be recognized.

The oldest rocks of the Zarqa group outcrop in the lower reaches of the Wadi Hisban and the Wadi Zarqa, from which the group gets its name. There are good exposures of Triassic formations in the Wadi Hisban, whereas Jurassic outcrops are confined to Wadi Zarqa and some twenty kilometres of the escarpment of the Jordan Valley south from the mouth of the Wadi Zarqa. The most southerly outcrop is that described by Avnimelech (1945),[4] "from the foot of the hill on the eastern border of the Jordan Valley, some 15 km. south-east of Damia bridge".

TABLE 2.1. Geological Stratigraphy of the Jordan Valley Area.

Era	Period	Group	Thickness in metres	Stage	Lithology
Cenozoic	Quaternary	Jordan Valley Sediments			See Table 2.2.
	Tertiary	Belqa Group	700	Eocene	White calcareous and siliceous chalk with interbedded flinty chalks and limestone.
Mesozoic	Cretaceous		240-300	Senonian	Upper: Variable cherts and limestones.
					Middle: Variable bituminous chalks and limestones.
					Lower: White chalks
		Ajlun Group	20-80	Turonian	Variable limestones, sandstones and marls.
			450-600	Upper Cenomanian	Variable limestones and marls.
	Jurassic	Kurnub Group	200	Upper:	Fine sandstones, shales and limestone.
			110	Lower:	White, coarse sandstones.
	Triassic	Zarqa Group	300	Upper:	Limestone dolomites and sandstones
			70	Lower:	Shales, gypsum, and marls.

Sources:- 1) Natural Resources Authority. 2) Burdon (1959).
3) Baker and Harza (1955).

TABLE 2.2. Geological Stratigraphy of the Jordan Valley.

Era	Period		Groups	Thickness in metres	Lithology
Cenozoic	Quaternary		Recent	0 - 300	1. Quaternary Alluvium (Qal): A complex of sands, silts, and clays. 2. Quaternary Alluvial Fans (Qalf): Unconsolidated beds of gravels, sands, calcareous clays and clays.
			Jordan Valley III (Lisan)	50-150 25	1. Lisan Facies: Varved gypseous marls with rare intercalated bituminous and thin sandstone beds. 2. Samra Facies: Pseudo oolitic limestones alternating with white, chalky marls.
	Tertiary	Neogene	Jordan Valley II	350 70	1. Ghor el Katar Formation: Alternating conglomerates, sandstones, sandy marls, and marls. 2. Shaghur Formation: Well cemented calcareous sandstones and conglomerates, changing locally to limestones and travertines.
			Jordan Valley I		Undifferentiated Neogene Sediments: Conglomerates, sandstones, limestones and marls.

Source:- 1) German Geologic Mission (1964).

2) N.R.A.

The Kurnub sandstone group outcrops along the escarpment of the valley and in the watershed of the side wadis particularly, Rajib, Zarqa, Shueib and Kufrein wadis.

Typical outcrops of the Ajloun group may be seen in the Wadi Zarqa to Wadi Yabis area. Bedded breccia with huge blocks of Turonian and Cenomanian limestone border the Jordan Valley from Wadi Safara to Wadi El Jisra, and from the foot hills to the higher chalk slopes which rise behind to over 600 m.

The Belqa group outcrops along the escarpment and in the lower parts of the side wadis from Wadi Yabis to Yarmouk valley inclusive. With regard to the bitumen scattered in gravels at the Dead Sea area, its source is in the bituminous limestones of the former groups; bituminization takes place as a result of the mixture of considerable quantity of vegetable or animal matter with sediments; the bituminous matter may be forced from them either by heat, pressure, or the percolation of water.[5]

Scattered remnants of cemented conglomerates of Neogene age occur occasionally as part of the highlands and as part of the valley floor. There are fifteen scattered outcrops north of Qarn el Hammar between Wadi Arab and Wadi Rajib; whereas, to the south of Qarn el Hammar, Neogene outcrops are smaller and more limited; In Ghor Kebid, five separate outcrops are shown.

With regard to the Jordan Valley 2 (J.V.2) sediments, they prevail in the southern valley between Ghor el Katar and the Dead Sea. Along the foot hills, a massive conglomeratic Shaghur formation appears above different rock-units of the Tertiary. The Ghor el Katar formation and the basalt formation are observed at Ghor el Katar and Grain Sabt, 30 km. north of the Dead Sea. This is an olivine-basalt intrusive plug, or more probably a loccolith.(6) The Lisan marl beds are domed upwards surrounding the basalt. It is significant that with the exception of Grain Sabt, all volcanic activity has taken place outside the valley, particularly at the lower terraces of the Yarmouk valley and on the plateau between the Yarmouk valley and Wadi Arab.

It is of interest to note that there is a line of volcanic activity along the escarpment of the valley.(7) All of this activity has occurred after Miocene, but most of the flows were earlier than the formation of the Jordan and Yarmouk valleys. The peculiar form of the meander about 2 km. south of Jordan's exit from Tiberias Lake must be chiefly attributed to a block of basalt situated there. Another much larger basaltic outcrop, to the west and to the south of the confluence of the Yarmouk with Jordan, seems likewise to have decisive bearing upon the complicated course of the river. The basaltic block, opposite the confluence of Wadi Arab, greatly contributes to the characteristic bend upstream of the longest reach of the Jordan. Basaltic bedrock is also responsible for the extreme narrowness of the alluvial valley along the stretch of Qarn el Hammar.

Plate I.

The Shaghur formation.

Plate II. The Ghor el Katar formation.

More than 70% of the Jordan Valley is composed of the Lisan formation. The best exposures are found along the sides of the Jordan river flood plain where it has been dissected by the river and its tributaries. In some areas, a characteristic reddish alluvial cover is deposited on top of it ranging from a few centimetres to about two metres in thickness.

In the valley, a general correlation between geological parent material and soil type can be attempted. In the field, it is generally a fairly simple procedure to distinguish between the alluvium laid down on top of marl on the alluvial fans north and south of the Zarqa river and the saline water deposits on the southern valley and Katar hills. Invariably the alluvium on the alluvial fans gives rise to a brown stony cherty soil, while the saline water deposits produce a saline whitish grey soil.

Similarly, the flood plain area develops solonchak soils, whereas the Kurnub group sandstone is important in being the only non-calcareous formation in the south eastern part of the escarpment. They are however, in many areas, contaminated by calcareous material derived from Zarqa group material moving down slope.

Structure and Tectonics

The structure of the Jordan Valley is dominated by the late Tertiary and Quaternary faulting which has produced the Dead Sea Rift Valley (fig.2.8). There is no major single fault bordering both the eastern and western side of the valley.[8] Instead, the valley is crossed diagonally by two major faults, the Er Risha fault in the Wadi Arabeh and the Jordan Valley fault which extends from the north-west corner of the Dead Sea, possibly to the south east corner of Tiberias Lake. For most of their length, they are covered by Neogene, Pleistocene and Recent sediments. They are, however still active and their courses are marked by scarplets, shatter-ridges, springs, sudden contacts between Neogene and Recent, and similar features.[9] The Er Risha fault has an extension along the eastern shores of the Dead Sea, whereas, the Jordan fault forms the western shores. It is of interest to note that the Jordan fault extends along the eastern shores of Tiberias Lake and splits into two faults swinging away to the north-east through the Hermon massif and thence into the Anti-Lebanon. On the other hand, there is a fault inferred within Tiberias Lake and parallel to its western shore,[10] extending towards the north passing through the eastern side of the Qiryat Shemona ridge which here is called Tel Hay fault.[11] The fault splits into two faults at Marjayoun, one of them runs along the western escarpment of the Lebanon Bekaa rift, thence northwards through Ghab plain of Syria, and finally to Hatay, in southern Turkey.[12] The other system continues towards Beirut.[13]

Transverse faults affect the whole of the eastern and western blocks bordering the Jordan Valley. The structural pattern is that of two crossing fault systems: a WSW - ENE system of Neogene faults rejuvenated in the Pleistocene, and a SE - NW system of step faults generated in the Pleistocene. Some of these faults can be traced well into the valley, while others are wholly located to the west and east of it. Most of the side wadis run into these transverse faults which have played a great role as a means of communication in the region since ancient times.[14]

The Quaternary sediments as observed in the southern valley show four different phases of structural movements.[15] The first major phase of displacements occurred prior to the deposition of the Shaghur formation, that is prior to the Lower Pleistocene. The Shaghur formation overlies with an angular unconformity all older formations, including Lower Tertiary. A second phase of structural movements affected strongly the Shaghur formation, while the overlying Ghor El Katar formation was only disturbed to a lesser degree. These movements took therefore place towards the end of the Lower Pleistocene. The third phase of structural activity was during the Middle Pleistocene; The Ghor El Katar formation in turn is more affected by structural movements than the Lisan formation overlying it with an angular unconformity. During this phase, the basalt occurred at Ghor El Katar, and at many other places along the rims of the valley. The fourth structural movements occurred during the Post-Upper Pleistocene in which the Lisan formation has been displaced by minor block-faulting.

The forementioned lithological conditions of the Jordan Valley, are the result of the very complex history during the latest geological periods. It is important to note that the Jordan depression outlined itself in the Lower Miocene as a series of isolated shallow basins at first, rather than as a continuous rift. Some of these basins may have been covered by inland lakes or flooded by the sea. During the Upper Pliocene and its transition into the Lower Pleistocene, there existed two lakes or a tier of lakes in the valley.(16) At the beginning of the Pleistocene there was a series of separated basins, the Aqaba basin in the south, the Jordan-Dead Sea basin, the Tiberias-Beisan basin and the Huleh basin. At first these last two basins were joined together, but the great outflow of basalt in Mid-Pleistocene times built a great dam right across the valley between Huleh and Tiberias lakes. The next development was the change caused by the very heavy rain at the end of the Mid-Pleistocene. The tremendous floods of this period brought into being a vast continuous inland lake, which included the present Lake Tiberias in the north and extended some 30 km. beyond the present southern shores of the Dead Sea. Bays of this lake extended deeply into the valleys of the bordering mountains, as seen from remnants of Lisan marls in the foot-hills more than 300 m. above the present level of the Dead Sea. Since the lower portion of the sediments of this lake contains limnic gastropods and pelecypods, a fresh water environment of deposition is suggested. This, however, changed gradually into brackish water conditions, with unfossiliferous, chemical precipitations alternating with shale, silt, and coarse clastics.[17]

Blankenhorn correlated the pluvial periods of Palestine with the different glacial periods of Middle Europe. According to him,[18] the pluvial period was at its height, with glaciers on the Lebanon at the time of the Mindel Glaciation of the Alps. There was a correlation between the oscillation of the lake level - due to the successive glacial and inter glacial (rain epoch and dry epoch) periods - and the formation of Jordan Valley terraces. Blankenhorn[19] correlated the second Ice-age with the formation of the high terraces; on the other hand, the correlation was clear between the third ice-age and the formation of the lower terraces. Alluding to Hooker's discovery of glacier moraines on the Lebanon, Lartet[20] inferred that a climate which clothed these mountains with permanent snow and ice would have lessened evaporation, and led to an increase of the waters of the Dead Sea. This view is not correct due to the fact that ice covers the peaks of Hermon massif at the present time. Some authors[21] believed that the outburst of volcanic phenomena has an indirect connection with the formation of the old lake of the pluvial period. However, the lake waters began to recede after Riss Glaciation and then developed the steppe and semi-desert climate of today. This change was earlier than the time of Mousterian man. According to Blankenhorn,[22] it was 50,000 years B.C., and the climate of today had been established by the Magdalenian in 10,000 B.C. Hence the great lake would have disappeared many millenniums before the historic period and the days of Abraham.[23]

The early date assigned to the disappearance of the Jordan Lake is supported by the salinity of the Dead Sea, as investigated by Irwin[24] who calculated that the Jordan would have required 50,000 years to supply the Dead Sea with its load of Magnesium.

Three important basal lines are to be observed in the lake terraces situated between - 200 m. and the present shore (- 398 m.) of the Dead Sea.[25] The highest terrace level I is at - 200 to - 210 m. A well developed terrace level II is at - 310 to - 339 m. Terrace level III is at - 375 to - 380 m. Between stage II and III, there are 4 - 6 intermediary stages. Hudleston[26] had given the term "shelves" to what may be called terraces, these shelves represent the old beaches which were called "extinct lake". According to him, they are ranging from "Extinct lake No.1" to "Extinct lake No.4".

The Jordan river appeared only after the drying up of the Lisan beds and after the development of most of the lake terraces; that is to say, it came into existence at the end of the Pleistocene. Furthermore, with the exception of its own flood plain which lies a few metres above the river, the Jordan shows no other river-terraces.

It is assumed that the Jordan flood plain (Zor) sediments are to be wholly assigned to the Holocene. With regard to the formation of the present lakes in the valley, it is assumed that the present Lake Tiberias, dates back to the beginning of the shrinking process of the Lisan Lake,(27) whereas the Dead Sea could have taken its shape between the end of the drying up of the Lisan Lake and the appearance of the Jordan. As regards the materials which have been removed from the surface of the drainage area of the Lisan Lake to the enclosed basin, Hull(28) holds the view that they are either used up in the terraces or are spread over the floor of the Dead Sea and Jordan-Arabeh Valley. It may be added to Hull's interpretation that the subsidence of the valley and the opening of the Dead Sea since the erosion of the great side wadis due to rifting, these factors may shed a light on the materials fate. An attempt has been made to assess a water balance of the Lisan Lake;(29) it is concluded that such a lake could have existed if the figures of the present average annual precipitation were increased by 200 mm. and if certain changes were to occur in the rate of evaporation and the runoff coefficient.

There has been considerable argument about the mechanics of the formation of the Jordan Valley. It is often called "rift valley" which implies that the early sedimentary plateau was arched, and that the central segment or "key stone" dropped and so produced the rift. If this occurred the trough was caused by tension, or a release of pressure on either side. Others call it a "ramp valley",[30] holding that the region was under compression, and that in order to release the strain the central block was broken and forced down, the escarpments on either side overriding the narrow wedge in the centre. Neither theory can yet be proved, though it is indisputable that the basement of the Jordan trough has sunk relatively to the western and eastern plateaus.[31] It is possible that both rift and ramp conditions occurred during different stages of the valley's history. Several theories have been advanced to account for the development of the valley, the most recent being the "wrench fault hypothesis" of Quennell.[32] The major wrench-faults of the rift system originally followed a sinuous pattern. The convex sections of the block margins are called "bulges". Horizontal displacement required the elimination of the bulges by warping or downthrusting them in an oblique-slip movement on the high-angle planes of the wrench-faults. The movement of Arabia in relation to Sinai-Palestine is believed to have taken place intermittently during two principal phases, between which there was a prolonged pause. During the first, the horizontal movement was 62 km. and the rotation more than 3 degrees. During the second, the displacement was 45 km. and the rotation more than 2½ degrees.

A sinistral movement of 160 km. along the Dead Sea fault was proposed originally by von Seidlitz (1931) and Dubertret (1932). Wellings accepted this hypothesis, as it agrees well with the position occupied by comparable facies types of the Cambrian limestone and of the marine Jurassic strata on both sides of the Dead Sea - Arabeh Depression.[33]

Recently, Freund (1961), in his study of the Lower Turonian of this area, found a similar shift of about 100 km., for two separate but contemporaneous facies types. Vroman (1961) found that along the entire length of the Dead Sea - Jordan rift there are indications of large-scale longitudinal displacements, and certainly not a slip of 100 km.(34) Freund(35)(1965), believed that a post Turonian sinistral normal fault movement of about 70 - 80 km. had occurred along the Dead Sea fault; however, Freund and Zak(36)(1966) have presented evidence of a recent left-hand strike slip dislocation of about 600 m. along the Dead Sea rift. Of these 600 m., a movement of at least 150 m. is younger than 20,000 years. Consequently, they have considered the hypothesis of a post-Cretaceous strike-slip movement of about 100 km. to be well founded. This hypothesis has been confirmed by Laughton (1966) who has concluded also that the average of Arabia Peninsula movement towards the north was 2 cm. per annum. On the other hand, according to a Geologist working in the phosphate deposit areas of Negeb and Rusayyifeh, it was found that they belong to the same geological period. Since the Rusayyifeh deposits located in the eastern side of the rift valley, are far from the Negeb deposits in a vertical distance estimated about 107 km., this gives a strong evidence in favour of a movement of 107 km. towards the north.

From the forementioned, it can be concluded that the formation of the Jordan Valley has passed through numerous processes during successive geological epochs. It is still in an unstable condition. Since there is abundant evidence of movement along the faults which bound the valley, it follows that it must be foci of seismic activity. Picard[37] drew attention to the existence of crescentic faults in the Jericho area. Parallel to this, crescentic faults diverge from the rift valley in NW - direction in the area of Tiberias. The intersection of the western border faults of the rift with the crescentic faults would then be responsible for the secondary epicentres of Jericho and Tiberias. Ămiran[38] (1952) has stated that on the average Palestine is affected by two to five strong earthquakes per century. Light to medium tremors are rather frequent, the number of light shocks recorded in different parts of the country per year varies on average between about two and six. Consequently, the dams which are being built on the eastern side wadis, should be designed to withstand earthquake shocks of major intensity.

Groundwater Potentialities.

Each successive opening and down movement of the rift during its formation has lowered the general base-level and has rejuvenated streams flowing into the tectonic depression, thus allowing them to cut further and further eastwards into the plateau and to capture additional areas for the drainage basin of the rift.

Intense rejuvenation by erosive processes has resulted in the exposure of the complete geological succession in many areas of the scarp zone. This exposure with prevailing faults, explain why springs are abundant. Therefore, depression springs and fault springs are the dominant types.[39] Below the major scarp of the rift, a line of springs occurs with outlets along the scarplets between the Ghor and the Zor.[40] All these outlets* are falling into a contour line, the elevation of which averages - 275 m.

Pre-Eocene Sediments:-

Zarqa and Kurnub Groups:-

Ground water may occur in these groups especially along the sides of the valley adjacent to the foot hills where they are exposed. Several springs and seeps issue from them, but they are usually saline. Wells drilled into these groups usually encounter saline water. The Kurnub sandstone is moderately porous and permeable, and consequently, the water transmitted acquires large quantities of salts. The mineralization of water passing through these rocks will increase in proportion with increasing distance from the source, which lies in the high rainfall areas of the

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* Ain Salama, Ain Sbertra, Ain el Shafat, Busset el Bal'a, and Ain es Su'eidiya.

plateau.[41] Numerous faults in these formations may act as barriers to groundwater flow preventing the flushing out of the saline waters. In addition there are several evaporite beds within the Zarqa and Kurnub groups in which infiltrating water becomes contaminated. The purer waters from these sandstones fall into the Bicarbonate group,* and reflect the presence of the highly calcareous material which acts as the cement.

Ajlun and Belqa Groups:-

Ground water occurs in the known limestone aquifers within these groups especially on the sides of the valley. Several wells issue from these aquifers as the formation dips into the valley. The waters belong almost to the Bicarbonate group of waters and contain a predominant amount of the Ca cation. Towards the centre of the valley, these formations are down faulted and occur at a greater depth. Therefore, only meagre quantities of ground water may be produced from them, and it may have high salinity values.[42] This is due to the local absence of secondary fractures and solution channels which reduce porosity and permeability of the limestone formations. Furthermore, the extensive faulting along the scarps of the valley may act as barriers and prevent such normal ground water movement that it prevents the flushing of the existing saline water.

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* HCO_3 + 50% total cations.

Post-Eocene (Jordan Valley) Sediments:-

The Jordan Valley waters are highly saline and are generally derived from recent alluvial deposits. It is probable that these waters have been transmitted through the Kurnub sandstones or along fault and fracture zones before entering the alluvium. The grouping of these waters shows them to be of mixed or Chloride classification. Some of the excess Na Cl concentration may be due to two factors, the movement of water through saliferous formations present at old Dead Sea levels, and evaporation causing salt concentration at shallow levels especially in low discharge springs.

Neogene:-

The well cemented conglomerates of this formation have very low porosities and permeabilities. In some cases secondary fractures and joints may be developed due to folding and faulting. Ground water of moderate quantities may be encountered in this formation where it occurs in the vicinity of major alluvial fans.

Lisan Formation:-

Ground water encountered is usually saline due to the chemical composition of these sediments. Since the Lisan formation makes up most of the Jordan Valley, it would be expected that most of the ground water is saline.

In rare cases, the saline water in the gravel beds of this formation has been flushed away and replaced by fresh water.

It is to be noted that the well cemented, hard rocks of the Shaghur formation form aquicludes, if not jointed or faulted due to the structural disturbances. The shaly fine clastic members of the Ghor el Katar formation, as well as the marls and chalks of the Samra and of the Lisan facies also act as major aquicludes.[43] The latter are locally developed as a confining aquiclude, and therefore, give reasons for some artesian or semi-artesian springs.

Quaternary Alluvium:-

Alluvial Fans:-

Ground water occurring in the alluvial fans of major side wadis accounts for more than 80% of the available fresh ground water in the valley. Ground water of good quality occurs around the apex and within these fans where fresh recharge is readily available. The water becomes more saline near the fringes. The fans are generally surrounded and underlain by saline water associated with the Lisan formation.

Jordan Flood Plain (Zor) :-

The alluvial cover is thin here, and does not constitute an aquifer. However, ground water does occur in the underlying Lisan formation. Geological formations

Plate III.

The Samra facies.

Plate IV. The Lisan facies.

and their water potentials are shown in the following table 2.3.

TABLE 2.3. Geological formations and their water potentials.

Group	Water Supply	Water yield potential
Recent Alluvium (Qal + Qalf)	Abundant, though specific yield may be low.	Poor - Excellent
(Lisan Facies	" " "	Poor - Good
JV 3 (Samra "	" " "	Poor
JV 1+2 (Neogene)	In north, freshwater limestone may be important aquifer; elsewhere rock is of minor importance.	Poor
Belqa (Eocene	Many medium and small springs originate from this formation.	Moderate - Excellent
Group (Senonian	Two groundwater aquifers in this formation, the fractured chert beds and the top of the bituminous chalk.	Moderate - Good
Ajlun (Turonian	Contains some small springs generally only of local importance.	Good
Group (Upper Cenomanian.	It is good aquifer.	Poor - Moderate
Kurnub Group	Several large springs flow from this formation. Porous formation.	Poor - Good
Zarqa Group	Water possibilities unknown, but group supplies several minor springs.	Poor - Good

Sources: 1) Baker and Harza (1955). 2) Natural Resources Authority.

Distribution of Groundwater quality within the Aquifers:-

Groundwater quality in the valley usually deteriorates with depth. In rare cases a saline water aquifer may overlie a fresh water aquifer. Most of the developed areas of the valley are underlain by aquifers containing a total dissolved solids (T.D.S.) of 1000 - 2000 ppm. These regions usually lie on major alluvial fans between the apexes and the fringes. However, some groundwater encountered in the Lisan formation may contain a T.D.S. of 1000 - 2000 ppm. as in the north and west Karameh areas.

A groundwater zone of very high grade salinity has been delimited by the geoelectrical soundings in the Lisan facies occurring in a central longitudinal strip. This strip extends, varying between 3 km. to 6 km. in width, from the north end of the Dead Sea for more than 40 km. towards north. Although less concentrated, the chemical quality of groundwater from this central strip closely resembles Dead Sea water.[44] Particularly, the bromine content indicates a close relationship to the Dead Sea. The close resemblance, may indicate, that the salinity of the groundwater in the strip stems from the original salinity of the residual water in the sediments of the brackish old Lisan Lake. This point emphasises the fact that the salinity increases towards the deep aquifers of the Lisan formation. Moreover, the increase of salinity with depth is due to the leakage of contaminated groundwater through deep faults in the deeper aquifers.

The isosalinity groundwater map of the valley at summer 1965 revealed that fresh water is encountered in the apex area of alluvial fans, whereas, the proportion of the salinity increases towards the west and south. This phenomena can be interpreted by the fact that the groundwaters moving westerly towards the river, become contaminated. On the other hand, the groundwater levels increase towards the west, i.e., Jordan river.

The groundwater level has declined more than 10 m. in the past 15 years, as the withdrawal rate has increased due to the agricultural development in the valley. In addition, there has been a serious increase in the salinity in the alluvial aquifers which is believed to be caused by the lateral movement of highly saline water from the margins of the fan toward the depression cone, and upward leakage from the sand and gravel artesian aquifer in the marl-clay sequence.[45]

Field inspection and review of the hydrologic data clearly show that the Jordan river constitutes a "line sink" or drain for the groundwater system as well as the stream flow; all eventually drain into the Dead Sea. The high salinity of the Jordan river near its mouth attests to this hydrologic regimen. Several areas in the Zor which constitute an evaporation sink from the artesian aquifer were also observed. Water is leaking upward through the marls and clay and is evaporated at the land surface which accounts for the high soil moisture content in certain areas.

Recharge.

Groundwater recharge to the aquifers of the valley occurs from direct precipitation into the alluvial plains, by infiltration of surface waters into the alluvial materials from the side wadis of the Jordan Valley during flow periods, and by groundwater movement through the unconfined shallow limestone aquifers east of the rift fault. Recharge to the confined aquifers occurs in the high rainfall area of the highlands east of the valley. About 900 mcm. of annual precipitation fall on the two groundwater zones of Ajlun dome and Salt dome. It is estimated that some 225 mcm. or 25% of precipitation infiltrate in the ground for the recharge. From the 225 mcm., there is some 120 mcm. lost as effluent seepage, base discharge from wadis, and spring discharge.[46] Thus, the annual recharge from the two ground water zones is less than 105 mcm. However, the annual recharge may be much less than these maximum estimates.

During the year of 1962/63, groundwater recharge into the aquifers of the southern valley was estimated to be 22 mcm., while a total of 36 mcm. of groundwater was extracted. 1962/63 was a season of below average rainfall. However, during the years of 1963/64 and 1964/65, adequate rainfall occurred to provide an adequate quantity of water to supply the year's pumping needs and provide additional groundwater to partially make up for previous groundwater deficits. During the year of 1965/66, ground water recharge into the aquifers of the southern valley was estimated to be 20 mcm., while a total of 40 mcm. of groundwater was extracted. However, the high recharge of the year 1966/67 provided an adequate quantity of water to make up for previous groundwater deficit.

In the northern valley, an annual recharge rate of 45 mcm. is estimated, while, a total of 3 mcm. of groundwater was extracted. The recharge rate is based on flow measurements from springs draining the alluvial and Lisan aquifers. Other possible sources of recharge are canal losses, and excess irrigation water returns.

During the past several years, approximately 250 wells in the alluvial water table aquifer have been abandoned because of decrease in yield and increase in salinity of the water, making it unsuitable for crop growth. This situation will continue as long as withdrawal rates exceed recharge, resulting in further water level decline and increase of salinity in the upper aquifer. Conditions are not uniform in each one of the alluvial fans as there are many factors associated with this variance: thickness of saturated zone, areal extent, amount of recharge and discharge, permeability of materials and extent of irrigated area.

The groundwater level map of summer 1965, of the southern valley, indicates that the water table gradient follows the topographic surface (fig.2.9). The groundwater flow is from areas adjacent to the foothills towards the Jordan river with a slight bend to the south. The groundwater contours are closely spaced in some areas near the escarpment especially east of Kufrein and Southern Shuneh. The groundwater contours are also closely spaced near the Jordan river indicating low permeabilities.

Pumping from wells has frequently disturbed the normal gradient. In some areas the gradient is fairly flat over large pumped areas and is steep on the fringes. This is usually the first step towards the formation of a cone of depression. Cones of depression underlie several areas in the Jordan Valley at present. In Southern Shuneh a cone of depression is forming; moreover, in Jericho, Auja and Fari'a areas, cones of depression already exist. These cones of depression indicate that serious overdrafts are taking place in these areas of the valley.

The southern valley needs an immediate remedy for the groundwater problem. The best method will be the artificial recharge to the alluvial fan aquifers to maintain a higher hydrostatic head and alleviate further intrusion of saline water. Two readily available techniques are available. Firstly, aquifers can be recharged via the many abandoned wells by diverting the flow from springs during the periods of low demand. Canals can be used for delivery of water by gravity to recharge selected abandoned wells. Secondly, water wells can be constructed into the Upper Ajlun limestone aquifers in the apex area for supplemented pumping. The wells should be located at a safe distance from the springs in order not to interfere with their normal flow. The concept of artificial recharge to the shallow alluvial fan aquifers appears to be a necessity if these aquifers are to be maintained for further utilization. The interception of additional water from the limestone aquifers has potential merit as it would further intercept water now constituting recharge into the lower artesian, saline aquifer. This would result in a head loss to this system in time, and reduce the severity of upward leakage into the shallow system.

Finally, the construction of storage dams on the side wadis will be important and necessary for supplementary recharge to the aquifers in the valley. Moreover, they may alleviate the salinity and regulate the levels of groundwater in the wells.

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Chapter 3.

HYDROLOGY

Introduction:-

The Factors affecting the Hydrology of the Jordan Valley:-

These factors are generally divided into physical and human factors. The climatic factors are the basic ones for they have a great influence upon the nature of the discharge of the streams, springs and wells. The appearance of stream floods is preconditioned by the distribution of precipitation during the rainy season. Precipitation is heavy at the northern part of the Jordan river basin, being 1500 mm. per year on the slopes of the Hermon mountains. The minimum rainfall occurs at the southern part of the basin, being some 100 mm. per year at the Dead Sea. The average annual quantity of precipitation for the whole basin is approximately 430 mm. This quantity is equally divided and each of the Jordan river catchment north of Lake Tiberias, and south of it, and Yarmouk river catchment, acquire one third of the total rainfall.(1)

The Geological factors include the kinds of rock and their composition, permeability and other features. On the other hand, the topographical factors include the size and shape of the watersheds, the contour and density of the streams' drainage. The gradient of the ground, whose influence is generally complex and important for flow concentration, may have a considerable effect in the stream watersheds. There is hardly any vegetation in these watersheds to affect peak floods.

Human factors include the changes made by the high exploitation of the wells and springs. Also, the diversion of river waters is as important in decreasing the flow, as is the construction of dams in regulating the peak floods.

These factors should be taken into consideration when any investigation is done for the hydrology of the Jordan basin. They explain why the discharge of the Yarmouk is more than that of Zarqa which in its turn is more than that of Wadi Shueib. Furthermore, they explain the fact that the discharge of the eastern Jordan affluents is higher than that of the western Jordan affluents.

Springs and Wells discharge.

Springs represent the visible discharge from the aquifers; invisible discharges include seepages and evaporation etc., Springs occur where the groundwater table intersects the surface topography. The total spring discharge for East Jordan was estimated at 282 mcm. per year.[2] Of the 282 mcm., some 79 mcm. issues from small hill springs, is used locally for irrigation or domestic purposes and so never reaches the main wadis. The perennial flow of the wadis comes from the main springs, and their combined yield is estimated at 123 mcm. per year. The distribution by wadis is given in the following table:-[3]

TABLE 3.1. Estimated annual discharge of the main springs of the side wadis.

Spring	Estimated annual discharge (mcm).	Spring	Estimated annual discharge (mcm).
Wadi Arab	15	Wadi Rajib	5
" Ziglab	8	" Zarqa	45
" Jurum	11	" Shueib	10
" Yabis	5	" Kufrein	12
" Kufrinja	6	" Hisban	6

It is estimated that the total quantity pumped from the wells in the whole Jordan Valley is about 72 mcm. per year,[4] the largest part of which is withdrawn from storage. Of the 72 mcm., some 43 mcm. has been pumped from the wells of the eastern side of the valley, and 29 mcm. from the wells of the western side. The maximum capacity of all pumped wells in the valley is calculated to be 21,500 m^3/hour. If the value of 72 mcm. is spread throughout the year, it will give an average of 8220 m^3/hour pumped (2.3 m^3/second). Therefore, the average use of wells could be estimated as 38% of the maximum possible pumping capacity. On average, the wells are pumped about 9 hours per day.

Springs-Wells discharge problems:-

Since 1950, the increasing agricultural development within the valley has had many consequences. Drilling numerous new wells and withdrawing large quantities of water have been distinctive phenomena of this development, particularly in the southern valley (fig.3.1). A total of 842 wells drilled or dug have been recorded in 1966 in the Jordan Valley. Of these, 473 were drilled in the eastern side of the valley, and 269 in the western side. Of the 473 wells in the eastern side, 306 are presently in use, 65 are capped, 128 are abandoned, while 74 are structural or coreholes.

It is worth mentioning that the southern valley pumps much more water than the northern valley. In other words, pumping of well waters increases towards the south. The Kufrein-Rameh-Sweimeh areas recorded the highest quantities pumped, with an estimated withdrawal of 21.52 mcm. per year. The Southern Shuneh area was next with an estimated withdrawal of 13.42 mcm. per year. Karameh-Ghor Kebid area was third with an estimated withdrawal of 9.78 mcm. Undoubtedly, climate, soils and other water resources play an important role in determining the needs of the different zones for the waters of wells.

The over-pumping of the wells has caused a problem in the decline in water level. An examination of the Isodecline map of the period 1961-1965 will reveal that a sharp drop in water levels has taken place in most wells in the southern valley (fig.3.2). The decline ranges between 0 to 20 metres. On the other hand, a decline of 0 to 5 m. is recorded over a large area, whilst, a decline of 15-20 m. is recorded over a small area. That is to say, the higher is the decline in water levels, the smaller is the area in which the decline has occurred. The correlation is clear between the high decline and the settlement in the southern valley. This means that great quantities of pumped waters have been used for domestic uses and irrigation.

Salinity of well waters is a second problem caused by the over-pumping of wells (fig.3.3). It has been forementioned that the areas of highest salinity correspond to the areas where the Lisan (J.V.3) and Kurnub rocks are exposed. In general, salinity is high in the southern valley since a high percentage of wells are drilled in the Lisan formation.

Contaminated water from the north and west is being mixed with fresh water because of pumping and deepening of wells. Well No.25 had a T.D.S. of about 2000 ppm. in 1960, and a T.D.S. of 3168 ppm. in 1962; this indicates an increase in T.D.S. of 1168 ppm. (58.4%) over a period of two years. Well No.33 was drilled by UNRWA. for Karameh Refugee Camp in 1956. A water sample from that well had a T.D.S. of 1843 ppm. in April 1961; this water has deteriorated to the point where it is no longer potable.*

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* Personal communication with Karameh Camp Manager in January 1967.

Well No.77 drilled by Southern Shuneh Municipality was deepened from 95.5 to 120 m. in January 1963. The water level was at 91.5 m. when deepening took place; seven months later an additional 7.5 m. drop in water level took place and the most prolific aquifer was dewatered.* Moreover, several wells in the immediate areas are reporting sharp drops in their yields.

Groundwater salinity has induced another two problems. The first direct problem is the successive abandonment of the wells which were formerly used. In 1962/63, whereas, the total of the capped and abandoned wells was estimated at 320 wells, it is estimated in 1965/66 at 438 (137%). As the cost rate of a well construction is 1000 J.D., the total losses are estimated at 438,000 J.D. The consequences were either the damage or abandonment of numerous farm units. The second indirect problem is the contamination of the soils by using the saline waters from these wells. An investigation has been undertaken in the southern part of the valley to know the amount of increasing salt in the soils irrigated from the saline waters. The results are given in the following table:-**

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* Personal communication with the Engineer of Southern Shuneh Municipality in January 1967.

** Calculations have been undertaken by Groundwater division in (N.R.A.) according to the water unit of (5 ac. ft./ac./year).

TABLE 3.2. The amount of increasing salt in the soils of southern valley irrigated from the saline waters.

Well No.	Spring of 1962		Spring of 1965		Accumulated salts. Ton/year
	ppm.	EC x 10^6 micromhos/cm.	ppm.	EC x 10^6 micromhos/cm.	
61	610	953	1,100	1719	7.5
20	840	1312.5	1,080	1687.5	7.36
51	1,400	2187.5	1,500	2344	10.20
54	950	1484	1,080	1687.5	7.36
75	-	-	2,500	3906	17.00
76	-	-	2,500	3906	17.00
79	1,170	1828	2,600	4062.5	10.70

It may be seen that the situation is so serious that it needs urgent solution; a long-sighted policy should be designed according to the results of successive investigations on the groundwater. However, since 1962, drilling of new wells was prohibited between Palestine Grid lines N : 132 and N : 160 in the eastern side of the valley, and between N : 173 and N : 183.500 in the western side. A one kilometre spacing restriction between wells was also imposed north of coordinates 183.500 up to the Armistice Line. A five hundred metre spacing restriction between wells was also imposed on all other areas in the Jordan Valley. This restriction is based on the fact that isolated wells generally do not show such a large decline in their water levels as the closed spacing wells. This fact leads us to a new problem based in spring and well interference.

The over-pumping of wells has induced a problem of interference between the wells from one side, and interference between the wells and springs from the other side. This problem is prevalent in the valley, particularly, in Ain el Baida-Bardala area where dispute has broken out between well and spring proprietors. Field observations show that the springs have been affected by the over-pumping of the neighbouring wells.

After discussing the preceding problems, it should be essential to shed some light on the best plans for their remedy. It is very important to continue the ban of the drilling of new wells. Furthermore, further hydrogeological investigations should be undertaken over the years for all of the groundwater resources particularly in relation to their inventory and evaluation. This evaluation will be the keystone toward designing a relevant foundation for their utilization. It may also become necessary to control pumping in order to prevent the depletion of existing groundwater reserves and to save the existing aquifers from further serious contamination. This control should be undertaken as soon as possible for two reasons; firstly, the decision of preventing to drill new wells or the restriction of the drilling has induced adverse consequences; that is to say, the old wells were exposed to more and more over-pumping due to the bitter rivalry between their proprietors concerning the use of their water in cultivation of new lands. Secondly, the control prevents the disputes resulting from the interference of wells and springs.

It is essential to search for other regions beyond this zone to act as the source of groundwater in the future. It is assumed that the best relevant parts for drilling new wells are towards the rift border, near or even in the highlands. The field observations show that most of the wells within this border zone have fresh waters since they are too far to be contaminated with saline groundwater. In addition, part of their water may be exploited in the process of artificial recharge to support the aquifers of the valley. Care must be taken when beginning drilling new wells in the suggested area; the spacing between the wells and the springs should be designed on reasonable distances lest the problem of interference between them should occur. Spacing restrictions between the new wells should be imposed also.

The construction of storage dams on the side wadis would be a good support to the groundwater in the valley. The field observations emphasise that using any new source of fresh water, to irrigate the lands of the valley, will be a considerable opportunity for the groundwater in the valley to be in a state of continuous flow. Consequently, it becomes possible for flushing the aquifer by downward leakage.

Perhaps, it will be daring to propose that the extraction of waters from the wells should be ceased for a period not less than ten years, or at least, there should be a compulsory capping for all the wells of the southern valley which are located outside the alluvial fans. There must be a cycle or dual rotation for using the groundwater. It will be suitable to postulate a period of ten years for each of the extraction and the cessation process. This may be the best remedy for all the foregoing problems since the opportunity will be given to aquifers to increase their reserve from the fresh water.

The Discharge of Jordan Basin.

The entire catchment area of the Jordan river is about 17,000 square kilometres of which only 2,740 km^2. or 16 percent lie north of the outlet from Lake Tiberias. The major tributaries of the Jordan river are the Yarmouk and Zarqa rivers and a series of minor wadis.

The average annual runoff to the Dead Sea via the Jordan and its tributaries would, in the absence of any irrigation use of well, spring or river water, be some 1580 mcm. North of Lake Tiberias, the Upper Jordan has three principal headwater tributaries. These streams are fed by the winter rains and spring snow melt of the Mount Hermon massif. The Hasbani mean annual flow can be taken as 138 mcm.; but over a twenty year period this has varied from 52 to 236 mcm. The second major source is the river Banias, whose mean annual flow can be taken as 121 mcm.; over a twenty year period this has varied from 63 to 190 mcm. The third and most reliable of the headwater tributaries is the Dan, with a mean annual flow of 245 mcm.; over twenty years its annual flow has only varied from 173 to 285 mcm.(5) These three main headwater streams unite to form the Upper Jordan.

Although the natural flow of the Upper Jordan into Lake Tiberias is approximately 760 mcm., the outflow from the lake is only some 490 mcm. The difference is accounted for by evaporation from the lake surface, variously estimated at 270 mcm. per annum.(6)

Eight kilometres south of the exit from Lake Tiberias, the Jordan receives the waters of its major left bank tributary, the Yarmouk. This river has a mean annual flow of 443 mcm. (before any deductions are made for existing irrigation), having about 40% of the drainage area and contributing about 44% of the total discharge of the Jordan.

The Lower Jordan receives about 505 mcm. annually from its eastern and western tributaries. 268 mcm. represents the perennial flow of springs and streams, while 237 mcm. represents flood runoff during winter spates.(7) Generally, the mean annual discharge of the river at King Husein Bridge is estimated at 1012 mcm.

The discharge characteristics of the Yarmouk are reflected in the figures of its monthly discharge (Table 3.1 (App.3)), especially when compared with the monthly discharge of the Jordan (Table 3.2 (App.3)). The figures of the monthly flow totals of the Yarmouk and of the Jordan at its exit from Lake Tiberias are for the period 1926/27 - 1931/32;(8) these figures indicate that there exists a noticeable lag of at least 2 weeks in the maximum monthly discharges of the Jordan in relation to those of the Yarmouk. The highest monthly discharges of the Jordan generally occur from January to April, of the Yarmouk in February. The lag in the maximum discharge of the Jordan and its spread over a period of approximately two months are caused by the storing effect of Lake Tiberias. In addition to the setting in and duration of the snow melting on the summit region of the Hermon massif. It is noted also that the highest monthly discharge of the Yarmouk surpasses by 50% and more that of the Jordan.

The mean annual discharge of the Yarmouk at Adasiyeh covering the period of 1927-1963 was about 443 mcm., with a maximum value of 870 mcm. (1929) and a minimum of 260 mcm. (1960) (Table 3.3. App.3). The peak of the Yarmouk flood recorded at Adasiyeh in 10.2.1954 was estimated at 990 cu.m/second.[9] There is a close correlation between the peaks of both the rainfall and the floods. However, over a period of 37 years, the big floods occurred two times only. The flood discharge through this period averaged 47 percent.

The variation is clear in discharge of the Lower Jordan further downstream, after almost all its major tributaries have joined the river (fig.3.4). The measurements at the King Husein Bridge[10] covering the period 1932/33 - 1962/63 indicate that the monthly discharge of the Lower Jordan ranges at lowest stages from about 13 mcm. (August 1963) to about 80 mcm. (Sept.1937), and at high and flood stages from 94 mcm. (Feb.,1934) to about 370 mcm. (Feb.1935) (Table 3.4a and 3.4b. (App.3)). The highest discharge occurs in the months January-March, with February as the month in which the highest discharges are most frequent. The lowest monthly discharges are found at the end of the rainy season, in April, or before the beginning of the rains in November-December.

Base Flow of the Major Side Wadis.

Wadi Arab:- The mean annual discharge at the period of 1929-1963, was 33.7 mcm., with a maximum value of 40 mcm. (1955) and a minimum of 18 mcm. (1963). The flood discharge throughout this period averaged 4 percent. The mean monthly values of discharge indicate that maximum flows take place between December and March with a peak flow in January. However, the stream is spring fed, and therefore, has a remarkably steady flow. Because of this uniform flow, the dry season runoff has been essentially fully used for many years, except for the water passing at night when the individual farmers do not normally irrigate.

Wadi Ziglab:- The mean annual discharge at the period of 1929-1963 was 11.8 mcm. with a maximum value of 14 mcm. (1950) and a minimum of 6.6 mcm. (1961). The flood discharge throughout this period averaged 9.6 percent. The mean monthly values of discharge indicate that maximum flows take place between October and March with a peak flow in January. However, the stream is spring fed particularly from the springs located - 200 m., and therefore, has a remarkably steady flow.

Wadi Jurum:- The mean annual discharge at the period of 1929-1963 was 12.7 mcm. with a maximum value of 15 mcm. (1954) and a minimum of 8.5 mcm. (1961). The flood discharge throughout this period averaged 9 percent. The mean monthly values of discharge indicate that maximum flows take place between December and January. However, the stream is spring fed, and therefore has a remarkably steady flow.

Wadi Yabis:- The mean annual discharge at the period 1929-1963 was 4.9 mcm., with a maximum value of 9.4 mcm. (1943) and a minimum of 1.4 mcm. (1963). The flood discharge throughout this period averaged 8 percent. The stream has not a steady flow since it depends on the rainfall and therefore, it is affected with the fluctuation of precipitation with a peak flow taking place between February and March.

Wadi Kufrinja:- The mean annual discharge at the period 1929-1963 was 5.7 mcm., with a maximum value of 11 mcm. (1952, 54) and a minimum of 1.8 mcm. (1960). The stream is like Wadi Yabis in its depending on the erratic rainfall more than the springs. Its peak flow occurs in February. In summer, it is almost dry since most of its small flow has been distributed on the irrigated farms outside the Ghor.

Wadi Rajib:- The mean annual discharge at the period 1929-1963 was 3.6 mcm. with a maximum value of 8.1 mcm. (1945) and a minimum of 1.2 mcm. (1934). In its flow, the stream depends on the rainfall with peak flow from March to May. In summer, its flow is meagre that most of its waters are lost in irrigation before its confluence with the River Jordan. It is worth mentioning that it has the least summer flows of all the side wadis.

Zarqa Stream:- The mean annual discharge at the period 1929-1963 was 54 mcm. with a maximum value of 99 mcm. (1950) and a minimum of 28 mcm. (1961). The flood discharge throughout this period averaged 35 percent, while the flood recorded maximum was 400 cu.m./second. The mean monthly values of discharge indicate that a maximum flow takes place between December and March with a peak flow in March.

Wadi Shueib:- The mean annual discharge at the period of 1929-1963 was 9 mcm. with a maximum value of 17 mcm. (1943) and a minimum of 3 mcm. (1963). The flood discharge throughout this period averaged 17.8 percent. The mean monthly values of discharge indicate that maximum flows take place between February and May, with a peak flow in April.

Wadi Kufrein:- The mean annual discharge at the period of 1929-1963 was 11 mcm. with a maximum value of 24 mcm. (1943) and a minimum of 3.5 mcm. (1963). The flood discharge throughout this period averaged 15.4 percent. The mean monthly values of discharge indicate that maximum flows take place between March and May, with a peak flow in April.

Wadi Hisban:- The mean annual discharge at the period of 1929-1963 was 5.3 mcm. with a maximum value of 8.8 mcm. (1943) and a minimum of 2.1 mcm. (1963). The peak flow occurs in March. The following tables show the base and total flow of rivers and side wadis according to geographical position commencing at the northern end of the valley.

TABLE 3.3. Average, maximum, and minimum annual base flow of streams and side wadis.

River or Wadi	Drainage Area (Km^2.)	Period of Record Years.	Base Flow in Million Cubic Metres: Average	Maximum	Minimum	Flood Runoff %	The highest months of flow.
River Yarmouk* (At Adasiyeh)	6,805	1927-1963	443.3	870 (1929)	240 (1960)	47	February
W. Arab (At N.Shuneh)	254	1929-1963	33.7	40 (1955)	18 (1963)	4	January
W. Ziglab (AT Ghor)	107	"	11.8	14 (1950)	6.6 (1961)	9.6	"
W. Jurum "	27	"	12.7	15 (1954)	8.5 (1961)	9	Dec.-Jan.
W. Yabis "	131	"	4.9	9.4 (1943)	1.4 (1963)	8	Feb.-March
W. Kufrinja "	119	"	5.7	11(1952,54)	1.8 (1960)	?	February
W. Rajib "	80	"	3.6	8.1 (1945)	1.2 (1934)	?	March-May
River Zarqa (At Deir Alla)	3,440	"	54	99 (1950)	28 (1961)	35.6	March
W. Shueib (At S.Shuneh)	187	"	9	17 (1943)	3 (1963)	17.8	March-April
W. Kufrein (At Ghor)	161	"	11	24 (1943)	3.5 (1963)	15.4	April.
W. Hisban (At Ghor)	90	"	5.3	8.8 (1943)	2.1 (1963)	3	March.
Total	11,401		595	1116.3	314.1		

Source:- Central Water Authority, Technical Paper No.33. (1964).

* The River Yarmouk has average of total flow and not of base flow.

TABLE 3.4. Average, maximum, and minimum annual total flow of streams and side wadis.

River or Wadi	Period of Record Years.	Total Flow in Million Cubic Metres		
		Average	Maximum	Minimum
River Yarmouk	1927-1963	443.3	870.0	240.0
River Zarqa	1929-1963	85.2	148.0	31.8
TOTAL		528.5	1018.0	271.8
Wadi Arab	1929-1963	35.0	41.8	14.0
" Ziglab	"	13.3	15.7	7.0
" Jurum	"	12.8	14.8	8.5
" Yabis	"	5.6	10.2	1.6
" Kufrinja	"	12.2	24.3	1.8
" Rajib	"	3.7	8.1	0.8
" Shueib	"	11.2	19.5	4.0
" Kufrein	"	12.3	25.8	3.0
" Hisban	"	5.5	8.9	2.0
TOTAL		111.6	169.1	42.7
GRAND TOTAL		640.1	1187.1	314.5

Source:- C.W.A. (1964), Technical Paper, No.33.

It can be concluded that the Yarmouk and Zarqa rivers have the highest annual discharge due to their ample drainage areas (fig.3.5). On the other hand, Wadi Arab has the highest annual discharge of all the side wadis, since it has the largest drainage area and the highest precipitation. There is a correlation between the maximum of discharges and the wet years for most of the side wadis and vice versa. That is to say, the tributaries to the Jordan exhibit flow characteristics similar to the rainfall pattern. Exceptions are Arab, Ziglab, and Jurum wadis which have a relatively constant flow throughout the year. This is evident when a comparison is made between Ziglab and Jurum from one hand and other side wadis from the other hand. For instance, while Jurum drains an area of 27 Km^2, with average base flow of 12.7 mcm., Wadi Shueib drains an area of 187 Km^2, with 9 mcm.

The percentage of flood runoff of the side wadis reflects the former fact concerning the contribution of rainfall in rising the percentage of flood runoff. Again it is noticed that the percentage of flood runoff is high in the discharge of the rivers and wadis, with the exception of Arab, Ziglab and Jurum wadis; these latter three wadis have a regular flow from the springs.

The northern side wadis have their highest flow in either December or January, whereas, from Wadi Yabis towards the south, most of the wadis have their highest flow between March and April. This phenomena can be interpreted by the fact that the date of rainfall in the north is earlier than in the south.

No accurate information exists concerning the amount of solid material removed annually from the area. Nevertheless, on the basis of many observations, it seems that the total charge volume transported by the rivers and side wadis is very high. This vividly illustrates the degree of soil erosion which is taking place within the area annually.

The amount of suspension load is exceedingly high during the flood stages. Owing to the climatic conditions of the catchment area of the Lower Jordan, large quantities of fine grained material accumulate during the rainless period to be swept down into the wadis and rivers during the first heavy storm of winter which is ten times as great as the other storms throughout the year. This emphasises the fact that fallow ground, at the beginning of the wet season, is an extremely important factor in soil erosion. This is directly evidenced by large tracts of alluvium covering the alluvial fans of the side wadis in both the Ghor and the Zor, in addition to the thick mud covering the Zor after flood recession.

Since the problem of soil erosion in the area is basically the result of water movement across the soil cover, it is therefore, essential that some knowledge of the rate of water intake of the differing soil types in the area should be known.

Studies of 22 soil samples in the northern valley show that under ideal natural conditions, i.e., flat land, almost 50 percent of the samples showed an ability to infiltrate water at the rate of less than

10 mm/hour, while 73 percent of the samples showed less than 20 mm/hour. When it is remembered that the maximum rainfall intensity recorded in the northern valley is 59 mm. in half an hour, it would appear that runoff amounts play an important role in the soil erosion.

Studies of 11 soil samples in the southern valley indicate that 18 percent of the samples showed a rate of less than 10 mm./hour, while 54 percent of the samples showed a rate of less than 20 mm./hour. This variation in the rate of infiltration between the northern and southern valley is due to the fact that the soil textures tend to be heavier toward the north of the valley. Therefore, in addition to the effect of runoff in the soil erosion, the very marked structural instability of the southern valley soils is a dominant factor. After the addition of water, the breakdown of the soil occurs and the finer particles in the soil fill the pore spaces of the underlying soil and form an almost completely impervious surface layer. Consequently, any further precipitation falling upon this surface tends to pack down superficial layers still further, and runoff directly downslope.

Through many field observations, it has been noticed that the streams flowing into the Jordan Valley are characterised by line deposition. Most famous among these streams is the Wadi Arab. A specimen of incrustation formed in 15 months is some 10 mm. thick. However, the rates of deposition in these streams vary according to the calcium contents, velocity and distance.

TABLE 3.5. Infiltration rate of the soils of the Valley.

	Infiltration rate mm./hour (Samples %)											
Zone	Total of the samples.	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	+100
Northern valley	22	50	22.7	9	4.5	4.5	0	9	0	0	0	0
Southern valley	11	18	36	27	0	0	0	0	9	0	0	9
The whole of the valley (11)	38	39.5	26.3	13.1	5.2	2.6	0	5.2	2.6	0	2.6	2.6

Accordingly, the design criteria applied on the East Ghor Canal Project avoided the use of Syphons unless their sizes are large and could easily permit manual or mechanical cleaning facilities. An example of such syphons is Wadi Arab Syphon which had been abandoned mainly because of incrustation.

Quality of Water in the Valley.

It is a significant fact that the seasonal characteristics of the flow of the springs and streams appear to be related to the age of the strata from which they flow. Therefore, some streams have a constant flow and are not sharply affected by rain, and some others respond quickly to rain and have a highly seasonal variation of flow. Not only are these variations of great importance in the question of irrigation, but they also affect the quality of waters.

Many incomplete investigations have been conducted in the past in connection with the quality of water from the various sources proposed for irrigation of the valley. Nevertheless, the Master Plan report(12) of Baker and Harza (1955) includes complete water analyses of major rivers and side wadis. (Table 3.5 (App.3)). In addition to its reliable investigations, some water samples have been collected throughout the field.

Quality of stream water:-

Water analyses show that the quality of the water in all the streams investigated deteriorates with diminished flows; i.e., the electrical conductivity of the Jordan river differs according to the variations of flow. At King Husein Bridge, its maximum is 3500 micromhos/cm. in July 1967, during which irrigation and evaporation rise to the maximum. Furthermore, the percentage of Sodium (55%) is the highest of the totals for the year. On the other hand, the quality of water improves during the winter and spring when the river discharge rises. The improvement is emphasised by the low values of electrical conductivity (2248 micromhos/cm. in January 1968) and the drop of Sodium percentage (52.6%). At Adasiyeh, the Yarmouk waters have an electrical conductivity ranging from 725 micromhos/cm. in January 1966 to 760 in July 1966; while the Sodium percentage ranges from 42% in winter to 43% in summer. (Table 3.6. (App.3)).

The quality of water in the Jordan river deteriorates as it flows toward the south. The river enters Lake Tiberias with an average salinity of 20 ppm. (31 micromhos/cm.), leaving it with an average of 350 ppm.[13] (547 micromhos/cm.). This greater amount of salinity results from the salty springs of lake, and from the evaporation of an average of 270 mcm. per annum. The average salinity rises at the point of the Yarmouk confluence to 1300 ppm. (2031 micromhos/cm.); at Qattaf, it rises to 1378 ppm. (2153 micromhos/cm.); at Wahadineh, it rises to 1511 ppm. (2361 micromhos/cm.), and at King Husein Bridge, it arrives to 1970 ppm. (3078 micromhos/cm.). This tremendous salinity has resulted from a reduced inflow into the river of waters of low salinity which have been diverted by Israel and Jordan.* In addition, Israel has diverted to the Lower Jordan, the waters of saline springs, which are around and in the bottom of the lake. These springs have supplied some 160,000 tons of salt to the river per year.(14) There are other saline springs in the Lower Yarmouk Valley, in Wadi Malih and in the bed of the River Jordan just below King Husein Bridge.(15) These springs with the Jordan tributaries contribute together in increasing the salinity of the river. The return flow from the irrigated fields would also tend to increase the salinity.

Postulating 1600 ppm. (2500 micromhos/cm.) as the border of salinity water validity, it can be concluded that the waters of the Lower Jordan have been so deteriorated south of Wahadineh that their quality is not high enough for irrigation.

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* In 1964, Israel accomplished the diversion of about one third of the river discharge from Lake Tiberias, and in 1970, about two thirds of the discharge will be diverted outside the river basin. On the other hand, Jordan completed the East Ghor Canal Project in 1965, the canal of which takes its water from the Yarmouk.

Generally speaking, the chloride has the highest percentage in the waters of the Lower Jordan; it is assumed that about two thirds of the chloride in the Lower Jordan comes all the way down from Lake Tiberias. Sodium is the second in percentage; however, its danger is less than chloride due to the fact that there is a considerable amount of gypsum in the soils of the valley. Unfortunately, magnesium is the third in percentage after chloride and sodium; therefore, it may be toxic to plants, in addition to its harmful effect on the soil structure.

With regard to the Zarqa river, the salinity of its water is less than that of the Jordan river, but a certain salinity hazard does exist. The Electrical conductivity of its water is 1500 micromhos/cm. in summer, whereas the percentage of Sodium is 51%. Therefore, the water from the Yarmouk river shows the best quality among the last three sources, but the salinity hazard is still medium to high.

The quality of waters of the side wadis is generally good, and it is better than that of the major rivers. However, there are some variations between the values of their salinity. i.e., Wadi Kufrein and Wadi Ziglab have higher values than the remaining wadis. However, most of these wadis have not the Sodium (Alkali) hazard which is found in the Jordan river. Furthermore, some of the rivers and side wadis have very low values of carbonate, while some others have none. Therefore, the water of all the samples were rated as "safe" with regard to residual sodium carbonate. None of the samples analysed contained boron in anything approaching a toxic concentration.

According to American standards,[16] it is possible to classify the waters of the rivers and side wadis in order to recognise their quality for irrigation, in addition to their effect on soils and plants. The classification differs according to the season in which the sample was taken. i.e., Whilst the Jordan river water at King Husein Bridge belongs to the class C_3S_2 in winter, it has the class C_4S_2 in summer. The Yarmouk water has the class C_2S_1 in winter, and the class C_3S_1 in summer. This means that the Jordan waters have high salinity and medium sodium in winter, and very high salinity and medium sodium in summer. On the other hand, the Yarmouk waters have medium salinity and low sodium in winter, and high salinity and low sodium in summer.

On the whole, the water quality can be divided into the following classes:

Class 1 (C_2 - S_1) :- The waters of this class have medium salinity and low sodium. This class includes the waters of Yarmouk river and the waters of Arab, Ziglab, Yabis, Kufrinja, Rajib and Shueib wadis.

Class 2 (C_3 - S_1):- The waters have high salinity and low sodium. Zarqa river and Wadi Kufrein waters belong to this class.

Class 3 (C_4 - S_2) :- The waters have very high salinity and medium sodium. The waters of Jordan river can be included in this class.

This classification of waters should be adequately considered when using them for irrigation. The waters of "class 1" can be used for irrigation agriculture with little probability that soil salinity will develop, providing a moderate amount of leaching occurs during normal irrigation operations. Crops with moderate salt tolerance can be irrigated with this water providing drainage is adequate.

The water of "class 2" should not be used on soils with restricted drainage. Even with adequate drainage, water from this class would require only slight dilution with water of "class 1" to remove any significant hazard of saline contamination through their use. Plants with good salt tolerance should be selected.

The water of "class 3" is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. Drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt tolerant crops should be selected. As we have seen in the case of "class 2", waters of "class 3" need to be improved by dilution with water of "class 1" to remove the hazard of salinity. Since all of agriculture in the southern Jordan flood plain (Zor) depends on the river for irrigation, one must stress the need to construct a canal taking waters from East Ghor Canal to the southern areas of Zor which are located outside the East Ghor Project.

Quality of Well Water:-

It is relevant to observe the analysis of the water samples which have been collected from some wells in May 1967, as representative of the well water in the valley. The analytical results of these water samples are shown in Table 3.7. (App.3). According to the U.S. Salinity Laboratory (1953), the quality rating of the well water can be determined from its sodium absorption ratio and electrical conductivity. The water classes of 17 wells are shown in the following table.

It can be seen that 47 percent of the well water belongs to the class C_3S_1, 35 percent belongs to the class C_4S_2, and 12 percent belongs to the class C_5S_2. Consequently, most of the well water can be divided into two equal major groups. The first group ranges between medium and high salinity with low sodium. Its conductivities vary from 780 micromhos/cm. to 1990. Sodium percentages vary from 24 to 49 percent. The ratios of Calcium to Magnesium range between 1:2 and 2:1. The second group varies from high to very high salinity with medium sodium. Its conductivities range between 3200 and 5250 micromhos/cm. Sodium percentages vary from 40 to 47 percent. The ratios of Calcium to Magnesium range between 1:2 and 1.25:1. It is notable that the first group is good for irrigation, otherwise, the ratio of Magnesium is too high in some samples compared with Calcium. The second

TABLE 3.6. Well water classes, samples from 17 wells in the valley.

Well irrigation water class	Number of wells.	Percentage	Location	Range of electrical conductivity. (micromhos/cm.)	Range of Sodium Percentage(%)	Range of ratio of Calcium to Magnesium
C_3 S_1	8	47	Southern valley	780 - 1990	24.1 - 49.1	1:2 - 2:1
C_3 S_2	1	5.9	Northern valley	2200	47.7	1:1
C_4 S_2	6	35.3	Southern valley	3200 - 4500	40 - 46.3	1:2 - 1:1
C_5 S_2	2	11.8	Southern valley	4700 - 5250	46 - 46.6	1:1.3-1.25:1
Total	17	100.0				

Source:- Field work.

group is doubtful for irrigation due to the high salinity and the higher ratio of Magnesium to Calcium. Sodium percentages are satisfactory with little danger of accumulation of harmful amounts of exchangeable sodium, particularly, in the southern valley where gypsum is present in the soil. Chlorides have higher values in this group than in the first one. Nevertheless, the two groups have no values of carbonate or boron. Therefore, they are safe concerning to residual sodium carbonate. Generally, most of the samples of the two groups belong to chloride water type in which chloride has more than 50 percent of the total anions, and with total soluble salts seldom less than 1000 ppm.

Water Resources Potential.

Is the valley in need of water and to what extent do the water sources meet its needs ? To answer these questions, an inventory and evaluation of the water resources should be discussed.

The valley receives water from five different sources, four of them being controlled by Jordan. The Yarmouk river has an average yearly runoff of some 443 mcm., while the eastern side wadis, mainly Zarqa, and Arab wadis, have some 220 mcm., the western side wadis, mainly Wadi Far'ia, and springs have some 60 mcm. The wells contribute with some 70 mcm.

These four sources are providing together some 793 mcm., out of which 50 mcm. will be used by Syria, leaving 743 mcm. for the valley. It is clear that this whole quantity cannot be used for irrigation purposes due to physical and human factors. The quantity which can be used economically may lie somewhere around 620 mcm. on average.

According to the cropping pattern of East Ghor Canal Authority (E.G.C.A.), the valley needs on average some 1,400 cu.m. of water per dunum and per annum at the northern part where rains are more abundant, and some 1,700 cu.m. per dunum at the southern part. It should be known that the part of the valley which belongs to Jordan covers some 950,000 dunums; out of that some 500,000 dunums are arable, the remaining part is waste land, mostly too saline to be brought under cultivation. Consequently, the valley is in bad need of some 800 mcm. per year for irrigation of the 500,000 dunums in question.

The fifth source of supply for the valley is the Jordan river. To be able to irrigate the valley adequately, some 180 mcm. of water have to be drawn from the river.

The amounts of Jordan water required varied from 100 mcm. in the Johnston Plan to 164 mcm. in the Main Plan, and between 149 and 157 mcm. annually in the Baker-Harza Plan. The smallest of these amounts might still be available even after Israel's full diversion of 320 mcm. per annum. However, owing to the salinity hazard of the Lower Jordan, in addition to the inability of Jordan to take the water from Lake Tiberias, the only solution for taking his share of water is concentrated in what is called "The Arab Plan of exploitation of Jordan river sources". This plan was designed to divert the entire flow of the Hasbani and Banias rivers for irrigation within Lebanon, Syria and Jordan.

Even if Jordan had met its needs of waters for the irrigation of the Jordan Valley, the problem of the best economical use of these waters would have been a principal of all the problems in the valley. The erratic flows of the Yarmouk and side wadis will be vulnerable to agriculture unless storage dams have been constructed. In 1962, it was noted that the available flows from these sources were less than usual due to that dry year; during the period May to September, about half the estimated discharge only had flown in the East Ghor Canal. (figs.3.6 and 3.7). In the case of reserving and regulating the water flow, it becomes possible to distribute the usable flows so regularly that the summer period can acquire more water than the winter period. Of course, this will be adapted with the critical months in which the plants are in bad need of water. (Tables 3.8 (App.3) and 3.9 (App.3)).

Present Water Use Problems.

Out of the 500,000 arable dunums of the Jordan Valley, some 350,000 are situated at the eastern side and 150,000 at the western side. Of the 350,000 dunums, some

170,000 are situated between the Yarmouk and the Zarqa rivers, and 180,000 between the Zarqa river and the Dead Sea.*

The northern valley includes the East Ghor Irrigation Project, an area of 125,000 irrigable dunums,** in addition to 22,000 dunums irrigated by side wadis due to their elevation above the canal. The southern valley includes some 61,000 dunums irrigated at present by side wadis and wells, in addition to some 25,000 dunums irrigated by pumping from the Jordan river in the Zor area.

It is clear that the northern valley depends basically on the East Ghor Canal in its irrigation, whereas, the southern valley depends on the groundwater. However, since the project is serviced at present by unregulated stream flows, an additional 43 mcm. of water is required to provide adequate water for its irrigation requirement***. (fig.3.8). The distribution of wells in the Eastern Jordan Valley shows that about 70% of the wells are concentrated in the southern valley. Moreover, water being pumped from the alluvial aquifers of the valley is approximately 43 mcm. annually of which only 3 mcm. is estimated as being extracted from the East Ghor

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* Personal communication with Mr.Hami in the Development Board.

** The project includes 15,000 dunums in the Zor area.

***Personal communication with K. Khayyat, the Manager of the water office in Deir Alla.

irrigation project area of the northern valley. Therefore, the southern part has overdeveloped ground water, whilst underdeveloped groundwater occurs in the northern part.

The combined unregulated flows of the Yarmouk and side wadis, supplying water to the East Ghor Irrigation project area, are inadequate to supply water for full irrigation of the developed project area as planned by the East Ghor Canal Authority cropping pattern. Tables 3.10 and 3.11 (App.3). While the total annual needs of this cropping pattern is some 153 mcm., the usual supply of these flows ranges between 100 to 110 mcm. per year. It is to be noted that the 43 mcm. of additional water is required between April 15th and October 10th to supply adequate water. The storage dam accomplished at Wadi Ziglab in March 1967, will provide 4.5 mcm. of water. Two small regulation and storage dams being constructed on Wadi Abu Ziad and Wadi Jurum which will provide approximately 1.5 mcm. of additional water for use during the period of shortage. Still required to provide an adequate irrigation water supply is 37 mcm. of water annually which must be made available during the period between April 15th and October 10th. (fig.3.9).

Preliminary investigations of the amount of water that can be obtained by groundwater development in the project area indicate that approximately 45 mcm. can be made available to the East Ghor Irrigation Project.* Natural recharge of groundwater estimated as available is approximately 30 mcm. annually and an additional 15 mcm. of water can be obtained annually through groundwater recharge systems.

Having mentioned the problems of water deficiency in the valley, it is stressed to say that there are ample arable lands waiting for irrigation, and the lands of the northern valley are in better condition than that of the southern part. Therefore, it will be of benefit if a water policy is designed for this valley. The policy should be divided into two stages; firstly, a short-term policy which is based on the groundwater exploitation; secondly, a long-term policy which is based on regulation of the Yarmouk and side wadi flows. A brief explanation of this suggestion is as follows.

A short-term policy should be undertaken as soon as possible. As long as the groundwater is necessary for irrigation, and it is integral to other irrigation sources as seen in the East Ghor Project area, there must be an urgent development of it. Since the overpumping results in the depletion of groundwater aquifers either in the southern or in the northern valley, there must be a development of artificial recharge in order to supply additional water. This development can be undertaken side by side with the foresuggested water use cycle in the southern valley, while it is not necessary at present to

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* Personal communication with J.W. Harshbarger, a Geological expert of USAID in Jordan.

apply this cycle on the northern valley which has not endured the groundwater problems of the southern valley.

Artificial recharge is a means whereby an additional quantity of surface water is introduced into underground aquifers over and above those surface waters that normally infiltrate. Many successful methods have been developed which can introduce surface waters into aquifers. The first method is to use many wells in the valley as combination recharge and production wells; water is injected into the wells when demand is low and pumped from them during times of maximum demand. This practice can be used in recharging wells from spring waters occurring in the East Ghor Irrigation Project Area in order to develop the estimated 45 mcm. which are required in summer. The second method is to build percolation ponds on pervious soils in certain relevant sites in order that water may be released into them to percolate into the underlying aquifers. These percolation ponds are easy and economical to construct. The third method is to construct earthen spreading dikes across the direction of flow to slow up and spread out the surface flow of the small side wadis. This allows for a faster percolation of the surface water. Finally, a technique may be worth trying in some of the smaller wadis is to create underground dams by grouting clay into the alluvium, such subsurface dams may be just as effective in trapping small or dispersed underflow as ordinary dams are in the conservation of surface flow.

Location and definition of areas of natural recharge and of possible artificial recharge require detailed exploration of local and regional groundwater; for it is important to know where waters of artifical recharge go and by what means they may be drawn on at a later time. It is expected that outwash fans of the Ghor, which are made up of gravelly material, are successfully located for works of artificial recharge of groundwater. The structure of a fan permits a way or channel into depths of the detrital basin; for the fan is made up of depositions from torrential floods with coarser materials at the head and progressively finer materials at the flatter and outer edges.

Consideration should be given to the dilution of some of the marginally brackish groundwater for agriculture as the East Ghor Canal structures are installed. In this way the amount of land which can be irrigated could be materially increased, and the concept of development of all water resources in the valley as a unit advanced.

Knowledge of the storage capacities of the groundwater reservoirs and the point at which they will overflow is required for efficient regulation. Drawing down the reservoirs to the maximum safe levels during the dry season so as to provide the greatest opportunity for ground water replenishment during the wet season should be carried out.

A long-term policy is based on erecting storage dams on the Yarmouk river and other streams of side wadis in order to regulate their flow. The oscillation of the flow as a result of the erratic precipitation makes it too difficult to secure adequate water for irrigation. The annual discharge of the Yarmouk river ranges between a maximum of 870 mcm. and a minimum of 250 mcm. In the case of successive low flows, the irrigated lands would have to be decreased. On the other hand, it was observed that the deficiency of water supply from the East Ghor Canal in the summer of 1966 caused the wilting of numerous banana trees. Suffice it to say, that storage of water, during the rainy winter months for the use during the dry summer months, may prevent the dangers of dry years, in addition to retaining large amounts of lost flood water. Not only will the distribution of stored waters be regular, but they will be also sufficient for meeting all of the irrigation needs.

It may be useful if some dams are constructed with a porous base which allows water in the reservoir to percolate into underlying aquifers. These dams can serve a dual purpose, both as flood control dams and artificial recharge structures.

Selected examples of artificial recharge:-

The practice of artificial recharge of groundwaters is becoming increasingly important in many countries as the demands for water lead to increasing utilization of all available sources of supply. Moreover, underground storage is being used more and more for the beneficial use of floodwaters that would otherwise run to waste. In the United States, artificial recharge is usually accomplished by collecting flood waters in detention reservoirs and releasing them slowly to permit percolation into the stream channel below the dam or into prepared percolation beds. In Los Angeles County, California, this serves the dual purpose of flood control and of water conservation. Such measures were carried out on the San Dimas basin of Southern California.[17] The groundwater of this basin is the only supply for irrigation. But natural recharge was not sufficient to meet the demands for irrigation water. In 1916 the groundwater level in the basin stood at 45 m. By 1930 the groundwater level had fallen to 141 m. By this time the same amount of water withdrawn by pumping lowered the water table more than formerly, showing that the bottom of the basin was being approached.

As a result of these difficulties, artificial recharge was undertaken. Flood control dams were built on the two streams that fed the basin. Spreading works were put in to spread desilted and more regulated flows of flood waters. Later an off-channel reservoir was built into which discharges from the larger flood control dam were emptied. Waters were then piped to wells and the groundwater recharged through them in the rainy season.

In time all runoff from the San Dimas drainage was brought under control and sunk underground during winter rainy seasons for pumping during the irrigation season. As a result the groundwater level was raised to within 30 m. of the surface, from which pumping is less costly and a safe supply is assured.

In Morocco, Drouhin[19] (1953) has described the use of flood waters for cultivation, and has shown that such floods yield the additional advantage of recharging the groundwaters below whence they are later used for pump irrigation. The three important projects studied in Morocco were as follows: Firstly, in the Tafilalet, for a dam to retain flood water and allow it to infiltrate into the watertable. Secondly, in the Dra Valley for a similar regulating dam which will make it possible to inject the water retained into the ring of groundwater reservoirs surrounding the valley. Thirdly, in the Souss Valley where the freshets from the Atlas mountains will be recharged into the Souss dejection cone which drains into the aquifer.

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Chapter 4.

FACTORS OF SOIL FORMATION

Climate

Climate plays an important role in soil formation. The direct effects are evident in the physical and chemical weathering. The indirect effects are represented by the biological factor including the soil inhabitants and the man in his strife against the severity of climate.

Winds:- A climatic index of wind erodibility based on wind velocity and on effective precipitation was found to be suitable for the delimiting of relative wind erosion conditions in various parts of the valley. The exposures of Lisan facies on the surface of some parts of the southern valley bear witness of the importance of wind as a geomorphologic agent, eroding the alluvial soil and carrying it far away. Not only is the southern valley considered as a wind deflation area, but it is also considered as a deposition area for the dust coming from the Negeb and Wadi Arabeh in the south. In addition to this, the valley is liable to the deposition of dust suspended in the eastern and western winds during their strong descent.

Chepil et al. (1962,1963)[1] have found experimentally that dust blowing varies inversely to the square of the effective moisture at the soil surface. On the assumption that the average moisture content of the soil surface is proportional to the effective precipitation at a given locality, the parameter can be calculated from climatic data.

By combining the two climatic factors affecting wind erosion Chepil et al. (1962,1963) have derived a climatic index C for the estimation of wind erodibility:

$$C = \frac{V^3}{(PE)^2} \quad \text{--------} \quad (1)$$

where V is the average annual wind velocity in miles per hour at a standard height of 10 m., and PE is the effective precipitation or moisture index according to Thornthwaite (1931),[2] which is essentially the sum of monthly precipitation-evaporation ratios. The average annual value of C for Garden City, Kansas, in the Great Plains is 2.9, and all the other values were expressed as percentages of this figure. Hence for a given locality the erodibility index C, would be:

$$C_1 = 100 \frac{V^3}{(PE)^2} / 2.9 \quad \text{-----------} \quad (2)$$

Chepil et al. (1963)[3] also demonstrated the usefulness of the index in predicting the severity of wind erosion during a given calendar year on the basis of conditions prevailing during the three preceding years, and found a significant correlation with the number of recorded dust storms.

The following limits were used to establish the various categories:- 0-17% very low erodibility, 18-35% low, 36-71% intermediate, 72-150% high, and over 150% very high (relative to the Kansas index, Chepil et al., 1962). Selected data for some typical stations in the valley are listed in the following table.

It can be concluded that wind erodibility increases from the north to the south. There are two distinctive zones of erodibility in the valley, the zone of very low erodibility in the north, and the zone of high erodibility in the south (fig.4.1). There is a clear correlation between the very low erodibility and semi-arid zone in the northern valley on the one hand, and between the very high erodibility and arid zone in the southern valley on the other. Moreover, the coincidence of the arid zone with an intermediate to very high index of wind erodibility makes it reasonable to consider this zone as one of frequent oscillations between either a depositionary or a deflationary surface.

Topography is one of the factors affecting the value of erodibility; Wadi Ziglab - Wadi Jurum area has the lowest erodibility index in the valley due to the fact that this area is facing the Esdraelon plain gap which makes the descending wind velocity less than that of other parts of the valley. On the other hand, the northern valley, as a whole, has less precipitated wind velocity than that of the southern valley owing to its more elevated floor. In addition to its effects as an erosive agent, wind also

TABLE 4.1. Wind Erodibility Indices for selected stations in the valley, (1965).

Station	Mean wind velocity. Miles/hour	Effective Precipitation Index PE	Wind Erodibility Index C_1 %	Erodibility Limits
Northern Shuneh (Wadi Arab)	7.9	42	9.6	Very low
Wadi Jurum	5.7	47	3	Very low
Deir Alla (Agr.St.)	5.8	26	9.9	Very low
Jericho	6.5	12	65.8	Intermediate
Dead Sea North	7.4	5	558.9	Very high

affects soils by its powers of deposition. It is not surprising to see a coincidence between the descending hazy winds and the phenomena of fog prevalence in the southern valley, particularly, at the Dead Sea area where the intense ascending evaporation is mixed with the descending dust inducing thick fogs.

Thus, winds as well as runoff, have contributed in forming soils by the deposition of dust and small grains of sand in the valley. The coarse material is deposited on the borders of the valley, while the fine grains are deposited on the centre of the valley along the course of Lower Jordan. These strong whirlwinds develop frequently and are visible from afar owing to the great quantities of dust which they carry.

Temperature, Humidity and Evaporation:-

The high temperatures of the valley are responsible for the great susceptibility to denudation of the valley floor and its border zone, in view of the composition of the Lisan-marls in which C_aCO_3 usually accounts for more than 30%. The high degree of desiccation, the short periods of moisture availability and the relatively high temperatures even in the rainy season greatly increase the intensity and the rate of chemical reactions. The intense insolation destroys most of organic matter in the soil and causes mean soil temperatures of approximately $40^{o}C$.

The texture and structure of the soils of the valley vary in the extent of humidity benefited from the air. The heavier the texture, the less is its availability of humidity. On the other hand, the larger the number of aggregates in the soil, the greater is the contact with the air.

The evapotranspiration potential in the southern valley is estimated to amount to about 1900 mm. per annum.[4] This very high evaporation potential adds very much to the friability of the clayey marls and to the lack of cohesion in the surface-material, which it renders very susceptible to deflation. Consequently, in the southern valley, the flat surfaces are covered by a thick layer of loose particles like ashes. The intense evaporation of the soil moisture promotes intensive capillary action, which renders highly saline on the top layers of the southern valley floor. This results in an extreme scantiness of vegetative cover especially towards the south.

The extreme dryness is also one of the main reasons why the slopes of the valley and of the bad lands zone accompanying it, are so excessively steep and consequently accounts for their proneness to collapse at the slightest increase in volume and weight caused by wetting. The high percentage of the streams and river Jordan loads derived from mass wasting is a result of the desiccation of slope material. This material is added every year to the alluvial fans of the streams and the flood plain of the Lower Jordan.

Precipitation:-

Precipitation has a mixed blessing in relation to its effects on soils of the valley. The rainy season is so important to the valley that the soils are leached during winter by the rainwaters. Moreover, the rains dilute the proportion of salinity in the waters of rivers and streams which are used in irrigation of the valley lands. On the other hand, the floods of these streams deposit a renewing soil every year on the Ghor and the Zor as a result of their loads of sediments.

However, when precipitation is misused, serious consequences may occur to the soils. The amount of rainfall lost by runoff ranges between 1-20 percent of total rainfall in Jordan.[5] This percentage is affected by many factors, such as gradient of land, rainfall intensities, and the abundance of vegetation. The gradient of the valley floor from the east to the west makes it dissected by the eastern side wadis. Violent rain storms of a cloud-burst type scour the loose earth from the slope down into the gorges; the wadis which are dry in summer and frequently in winter become filled with muddy, dark-coloured, roaring torrents, which can cause great devastation.

As is seen in the case of winds, the floods of streams in winter contribute in deposition of renewing deposits every year in the valley; at the same time, they sweep the soils of the valley to be precipitated down into the River Jordan. Moreover, a great percentage of the charge of Jordan river is derived from the floor and slopes of its alluvial valley. The total charge volume transported by the river is very high. This applies particularly to the silt-content of the river flow, for which records taken at King Husein Bridge exist, covering the hydrological year 1937/38. The silt quantity that passed this site in this year amounted to 3,010,000 tons. When a proportionate amount, caused by the very intensive high and flood stages of the recorded year, is deducted (1,680,000 tons passed by the site in the ten days of highest flow) there remain about 2,000,000 tons, which can be regarded as a normal yearly average.(6) This quantity is equivalent to some 4500 dunum of land lost every year, on the assumption that 250 mm. is the thickness of eroded soil.

The following table shows the transported sediments by floods of some side wadis, covering the hydrological year 1963/64.(7)

TABLE 4.2. Transported sediments by floods of some side wadis (1963/64).

Wadi	flood amount (mcm)	transported sediment amount (tons)	percentage of the transported material in the water.	watershed area (Km^2)
Wadi Zarqa	22	286,500	1.3%	3440
" Shueib	4.1	59,000	1.4%	187
" Ziglab*	1.5	50,000	3.3%	107

* Estimated figures.

Source:- NRA. (1966).

It is seen that most of the side wadis have the same percentage of transported material in proportion to the weight of their water courses. On the other hand, although the watersheds of these wadis, in the Ghor are small when compared with those in the plateau, the total charge volume transported by them is high; this is due to the fact that infiltration rates in the soils of the Ghor are low.

Geomorphology.

The distance between Lake Tiberias and the Dead Sea being approximately 105 km., and their height difference 180 m., the overall slope of the valley floor that extends between them amounts to 1.79 m./km. (fig.4.2).

The sides of the valley are very distinct in that they are usually both high and steep. In the northern part of the valley, the bordering sides are monoclinal folds dipping 10-45 degrees beneath the valley.[8] In the Dead Sea area, the rift fault scarps have produced great steep cliffs that are as much as 300 m. high; large talus slopes, some as much as 100 m. high, extend along many of these cliff faces.

The contour map of the valley (fig.4.3) shows that a significant gradient occurs in the floor of the valley. The elevation of the Jordan at the Yarmouk confluence is - 250 m., decreasing to - 275 m. north of Ziglab confluence, - 300 m., south of Yabis confluence, - 325 m. north of Kufrinja confluence, - 350 m.

south of Rajib confluence, and - 375 m. north of Kufrein confluence. Only two major irregularities in the course of the Jordan are to be seen and these are taken as possibly representing rejuvenation points, held up on locally resistant beds. The first break of slope ranges between the Lake Tiberias (-212 m.) and -275 m., whilst the second break ranges between -315 m. and -360 m. (Zarqa confluence with Jordan). This means that the breaks of the river have occurred in the northernmost portion of the Jordan course attesting the decisive influence of harder bedrock on the development of the gradient.

Not only is there a gradient in the floor of the valley from the north to the south, but also, a gradient is evident from east to west. The cross-section ranges on average between -200 m. and -286 m. contour lines in the northern valley, whereas, it ranges between -200 m. and -380 m. in the southern valley (fig.4.4). The valley varies in width from more than 10km. near the Dead Sea (Ghor Rameh) to about 5 km. in the north, with a minimum 2-3 km. in its central part. The slope from its lateral extremities to the line of its centre is about 5°, forming a very open V in section.(9)

The names Ghor "depression" and Zor "thicket"(10) designate the two terraces that constitute the bottom of the valley (fig.4.5). The Ghor is the higher terrace and has been formed by the Lisan marl sediments which were deposited in the ancient Lisan Lake. The Zor - the lower terrace - on the other hand, is the alluvial plain of the Jordan and is the result of the fluviatile erosive action of the Jordan upon the Ghor. The depth of Zor, relative to the Ghor, is 20-30 m. in the north, and 30-40 m., in the south, and its slopes form vertical cliffs.

The Jordan is a relatively young river. Its erosive action on the Ghor and the formation of the Zor were regarded, up to present, to have taken place in an uninterrupted one-stage process.[11] This assumption was based on the fact that no intermediate terraces were found between the Ghor and the Zor, whereas mention was made of terraces formed by the retreat of the Lisan Lake. In the course of regional surveys made by Nir and Ben-Arieh (1965),[12] relicts of an intermediate terrace were found between Lake Tiberias and Kefar Ruppin. This terrace is fluviatile, a fact which can be deduced from its morphological character. Therefore, its existence serves as an indication of the formation of an intermediate alluvial terrace between the end of the Lisan period and the present day Jordan.

According to field observations in the eastern side of the valley, this view seems to be reasonable. In the Sheikh Husein Bridge area, the most developed relicts of the intermediate terrace can be seen; and their fluviatile character is well observed. The measurements have been taken by altimetre for this terrace. There, the absolute altitude of the Ghor was -240 m., that of the intermediate was -260 m., and that of the Zor was -274 m.

Plate V. The vegetation and escarpment of the Zor.

Robinson[13] referred to this intermediate terrace as a precipitous offset composed of clayey pyramids and rounded sandhills and called it the upper or outer banks of the river in contrast to the banks of the channel itself. The so-called "shrinking of the Lisan Lake" cannot explain the steep slope that exists between the Ghor and the intermediate terrace. A gradual shrinking would certainly have occasioned gentler and longer slopes.

The absence of this fluviatile intermediate terrace from the area between King Husein Bridge and the Dead Sea emphasises the point that during historic times, the Dead Sea has stood higher than it is today. According to Huntington,[14] in the sixth century B.C., the mouth of the Jordan river was about 7 km. above the present mouth. Therefore, the existence of this terrace can be attested by the lowering of the base level of erosion of the Jordan brought about by post-Lisan climatic fluctuations.

Geomorphological Aspect of the Valley.

The badland Zone:-

About 20 km. south of the junction of Yarmouk with the Jordan begins an almost uninterrupted zone of badlands. The relatively high amount of precipitation in the north and the presence of heavy loams in the deltaic plain of the Jordan greatly inhibit the formation of badlands.

The badland zone is not uniform in width; at its northern onset its average width is less than 1 km., it broadens gradually to the south to attain a maximum width of about 3 km. at the junction of Zarqa with the Jordan. Further south, the badland zone narrows again, to cease entirely with the entrance of the Jordan into the deltaic plain. Narrow belts of badlands extend also for a considerable distance along several of the tributaries of the Jordan.

The Arabic name is "el Katar" meaning the humps of camels. The badlands exhibit in miniature all the features of a dissected desert landscape, for they contain the ridges, buttes, and mesas - etc., all of which are a result of high erosion.(15) There is a close spacing of the channels which traverse the entire width of the Lisan marl deposits.(16) Observations in the field show that the average depth of these little rills is one metre, their width is some two metres, and they wind through lofty banks, nearly thirty metres high. Most of the hills have steep slopes, they are rugged, and have a dry soil of very white appearance, and of a salty nature. Most of the gullies in this zone show a great deal of subsurface - channeling caused probably by the impermeability of the surface material and its increased resistance to erosion due to induration as a result of capillary action, which causes solutions to undergo precipitation at and near the surface. The badland zone is probably the most important source area of soil. Its importance follows not only from the quantities of material yielded by them, but also from the quantities of material yielded by them, but also from the permanence of the supply processes.

Mass-wasting processes are generally due to the short duration of the rains and the long intervals between them, in addition to the torrential character of rainfall on the bare steep slopes. The Lisan marl formation of the valley together with the high range in temperatures are decisive factors in these processes.

Free fall and rolling down of waste material occurs along the alluvial valley (Zor) of the Jordan, within the gully network of the bad land zone and along the escarpment of the Ghor. Cracking is the direct cause of mass-wasting. On the same rim of steep to perpendicular slopes there develop tension cracks, running more or less parallel to the upper slope edge. Their distance from the edge is usually less than one metre. They are distinguished from the desiccation cracks by their greater extension and by their considerable depth, that attains at times a few metres.(17) The moistening increases the weight of the upper parts and renders them more susceptible to gravitational movement.

The earthquakes seem to be responsible for the great frequency of fractures, which disjoin long stretches of the Zor slopes. There exist many records that the extraordinary amounts of material dumped into the river bed as a result of earthquakes have stopped the flow of the Jordan for considerable lengths of time. Major damming of the river flow occurred in the years 1267, 1546, 1906 and 1927.(18)

Plate VI. Talus-mantle at the base of an almost perpendicular bluff of the Zor escarpment.

The Meanders of rivers and the abandoned channels:-

The meandering of the Jordan between Lake Tiberias and the Dead Sea is one of its very marked peculiarities, and points to a reduction in the velocity of its current. The contrast between the gradient of the river and its meanderings can be ascribed to the following factors. Firstly, construction of the side deltas by major tributaries, particularly the Yarmouk, forces the course of the Jordan to make meanders. The large Yarmouk delta within the Lisan Lake formation constitutes the southern boundary of the Lake Tiberias, and it is responsible for the westward inclination of the southern steep bank of the lake.[19] This sloping delta was the main reason why the Jordan found its outlet in the south-west corner of the lake, and making an arch meander counterpart the Yarmouk. Secondly, the numerous slip-off faces of the eastern river bank and the mass-wasting of some parts of the Zor scarps due to the river floods. Thirdly, the tremendous charge volume transported by the river affluents forms such transverse bars at their mouths that the Jordan course current runs into these bars inducing meandering of the river. Moreover, many tributaries such as the Zarqa river and Wadi Shueib migrated their old mouths due to these bars and to their fans. Fourthly, vegetation which plays a decisive part in the formation and conservation of all the islands of the Jordan leads to river meanderings. Finally, the rejuvenation of the river and its tributaries as a result of the subsidence of their base level is considered as a principal factor in the meandering of these water courses.

The flood-plain and the meander-belt are conspicuously asymmetrical. This asymmetry is strongly unilateral, as for the most part the river runs close to the western border of its alluvial valley. Therefore, the western border is the mobile one, constantly affected and worn back by the erosional activities of the river, whereas the eastern border remains static at present for most of its length. Thus the eastern enclosure of the valley, formed by the bluffs, is not affected by erosion proper.

The consequences of the tendency of the river course to shift westwards are that two thirds and more of the Zor area extend to the east of the present river course. Moreover, the greatest lengths of abandoned channels are to be found on this side. The abandoned channels represent the older meander developments. Their oldness varies directly with proximity to the eastern border of the Zor. The distribution-density and spacing of the abandoned channels are unequal, particularly in the north. Generally, all the foregoing features show that the valley of the Jordan and its floor are still very immature.

Lacustrine and Wadi terraces:-

In the Pleistocene, the Jordan valley has been deeply filled by lacustrine sediments, supplemented by gravel and sand washed from tributary valleys and neighbouring alluvial slopes. Pauses in the lowering of the lake surface would establish a base level of erosion for the inflowing streams, thus allowing them to widen their channels, so that

Plate VII. The Jordan Valley north and south of Wadi Kufrinja, with its extensive fan, typical of all major affluents of the Jordan. Note the abandoned channels of the River Jordan. (Scale 1:10,000 - 1944).

when another lowering of the lake occurred and the streams re-commenced the erosion of their channels, a terrace would be left on the sides of their valleys.[21] These terraces would slope with the grade of the streams which formed them, and on reaching the Jordan valley, would unite with the horizontal terraces formed by the waters of the old lake.

The scarps and banks, by which the terraces of the Jordan Valley are terminated, indicate pauses in the shrinking of the old lake.[22] They appear to be receding under the attack of dendritic rills which die out a short distance down slope. In sapping the scarplets, these rills remove the surface alluvium to expose the underlying whitish marls. When several scarplets make up a regular, parallel pattern, they could be regarded as the "discontinuous gullies";[23] but as the various reaches of a discontinuous gully are ultimately integrated into a single, continuous gully, so the scarplets may give way to a continuous slope. This mode of downwearing can take place only during rains of sufficient intensity to induce sheetflow.

The gradients of the side wadis (fig.4.6) are the result of the morphological history of the rift valley. With the subsidence of the rift, a pronounced erosional phase commenced. Quennell's[24] reconstruction (1956b) of the old stream profiles combined with a study of old terraces, platforms and surfaces of deposition indicate that there are seven low level surfaces* formed in connection

* at 650-500 m., 300 m., 180 m., 100 m., -20 m., -100 m., and -290 m.

with the first phase of movement, plus the present -398 m. base, established by the second phase of movement. The changes in Dead Sea level have continued even after the subsidence of the rift, owing both to climatic and tectonic causes. Therefore, it is natural to see several breaks in slopes, the first being the principal, and the others secondary ones. The major line of falls indicates the true contact or "knick point" between the two erosive phases.

Erosion in the valleys draining into the Jordan Rift Valley was followed by a phase of tufa formation by the major springs. The tufas were then eroded; and the deposition of poorly-sorted gravel and soil filled the valleys and formed fans at their mouths. Stream downcutting into these deposits resulted in the upper terrace (fig.4.7). A briefer period of aggradation, followed by erosion which is still active today, formed a lower terrace.[(25)] These terraces are very evident at the junction of Wadi Shueib with the Ghor.

The tufas are thought to represent a wetter phase, and the succeeding terrace a period of active mechanical weathering. The lower terrace probably resulted from a slight change in the rainfall regime.

Alluvial Fans:-

Some changes take place in all the Jordan tributaries entering the rift valley due to the change in their currents velocity. The low velocity induces the deposition of their loads and the formation of alluvial fans.

Vast fans are developed at their exit from the mountainous area to the Ghor; whereas secondary fans are built with their entrance into the Zor. As usual, the course of the tributaries is liable to overflow upon the fan surfaces, with vast amounts of gravel and sands deposited in them and moved on from one flood stage to another. In several cases no distinct channel-beds appearat the lower portion of these fans. All this indicates the great amount of deposition that occurs before the entrance of the tributaries into the Jordan, depriving it especially of coarser load supply.

It is to be noted that a higher percentage of coarse-grained alluvial sediments is concentrated in the east of the fans, while the fine sediments occur in the west of them. Moreover, the fans of the Ghor have higher percentage of coarse sediments than the fans of the Zor; this is due to the fact that the break between the mountains and the Ghor is higher than that between the Ghor and the Zor.

This geomorphological aspect has many consequences concerning soil formation. It is usual that the eastern fringes of the fans have lighter soils than the western ones. Furthermore, the soils will be, generally, heavier in the Zor fans than those of the Ghor. For instance, more than 400 soil analyses, in the Yarmouk deltaic sediments, have established that the soils are lighter in the east and heavier in the west.[26]

Field observations show that the side wadis have two sources. Firstly, the wadis coming from the eastern plateau of Jordan, and secondly, the wadis leading from the Ghor to the Zor. The first group is the major wadis which built prominent alluvial fans incrusted with holocene material from which suitable agricultural soils developed; however, they influence the soils of the Ghor by causing continuous soil erosion. The second group are less benefit and more danger on the valley; in addition to their inability to build wide fans, they erode numerous parts of the valley soils throwing them in the River Jordan.

Generally speaking, the majority of the valley is characterised by long, gently sloping gradients well adapted to irrigation agriculture. Major exceptions to this condition are found where numerous small wadis cross the area, in addition to the occurrence of small ridges formed by wave action of the receding old lake, as near Ghor el Katar and Ghor Nimrin.

Vegetation.

Factors of plant life:-

Water:- Plants must have sufficient water to live, grow and regenerate. We have seen that the total annual amounts of precipitation in the valley are erratic.

A drop of the average 30 mm. may cripple vegetation. The instability of the annual rainfall makes all of the area covered with vegetation in one year, and restricts the annual vegetation to wadis and depressions in others. Moreover, where a number of dry years follow each other, certain dwarf shrubs desiccate and die off. Consequently, the vegetational composition of a plant community may alter drastically from one year to another.

Temperature:-

For each plant there are certain maximum and minimum temperature limits for normal growth, and also limits beyond which the plant cannot survive. For instance, the shrub of Zizyphus lotus is limited to altitudes not exceeding 300 m. above sea level; moreover, Suaedetum is limited to an altitude ranging between -300 m. to approximately +50 m. above sea-level.[27] A series of tropical plants, thriving in the southern valley, (300-400 m. below sea level), do not advance northward to where winters are colder.[28]

Light:-

Light energy is required for photosynthesis of the carbohydrates required by plants, and it is thus another important factor in the plant life. The amount and intensity of light are generally sufficient for the plants of the valley owing to scarcity of the clouds.

Winds:-

These affect the rate of humidity and evaporation in the valley. Moreover, winds can dry out the soils and their force may also move vegetation or break stems. They assist the spread of vegetation and are important agent of seed dispersal. Complete withering of Christ thorn was observed on the windward side of the shrubs, but the other side remained green and unaffected.

Soil conditions:-

The moisture and chemical contents of the soil help to remove, or make available, food of organic origin for the new plants, aided by the action of various living organisms. The saline soils in the southern valley induce salt cedar and scrub, with irregular clumps of reeds and tamarisk. According to Russell,[29] plants growing in soil with an appreciable content of soluble salts may accumulate mineral salts in their tissues in considerable quantities - amounting sometimes to as much as 50 percent of the dry matter. According to Lesage,[30] high salinity brings with it a diminution of chlorophyll and starch in plants intolerant of it. However, the principal plant associations of saline areas in the southern valley consist of salsolaceous plants which are more or less tolerant of salinity.

Biotic factors:-

It is clear that there are endless examples of biotic influences on vegetation: from the insect world of locusts and caterpillars, and the animals which feed on them, to man and the remarkable changes made by his clearing of natural vegetation, his use of grazing animals, which prevent the re-growth of shrubs, and his powers of control over the growth and activities of fungi and insects.

At the present time, violent changes are taking place in the vegetation of the valley, due mainly to the improved methods of agriculture carried out by farmers. In the East Ghor Canal Project area, large numbers of bushes of the Lotus (Zizyphus lotus) and the Christ thorn (Z.Spina-Christi), which are characteristic plants of this area, have disappeared. After 1950, the gallery forest of Jordan river, which the travellers had called "the pride of Jordan", suffered heavy losses through land reclamation in both banks of the river.

Adaptations of the plants in the Jordan Valley.

The plants of the valley may be divided, according to their water metabolism, into the following groups:-[31]

Plate VIII. The alluvial valley of the Jordan near the entrance of the Zarqa, flanked by an extremely wide badland-zone. Note the Gallery Forest of the Jordan (Photo Kluger 1937).

The Hygrophytes group concentrates along the banks of the River Jordan and the shores of the Dead Sea. It is composed of the succulent plants (Zygophyllum, Salsola) which are great conservers of water. Their transpiration is low and they succeed in retaining their leaves throughout almost the entire dry season. The Mesophytes group avoids the extreme conditions of the summer months. It is composed of the ephemeral annual flora of late winter and early spring, it grows after the first rains and dies with the first Khamsin. The Xerophytes group has a rather high transpiration, but reduces the transpiring surface progressively by dropping the older leaves.

The first and third groups are perennials, while the second one is annual group. Those plants which persist from year to year, the perennials, have been divided into two classes.[32] Firstly, there are those which are dormant during the dry season. These disappear from the landscape during the summer heat, remaining below ground in the form of bulbs, tubers, or "rootstocks". They are adapted to withstand intense drought. Secondly, those which exist more or less actively during the dry season. They consist of herbs and the majority of the dwarf shrubs, whose aerial parts disappear during the dry season.

Vegetation if it is to survive, must become adapted to the valley environment. Since the availability of water is the most important limiting factor, valley plants show morphological adaptations that enable them to withstand the lack of moisture and prolonged periods of drought. These adaptations include increased ability to store water in their succulent stems or leaves; thickening of the leaf cuticle or reduction of leaf surface or the entire absence of leaves to lower the transpiration rate, and the ability to survive as a seed through many years of aridity.[33] Many plants are pinkish to lessen the absorption of heat. Hairs, whether woolly or scaly, which early become filled with air and give the plants a whitish or grey appearance, may serve as protection against the sun's rays.[34] A very effective protection against transpiration and light is obtained by the leaf surface being placed vertically; such leaves more or less avoid the rays of the sun. Most of the leaves of the southern valley plants are modified to thorns in order to reduce excessive transpiration. Many plants in the northern valley have deep roots enabling them to draw water from considerable depths below the ground surface. In the southern valley, however, the root remains flat because the salt content of the soil increases with the depth and no water resources are available to the plant, at greater depths.

Categories of Natural Vegetation.

Before dividing the Jordan Valley into its phytogeographical zones, let us recognise the bioclimatic sub-divisions in Jordan. These have been calculated by Long (1957)[35] according to the rainfall/temperature quotient of Emberger (1955):

$$Q = \frac{P}{\frac{(M + m)}{2}(M - m)} \times 1000$$

where P is the annual average rainfall,

M is the average maximum temperature of the hottest month,

m is the average minimum temperature of the coldest month.

The distribution of the resulting bioclimatic zones was prepared in a map of the Eastern Jordan. Concerning the Jordan Valley, it is divided into two sub-divisions. Firstly, the Arid Mediterranean bioclimate, very warm variety which is represented by the stations of Northern Shuneh, Wadi Jurum and Deir Alla in the northern valley. Secondly, the Saharan Mediterranean bioclimate, very warm variety which is represented by Wadi Shueib station in the southern valley. Not only do these two bioclimatic zones coincide with the former two climatic regions of the valley, but they also coincide with the further two phytogeographical zones of it. Eig (1931-32)[36] divided Palestine into three main phytogeographical sub-divisions, the Mediterranean, the Irano-Turanian, and the Saharo-Sindian. The valley is part of the two last sub-divisions. A revised version of Eig's map was produced by Zohary[37] in (1947) with addition a Sudano-Deccanian sub division to the valley. A range classification survey of Jordan was completed in (1956) by Hunting Technical Services Limited;[38] in (1957), Long gave a description of the vegetation of Eastern Jordan.

Long's classification is based on the vegetation of uniform sites, while the Hunting survey has concentrated on land forms which show topographic diversity.

The flora of the Jordan Valley and its distribution fall into three main phytogeographical territories (fig.4.8):- The Irano-Turanian, the Saharo-Sindian, and the Sudano-Deccanian. Looking to the Zarqa valley from the peak of the Jordanian plateau till its confluence with the Jordan river, one can clearly see different types of vegetation. The highest parts are distinctive with the oak forests which carry a typical Mediterranean vegetation. The intermediate slopes have a mixed vegetation in which the Irano-Toranian element is strongly represented. The lower slopes carry a Saharo-Sindian vegetation. Finally, the Sudano-Deccanian vegetation covers the lower Zarqa valley.

The Irano-Turanian Territory:-

The predominant habitats of this vegetation are non-saline grey calcareous steppe soils north of the river Zarqa, with annual rainfall of 200-350 mm. Vegetation consists of steppe forest, thorny and broomlike brushwoods, and dwarf shrub communities. They are included within a single class, the Artemisietea Herbae-Albae, which comprises the Lotus (Zizyphus lotus) association in the valley, and the Ratam[39] (Retametalia raetum) in the escarpment.

The Saharo-Sindian Territory:-

This is the largest of the three territories. However, the boundaries it shares with the Irano-Turanian territory are vague. The annual amount of precipitation is less than 200 mm.[40] The habitats of this vegetation are saline soils especially the Lisan marl soil. Vegetation is extremely poor, and mainly confined to depressions, wadis and runnels. It is mostly composed of grass steppe, of which the dominant plant is a species of spear grass. Associated with spear grass is an annual member of the daisy family.

It is convenient to divide this territory into the following types:-

Automorphous saline type:- The habitat of salt bushes is confined to the dry salines of Lisan marl region in the plains above the "Broken Land" or bad lands. They are well characterised by the Salsoletum tetrandrae and Salsoletum villosae jordanicum associations.[41]

Permanent saline type:- This group characterises shores of the Dead Sea. Vegetation is zonally arranged along or around the shores.[42] The first zone is occupied by a band of Phragmites. In the second zone Juncus maritimus var. arabicus forms a broad belt. The third zone is inhabited by Aeluropus littorals. Sometimes a fourth belt is formed by stands of Tamarix maris-mourtui.

<u>Mud Flat type (Sebkha)</u>:-

It is confined to salines flooded for a certain amount of time. These are usually bare of vegetation except round the edges where there may be a sparse cover of annuals and Chenopods.* This is due to the physical nature of the soil and probably also to salinity. Small patches of vegetation may occur round places where there is free drainage. The distinct associations in the mud flats of the northern shore of the Dead Sea are <u>Tamarix tetragyna-Arthrocnemum glaucum</u>, <u>Suaedetum monoicae</u> and <u>Nitrarietum retusae</u>. While <u>Arthrocnemum</u> constitutes a more or less continuous cover, <u>Tamarix</u> is scattered here and there.

These flats represent the greatest centre of halopedic soils and halophytic vegetation of Jordan. Moreover, they exhibit the highest content of soluble salt ever found in Jordan. In some samples taken from this soil the amount of soluble salt reached 18% of total dry matter.[43]

<u>Broken Land "Badlands" type</u>:- This type of vegetation is very abundant and most characteristic of the great flats formed at the outlet region of the wadis crossing the badlands; sometimes, the grass invades the hill-tops of these badlands. This zone is rarely flooded, but it

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* Chenopods species are:- Qataf, Ghassul, Qali, Suweid, Suaeda of the Dead Sea, Melluha, and Salsol.

generally displays a more or less high watertable. The halophytic vegetation is represented here by the Suaedetea deserti association which has the following four alliances:[44] The Junco-phragmition, the Tamaricion tetragynae, the Atriplico-suaedion, and the Salsolion villosae. These associations are determined mainly by two factors, the amount of water available in the soil during the year and the percentage of soluble salts. It is worthy of saying that the soils of these plants are generally muddy or sodden in winter, dusty and structureless in summer. Their salt content ranges from 1 to 3 percent, without considerable variations between summer and winter.

Forest Wadis:-

The banks of River Jordan and wadis in the lower part of the Ghor escarpment as far north as the Yarmouk valley, contain a luxuriant hydrophytic vegetation due to their permanent supply of running water. Here, the vegetation is rank, with shoulder high thickets of thorn and thistle. Willow, cane, poplar, tamarisk and oleander grow in profusion. Reeds and rushes abound in the marshy spots.

It should be mentioned that the Gallery Forest of the Jordan comprises the Gharab (Populetum euphraticae) close to the water course and the Tarfa or Atl (Tamarix tetrandra, Jordanis, mannifera, articulata) forming the outer zone and growing in a somewhat saline soil.[45]

Sometimes, both associations merge together. Their plants tolerate a fairly high amount of soluble salts, which accumulate in summer on the dried-up river sides. The soil of this vegetation belt is under cultivation at present.

The Sudano-Deccanian Territory.

One of the most striking geobotanical features of the valley is the occurrence of a number of oases, designated when in natural conditions by a Sudano-Deccanian vegetation. These oases are often separated from one another by portions of saline or non-saline land. They are confined to special hydrographical conditions of the larger water courses, emptying into the Jordan Valley. The main factors conditioning the occurrence of such fertile oases in the valley are, firstly, the removal of chlorides by permanent currents of surface water; secondly, the accumulation of a more or less thick layer of soil with comparatively high moisture capacity, and at the same time rather good drainage conditions. Thirdly, surface or underground water is sufficient for tree growth.

The natural vegetation of these oases soils comprises a few arboreal plant communities, the most important of which are those dominated by Acacia tortilis which in its distribution does not advance further north than Ghor Kufrein, Ghor Nimrin and Jericho oases, and Cedar-Zaqqum (the Zizyphus Spina Christi - Balanites aegyptiaca) association, advancing as far north as Wadi Ziglab.[46] Of the other trees and shrubs represented in some of these enclaves (oases) the following may be mentioned here[47]:- Arak or Khardal (Salvadora persica), Osher (Callotropis procera), Anberghilan (Acacia farnesiana), Sant (Acacias syal, Tortilis, Laeta and Nilotica), Lotus (Zizyphus lotus), Hadaq (Solanum sodomeum), Gharqad (Nitraria tridentata), Tarfa (Aerva javanica), Hanthal (Citrullus), Rose of Jericho (Asteriscus pygmaeus), Lizzeiq and Seisaban.

At present, the primary associations of these enclaves are seriously affected by man, who has turned these enclaves to oases with irrigated agriculture, particularly in oasis of the Lower Zarqa Valley.

The effect of vegetation on the soils of the valley:-

Vegetation exerts a varied influence on the content and distribution of soils, quality of humus, content of mineral nutrients, movement of non-nutrient salts, conditions of soil moisture, soil structure, and many other properties determining natural fertility.

As the roots within the soil, and leaves and stems nearer the surface, decompose, an end product known as humus is formed. Humus which results from such decomposition is a complex colloidal mixture of substances, black in colour. Usually about half of it is humic acid combined with various bases.[48] It is noted that the basic content of humus formed by some plants in the southern valley may be high enough to give an alkaline reaction. Humus plays a very important role in helping to retain in the soil certain elements which the plants can use.

Organic matter is the most important factor in the formation of soil of good structure. The best water and nutrient regimes are produced in soil with a fine crumb structure in which the aggregate size is 1-3 mm. This type of structure is formed under a cover of perennial grass-legume vegetation.

The amount of plant residues entering the soil annually is a very important factor in humus formation. Under dry Artemesia-Stipa-festuca steppe, and ephemeral Artemesia desert vegetation, the total plant mass (aerial part and roots) gives the equivalent of 6-8 tons per hectare, but under semi-brush wood halophytic desert vegetation on grey-brown soils gives only 1 ton per hectare.[49] However, in this series of soils, almost the whole plant mass dies each year in the dry summer. Consequently, it is to be expected that the amount of humus produced in the Jordan valley by this dry steppe vegetation, will be small. This can be explained by the fact that vegetation of the valley is sparse, in addition to the thickness of most of its root system.

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Chapter 5.

SOIL ASSOCIATIONSOF THE VALLEY.

Compared with the western side of the Jordan Valley, the eastern side has seen fewer soil investigations. Up to the time of the Hydrographic Survey made by Ionides[1] (1939), no soil analyses are recorded in the eastern area. Under the contract between the Government of Jordan and the Baker-Harza Corporations,[2] the American Engineers performed preliminary evaluation and project planning studies for the utilization of the resources of the Yarmouk and Jordan rivers to irrigate the Jordan Valley. Their Master Plan report (1955) contains the analyses of selected samples of the soils as representative of the soils in the Jordan Valley. Moormann's[3] report (1959) on the soils of East Jordan is considered the first and the best specific soil investigation. However, with regard to the valley, it is generalised when compared with the Master Plan report. Within the scope of the work of the German Geological Mission[4] in Jordan, a soil survey was carried out (1965) in the area of Deir Alla. The surveyed area covers approximately 80 square kilometres and is located between the escarpment of the Jordan Valley in the east and the bed of River Jordan in the west.

It is important to demonstrate the methods of survey made by the Baker-Harza Corporations and the German

Geological Mission due to their direct relations with the Jordan Valley. With regard to the American corporations, their field investigations were aimed at constructing a map of land classification. Undoubtedly, their field investigations were concentrated basically on the detailed examination of soils, in addition to topography and drainage. Some 7,800 profile pits were opened to a depth of about one and one half metres to assure an accurate appraisal of soil profiles. Moreover, some 11,580 samples were analysed for salinity and alkalinity. In certain areas with salinity problems, infiltration tests were made under undisturbed field conditions to determine the rates of permeability. Total soluble salt content (TSS), hydraulic conductivity (HC), and reaction (pH, pH_5) were determined. Other tests included exchangeable sodium content (ES), cation exchange capacity (CEC), moisture, dispersion percentage, nutrient values, and mechanical analysis. Generally, the methods of analysis used were as outlined in Agriculture Handbook No.60, U.S. Department of Agriculture issued in 1954, exceptions being mechanical analysis, dispersion percentage, hydraulic conductivity, organic matter, available phosphorus and available potassium.

Hydraulic conductivity of disturbed soil samples was determined by U.S. Bureau of Reclamation procedure. Organic matter was determined by wet oxidation with chromic-sulphuric acid using the "Walkley-Black" technique. Available phosphorus was measured as proposed by Olsen et al. (1954). The infiltration studies were conducted in accordance with the method given in Salinity

Laboratory Handbook No.60. An additional guard ring, composed of earth, surrounded each infiltration cylinder to compensate for lateral water movement. A 15 cm. depth of water was maintained in the cylinder and earthen ring, and the rate of subsidence of the water surface inside the cylinder was measured hourly or more frequently if fast subsidence occurred.

With regard to the German Geological Mission, the aim of the survey carried out by this mission in the centre of the valley was the establishment of a representative soil map for a part of the valley. Soil mapping was done on topographical maps, which previously had to be reduced from the scale 1 : 2500 to scale 1 : 10,000. An existing land classification map (Baker-Harza 1955) was helpful in determining and separating soil units. A total of 36 pits were used for detailed profile description and soil sampling. Boundaries between the different units were determined by auger drillings.

Method of Classification:- In the classification of the soils the following primary factors were considered: parent material, age of soils, climatic conditions under which the soils developed, topography, and vegetation. Special attention was given to the study of the physical and chemical properties of the soils in order to draw conclusions regarding their genesis and group them in a classificatory scheme. The land classification photo maps of the Master Plan report were very helpful in establishing tentative reconnaissance and detailed soil maps.

Field observations revealed that the prominent characteristic of the soils in the valley is their alluvial origin. It is natural that the valley is filled with these alluvial soils because it was occupied by the old Jordan Lake, in addition to the numerous side wadis passing into it. Consequently, there is a distinction between the old alluvium and the recent alluvium. Most of the old alluvium soils are residual, whereas, most of the recent ones are transported. The colour of these associations of alluvium is so different that they can easily be distinguished. On the other hand most of the old alluvium (Lisan marl) in the valley is covered by the recent deposits. However, the thickness of the recent deposits is different according to the distance from the valley escarpment. Therefore, a distinction can be made between two associations of soils, thick alluvium and thin alluvium.

Parent material, climate and irrigation play an important role in the formation of saline soils in the valley. The source of the salts is in the old alluvium (Lisan marl) from which the soils developed and in the irrigation waters, of both the streams and the groundwater, which, upon evaporation, leave their salts in the soil. The climate of the valley leads to one of the soil gradations regarding salinity. We have seen that increasing aridity occurs as the southern valley is approached. This aridity is dependent on the slight fall off in precipitation and on the general rise in temperatures. Therefore, the tendency to form saline soils in the southern valley is stronger than in the northern part.

Owing to the importance of salinity and its effects on the soils, it is relevant to divide the soils of the valley into two major groups: saline soils and non-saline soils. The soils can further be divided according to the profile characteristics regarding the texture, structure and colour, in addition to the geologic and topographic maps, into five major associations.

Soil Character and Distribution.

Soils within the valley are divided into five major recognised associations as follows:

1. Thick-Alluvium over marl,
2. Thin-Alluvium over marl,
3. Residual from marl,
4. Residual from limestone, and
5. Recent Zor Alluvium. (Table 5.1)* and (Fig.5.1).

In the following discussions, analytical data for soil profiles considered are found in Appendix 5.1.

Association I : Thick-Alluvium over marl:-

This soil association is the most important soil of the Ghor due to the deep and well developed profiles. Its main distribution is in the Ghor between the River Yarmouk and the Dead Sea particularly on the alluvial fans.

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* It is found in the pocket of the thesis.

Precipitation and irrigation in the Ghor are the dominant factors in dividing the soil association into the following series:-

Series 1a : Reddish-Brown Soils:-

They are formed on alluvium laid down on top of marls and are generally located north of the River Zarqa in semi-arid conditions where rainfall varies from 250 to 450 mm. Higher rainfall together with irrigation over a long period of years has induced this bright reddish-brown colour by oxidation of the iron in the soil. Moreover, they create a weak clay pan by formation of a more highly developed subsurface horizon.

They are extremely deep soils with most of the profiles having a depth of 150 cm. However, two metres of good soil was noted in the case of profile 18 north of Wadi Rajib.

Analysis reveals the remarkable uniformity of the profile. Clay increases with depth (23 percent to 41 percent) and there is an associated decrease in the sand fraction. The saturation percentages are somewhat high, averaging 48 percent. Correspondingly, the moisture holding capacities are generally high, indicating the ability of the soils to store adequate amounts of available water for the growth of summer crops. Infiltration rates of water penetration in the soils are low, with a minimum of 0.5 mm./hr. to a maximum of 68 mm./hr. Adasiyeh area has the lowest rate since it is comprised of clayey soils with the clay fraction frequently exceeding 50 percent. Dispersion percentages are high averaging 60 percent; accordingly, structural aggregates of Reddish Brown soils readily disperse into a weakly viscous slurry which then seals surface pores, thus promoting run-off rather than infiltration.

Conductivities are invariably less than 2 millimhos/cm. at 25°C, and total soluble salt percentages are less than 0.2 percent which is the critical point of salinity.

The medium to heavy textures of these soils lead to increases in cation exchange capacities compared to the Greyish Brown soils south of River Zarqa. Cation exchange capacities are medium varying from 21 to 46 m.e./100g. and reaching their highest values in Adasiyeh area. Lime content is high and calcium is the highest of all cations. On the other hand, gypsum is less than 1 m.e./100g.

With the exception of relatively high potassium, the amounts of organic matter and available nutrients are low. The relative fertility of these soils would therefore seem to be more of a function of physical factors - structure, air, water relations, and soil depth - than of inherent chemical fertility. The low values of organic carbon and nitrogen contents point to the possibility of iron oxides contributing most to the dark colour of the soil material.

Values for pH range from 7.5 to 8.3 with the exception of the Adasiyeh area which has pH more than the critical value of 8.5. These values show a slight increase with depth inducing aslight degree of alkalinity in the subsoil. However, the exchangeable sodium percentage is well below the critical point of 15 percent varying from 0.5 to 15 percent and showing a slight increase with depth.

According to the investigations of the German Geologic Mission, this series of soils can be subdivided into the following phases:- silty loam and silty clay loam.

Silty loam soils:- Representative for this phase are profiles No.16,17 and 18 south of Wadi Rajib (figs.5.2. and 5.3). The clay content lies around 20%. The A-horizons contain less clay than the lower horizons. Signs of clay accumulations could not be observed in the subsoil. The soils have a remarkably high content of coarse silt. Salinity problems generally do not exist. The soluble salt content in profile 16 varies from 480 ppm. in the A-horizon to 110 ppm. in the C_c-horizon. The cation exchange capacity for the 0-82 cm. layers of profile No.16 lies at about 19 me./100g. For the C_c-horizon the (CEC) is only 11 me./100g. due to the lower humus content and perhaps also to a lower amount of secondary clay minerals. Exchangeable calcium varies from 53% to 64%, exchangeable magnesium from 28% to 34%, and exchangeable potassium from 2.9% to 4.4% of CEC.

Silty clay loam soils:- This phase is represented by profiles No.11 and 13 in the area north of Wadi Rajib. These soils have an Ap-AB_t-C-C_c profile, with the clay accumulation zone from 18-24 and 13-26 cm. depth respectively. The clay content in this horizon is 3-4% higher than that of the surface soil and the C-horizon. The AB_t-horizon can be distinguished by its angular blocky structure and its hard consistency, which makes this layer hardly penetrable by roots. The formation of a B_t-horizon is caused by the movement of clay particles from the Ap-horizon into the subsoil.

There is a clear resemblance between this phase of soils and the former phase in relation to the chemical composition and exchangeable cations. The only difference between them is that this phase has higher clay content in the AB_t-horizon of its soils than the former phase.

Series lb : Greyish-Brown Soils:- They are formed from alluvium laid down on top of marls and are generally located on the alluvial fans south of the River Zarqa in arid conditions where rainfall varies from 100 to 250 mm. (fig.5.4). Precipitation is so low that there is only a small amount of iron oxidation in the soil profile and there is also single grain lighter structure.

These soils, as Reddish-Brown soils, have deep and well developed profiles, but they differ in relation to the modified marls which are found occasionally in the profiles. From the point of view of mechanical composition they show different textures, varying from heavy textures in the vicinity of River Zarqa to light textures in the southern area. Sometimes, the heavy and light textures occur together in the same profile. Generally, textures range from clay loam to clay in the north and from loam to sandy loam in the south. Profiles reveal the remarkable unconstant features in the soil material. Profiles 13 and 17 show a high percentage of clay content whereas a decrease occurs in profile 15. The highest sand contents occur in profiles 5 and profile 12. On the other hand, the upper horizon differs from one profile to another; for instance, it is occupied by sandy loams in the profiles 5,12,15, whereas the clay loams replace the sandy loams in the profiles 26,27,20. Sometimes gravels and cobbles cover the surface in some profiles, while they are found in the subsoil of other profiles.

The saturation percentages are high with the heavy textures (60%) and low with the light textures (25%) averaging 44 percent. Correspondingly, the moisture holding capacities are generally high. Infiltration rates range from 13 mm./hr. to 75 mm./hr. being higher than the rates of the Reddish-Brown soils. The most striking differences, indeed, are to be found in a comparison of Adasiyeh area, which is in the extreme north of the Reddish-Brown soils, and Sweimeh area which is in the extreme south of these soils. The infiltration rates in the former area are 0.5 mm./hr., increasing to 75 mm./hr. in the latter. This difference is of course, due to the variation in the textures of these two areas.

Conductivities are high; some of the values are above the critical point 4 millimhos/cm., and vary on average from 84 to 110 millimhos/cm. However, some others have less than 4 millimhos/cm.; for instance, profile 17 has 1 millimhos/cm. on average. This distinction is also clear in relation to the total soluble salts percentages as they are more than 0.2 percent in some profiles (ranging from 2 to 3 percent on average) and less than this critical point in others (ranging from 0.04 to 0.08 percent on average).

Since the textures are light to medium, it is usual, therefore, to note a low cation exchange capacity varying on average from 5 (profile 17) to 14 me./100g. (profile 26). This point emphasises the forementioned fact that these soils have lower values of CEC than the Reddish-Brown soils. Sodium has the highest average values 48 me./100g. followed by magnesium 26 me./100g. and calcium 25 me./100g. Sodium, on average, accounts for 47% of cations and is therefore a hazard. One would expect a bad effect on the soil, particularly with the content of magnesium being so high. Fortunately, the gypsum content is medium varying on average from less than 1 me./100g. (profile 17) to 25 me./100g. (profile 26). As calcium has a considerable content also in these soils, the toxic hazard of sodium and magnesium are reduced.

The fertility of these soils depends on the physical factors more than the chemical ones. With the exception of the relative richness of potassium in the soils, the amounts of organic matter and available nutrients are low.

Values for pH range on average from 7 to 8.4 showing generally a slight increase with depth. The exchangeable sodium percentage varies on average from 11 to 57 percent showing an irregular increase with depth. Some profiles have percentages below 15 percent in the upper horizon and above 15 percent in the subsoil (profile 17) and vice versa (profile 27).

According to the foregoing characteristics of these soils, and to the Master Plan land classification photo maps, they can be subdivided into two phases: saline-alkali soils and non-saline, non-alkali soils. The first phase can be subdivided into three varieties: sandy loam, clay loam, and silty clay loam. The second phase can be subdivided into three varieties: sandy loam, sandy clay loam, and silty clay loam.

Association II :- Thin Alluvium over marl.

The main distribution of this soil association is in the Ghor between the River Yarmouk in the north and the Dead Sea in the south. It is bordered in the east by the thick alluvium, and on the west by the badlands (Katar) separating the Ghor from the Zor. It is noteworthy that this soil association is interrupted by occasional intrusions of the thick alluvium soil association I, as well as protrusions of the badlands. Consequently, it is natural to observe a mixture of soils in this transitional zone. However, the predominance will be for alluvium since this soil association is formed from thin alluvium laid down on top of marls. Therefore, this association is distinguished from the association I by its thinner profiles.

It is relevant to divide this association into two series: the Grey-Brown alluvial soils and Grey Solonchaks. Their division is based on the parent material and climate. The predominance of alluvium, north of Zarqa River, and the predominance of Lisan marls south of it, has lead to this variation in the colour. Moreover, the scarcity of rainfall accompanied with the higher temperatures in the south, have induced more salinity in its soils than that of the north.

Series IIa : Grey-Brown alluvial soils:- They resemble the Reddish-Brown soils in their formation from alluvium laid down on top of marls, and in their location north of River Zarqa in semi-arid conditions (fig.5.5). The main distinction is the thickness of the alluvial soils over marls, which is thinner here due to their position on the borders of the alluvial fans. The second differentiation is caused by the textures which are here heavier with fine fractions. Not only is the profile shallower, but it is also friable when compared with the well developed profile of the soil association I. Although it is rare to see residual marls in 150 cm. zone, the modified marls occur occasionally in this zone.

The analytical characteristics of these soils show that clay contents range from 18 to 45 percent, silt contents from 40 to 70 percent and sand contents from 8 to 36 percent. Generally, clay increases with depth, whereas sand decreases. Textures range between loam and silty clay loam inducing saturation percentages higher than those of the soil association I. The highest saturation is 62 percent (average of profile 6), whilst the lowest one is 45 percent (average of profile 29), averaging 54 percent for all the profiles. The heavy subsoils have been reflected in the slight increase in the saturation percentages with depth. Accordingly, the moisture holding capacities are so high that they could be very helpful for summer crops. Infiltration rates range from 5 to 61 mm./hr. being less than those of the soil association I. Dispersion percentages are high, averaging 65 percent. It is noteworthy that the high percentages concentrate in the soil surface and subsoil emphasising the harmful effect of runoff.

Conductivities are generally low, varying on average from 0.62 millimhos/cm. (profile 6) to 1.5 millimhos/cm. (profile 29). The only exception is profile 8 having 9.3 millimhos/cm. in the depth of 90-120 cm. The total soluble salts percentages are usually less than 0.2 percent.

Cation exchange capacity ranges on average between low values (18 me/100g., profile 13) and high values (35 me/100g., profile 6). These values are higher than the values of soil association I when excluding Adasiyeh area. The calcium cation has the highest value, 0.79 me/100g. followed by sodium (0.34) and magnesium (0.23 me/100g.). Gypsum content is less than 1 me/100g. Fertility of these soils resembles that of the soil association I.

Values for pH range on average from 7.6 to 8.2 showing generally a slight increase with depth. The exchangeable sodium percentages are less than 15 percent ranging on average from 1 percent to 10 percent. This point emphasises the fact of the absence of alkali hazard. The slight increase of the exchangeable sodium percentages with depth is noticeable.

According to the land classification photo-maps of Master Plan, this series can be subdivided into three phases:- loam, silt loam, and silt clay. The loam soils are represented by profile 16 which is located in cultivated land with irrigated cereals. It is a compacted profile to friable, with a grey brown colour. The depth of 52-97 cm. is distinguished with high hydraulic conductivity of 39.4 mm./hr., low EC. and TSP. of 0.43 and 0.04 respectively, low CEC. of 18 me./100g. with high SP. of 60%, and low ESP. of 3.7%.

Silt loam soils are represented by profile 30 which is located in irrigated farmed land. It is red brown friable moist profile. The depth of 0-90 cm. is heavy in most of the profile area. Clay content is 21 percent on average, while silt has the highest content of 49 percent on average. Comparing the upper horizon at 0-15 cm. depth with the depth of 60-90 cm., reveals that hydraulic conductivity is 10.7 mm./hr. in the upper horizon and becomes higher (19.1 mm./hr). with depth. EC. and TSP. are lower with depth, but they are not higher than 1 millimhos·/cm. and 0.8% respectively in the upper horizon. CEC. decreases from 21 me./100g. in the upper horizon to 14 me./100g. in the subsoil. SP. shows the same decrease from 45% to 39. Gypsum is less than 1 me/100g. in all the horizons. ESP. has a slight increase with depth varying from 0.87 to 1.5 percent.

Silty clay soils are represented by profile 6 which is located on the fringe of the Katar with smooth topography. It has modified marl at 127-150 cm. depth. TSP.ranges from 0.05 to 0.06 percent and values for pH vary from 8 to 8.2.

It is worth mentioning that this series of soils is represented by profile 12 of the German Geological Mission work in this area. This profile, which is located at the fringes of the Katar north of Wadi Rajib, shows that AB_t horizon at 16-40 cm. depth contains 33.9% clay. This clay content is higher than that of Ap horizon at 0-16 cm. depth having only 24.5% clay. This point emphasises the fact that clay content increases with depth. The humus content of the Ap-horizon is 1.8% i.e., 0.5% less than in the Ap of profiles of soil association 1. The C_c-horizon starts at 40 cm. below surface, followed by greyish to whitish marl at 60 cm. depth. Tunnels and cracks in the upper part of the marl are filled with reddish yellow soil.

Series IIb : Grey Solonchaks:-

This series of soil resembles the former series in its formation from thin alluvium laid down on top of marls (fig.5.6). It is generally located south of River Zarqa between Grey-Brown soils of the thick alluvium of the alluvial fans and Whitish-Grey soils of the Katar. The main distinctions from the former series are that the majority of this series occurs in large extensions primarily on the lower edge of alluvial fans, and are presently partly irrigated. On the other hand, current irrigation practices with an inadequate water supply have permitted accumulation of salts from the subsoil, particularly in those areas underlain by marl at a relatively shallow depth. Since the climate is hot and arid, there is no sufficient rain to carry the salts impregnating the soil down to the deeper strata. On the contrary, the high evaporation allows water to evaporate, leaving salts in the soil.

Profiles range from friable to compacted with modified and residual marls occasionally in 150 cm. zone. Textures are generally clay loam, but usually are too salty for mechanical analyses. The average saturation percentage is 54 percent being equal to that of the former type and ranging from 46% (profile 149.5/22) to 62% (profile 161.5/12). It is noteworthy that profile 12 has the highest saturation percentage because it has the heaviest textures of all profiles in this series and it is the second after the profiles 7 and 13 in Adasiyeh area. The gradual increase of saturation percentages with depth is reflected in the increase of heavy textures with depth. Infiltration rates are generally low ranging from 1 mm./hr. to 18 mm./hr. and are less than the former series. It is worth stressing that these rates vary inversely to the rainfall intensities occurring in short periods in this arid area. The result is the liability of soils to erosion by runoff.

Conductivities are high varying on average from 40 millimhos./cm. (profile 163/10) to 84 millimhos/cm. (profile 139/10). Generally, the upper horizons have higher values than the subsoil emphasising the fact that the salts are concentrated in the root zone as a result of high evaporation. For instance profile 139/10 at 0-30 cm. depth has a conductivity of 216 millimhos/cm. whereas at 60-90 cm. depth has 104 millimhos/cm. Total soluble salt percents are also high varying from 1 to 3 percent. These high values of soluble salt content form the main criterion for the name "solonchak", as a distinction from the former series where most conductivities are less than the critical point.

Cation exchange capacity is generally low averaging 21 me./100g. and varying from low values 14 me./100g. (profile 139/10) and medium values 28 me./100g. (profile 161.5/12). It is noteworthy that these values are less than those of the former series emphasising the fact that these soils have relatively lighter textures. The same interpretation can be used to explain the range between the values within this series. The sodium cation has the highest value averaging 21.5 me./100g., followed by calcium 12.5 and magnesium 8 me./100g. Sodium percentage is 53.1 percent on average ranging from 35.1 to 71.1 percent. This high percentage of sodium is a hazard; the bad effect on the soil is expected when it is known that the ratio of magnesium to calcium is 1 : 1.5. It is rather high compared to the former series which has a ratio of 1 : 3.5. Comparing the ratios of the soils of this association II with the soils of association

I, it becomes apparent that the soils of both associations locating south of River Zarqa have higher ratios of magnesium to calcium (1 : 1.2 on average) than those north of this river (1 : 2.8 on average).

Gypsum content is medium averaging 21 me./100g. and ranging from a low value of 4 me./100g. (profile 163/10) to a high value of 37 me./100g. (profile 145/28). In some profiles, it is noted that sodium percentage varies inversely to gypsum content. It is apparent that profile 163/10 for instance has the highest sodium percentage 71.1% and the lowest content of gypsum 4 me./100g. On the other hand, profile 145/28 has the lowest sodium percentage 35.1% and the highest content of gypsum 37 me./100g. With the exception of the relatively high potassium in the soils, the amounts of organic matter and available nutrients are low.

Values for pH vary on average from 7.4 to 7.6 averaging 7.5. Exchangeable sodium percentage with the exception of profile 139/10 (13%) are more than 15 percent averaging 33 percent. Consequently, a slight degree of alkalinity is the second problem after the serious problem of salinity. However, the occurrence of gypsum in reasonable amounts in all of the soils is a deterrent against the hazard of alkalinity.

According to the land classification photo maps of Master Plan, the saline series of soils can be subdivided into three phases: silt loam, clay loam and silty clay loam. Each of the latter two phases can be subdivided into two varieties. Firstly, clay loam with marl and clay loam with gypsum. Secondly, silty clay loam with marl and silty clay loam with gypsum.

Silt loam soils are free from marls and gypsum. They are represented by profile 21 whose hole was dug on an outwashed and farmed bench. The upper 75 cm. thickness of this profile comprises silt loam, while the lower 75 cm. contains silty clay loam. TSP. is 0.8% on average, and pH is 7.7.

Clay loam soils with marl are represented by profile 22 located in a native grass area with some gypsum on the surface. Red-Brown clay loam predominates throughout 150 cm. of the wet profile with residual marl within the depth of 135-150 cm. The complete analysis shows high exchangeable sodium percentage, high gypsum content and high total percent of soluble salts.

Clay loam soils with gypsum are represented by profile 9 which has a gypsum hard pan on the surface. It is composed of red brown clay loam at 0-60 cm. depth, grey clay loam at 60-75 cm. depth, and residual marl at 75-150 cm. depth. The upper 75 cm. of the profile includes large amounts of gypsum with plentiful moisture.

Silty clay loam soils with marl are represented by profile 2 located in a native grass area. It is composed of red brown loam at 0-45 cm. depth, slightly compacted red clay at 75-120 cm. depth and light marly clay loam at 120-150 cm. depth. TSP. is 2% and values for pH range from 7.6 at the upper surface to 7.9 at the subsoil.

Silty clay loam soils with gypsum are represented by profile 18 which is composed of heavy gypsum throughout 150 cm., including a red brown loam at 0-90 cm. depth, grey brown clay loam at 90-135 cm. depth, and residual marl at 135-150 cm. depth. TSP. is 1% on average, with values for pH varying from 7.6 to 8.2.

<u>Association III</u>:- <u>Residual soils from marl</u>:- (Lisan Marl soils):-

This association is formed from saline water deposits and marl type parent material. It occurs between the lower edge of the alluvial fans and the Katar as protrusions throughout association II. Its main predominance is concentrated on the surface and slopes of the hills of the Katar with the largest areas being found south of the River Zarqa. It can be divided into two main series :- Katar Solonchaks and Sebkha Solonchaks.

Series IIIa : Katar Solonchak Soils:- The main distribution of this series of soils is on the badlands which form greyish calcareous terrain. This ground may hardly be termed soil, since it is barely distinguishable from the soft underlying rock (fig. 5.7). Loams and clay loams are the predominant textures. The surface soil is usually spongy, fluffy, having a thin, moderately firm surface crust. It is underlain by a granular subsurface. mulch caused by the large amount of alkali salts that are present. The subsoil is compact with a structure either massive or laminated. Not only are large areas of these soils barren, but they also erode rather easily and tend to develop a badland topography. Saturation percentage is generally high averaging 46%. Infiltration rate is low being 10 mm./hr.

Heavy salt deposits, gypsum predominating, are common throughout the entire profile and are heaviest at the lower limit of the zone of evaporation. Conductivity is high averaging 64 millimhos./cm. and total soluble salt percentage varies from 1 to 3%. Gypsum content is medium averaging 21 me./100g. Calcium Carbonate percentage is high averaging 50%.

Cation exchange capacity is low averaging 15 me./100g. thus emphasising the poor status of the soil profile as regards plant nutrients. Sodium percentage is 61% and the ratio of magnesium to calcium is 1:1. This high percentage of sodium combined with a high ratio of magnesium are prominent evidences of soil sterility. The average values for pH is 7.5, while that of exchangeable sodium percentage is 37%.

Plate IX. Gully erosion in the badland area. Note the crystallization of salts along the course of the gully.

Plate X. Detail of salt crust in area of saline-alkali soils.

Located on a marly hill, on the left bank of the River Zarqa, profile 175, of the German Geological Mission survey, represents this series of soils and shows the following characteristics. The upper horizon A_i is composed of brown and grey loam throughout 0-16 cm. with very low humus content. It has a granular structure with intercalations of light grey clay of platy structure having coatings of iron oxides. It is highly calcareous with very frequent lime and gypsum concretions.

The bottom horizon C_n at 16-90 cm. depth, is composed of light grey clay with an absence of humus. It is highly calcareous with a high amount of gypsum crystals. The structure is platy with coatings of light red iron oxides on the surface of the plates.

According to the land classification photo maps of Master Plan, this series of soils can be subdivided into four phases: eroded soils of Lisan marl, loam soils, silt loam soils, and clay loam soils. Eroded soils represent the surface and slopes of badland hills. Soils have a solum of less than 30 cm. due to the severe erosion. They comprise soils in which the A-horizon is completely or partly lacking. Loam soils are represented by profile 24 located on the fringes of Katar and having a friable to compacted structure. They have the lowest salinity and alkalinity of all phases. Silt loam soils are represented by profile 20 which is on a 5% slope having heavy silt loam with friable profile. Total soluble salt percentage is more than 0.2% with value for pH averaging 7.9. Clay loam soils are represented by profile 26 located on the western slope of Katar looking on the Zor.

Series IIIb : Sebkha (Mud flat) Solonchak soils:-

This soil series occurs to a large extent in the salt pan south west of Deir Alla and in the northern flats of the Dead Sea (fig.5.8). These soils show concentrations of soluble salts which are detrimental to plant growth. The salts are distributed throughout the profile or appear in some horizons only. In some samples taken from this soil series on the northern shores of the Dead Sea, the amount of soluble salt reached 18% of total dry matter. The soils are heavy with a brownish tint in the upper horizon, darkening with the depth. The concentration of chlorides in the different horizons varies here considerably with the season due to loss of water in the summer. Among the soluble salts, magnesium plays a very important part. The salt pan of Deir Alla is the representative of this soil series.

According to the German Geological Mission, subdivisions of this series, based on variations in soil texture and salt distribution, are as follows: Highly saline silty clay, clay with high salinity in the surface, and low salinity in the subsoil, moderate saline silty clay loam, and moderate saline silty loam.

Highly saline silty clay soils are very saline. The uppermost 2 cm. have an electrical conductivity of 123 mmhos./cm., decreasing below 23-35 cm. depth, but is still 48 mmhos./cm. from 64-90 cm. The high soluble salt content induces a granular structure, which reaches as deep as 64 cm. Among the cations, sodium is predominating, followed by magnesium and calcium. The Mg:Ca ratio varies from 10:1 in the A-horizon to 10:3 in the G_o-horizon. The sodium adsorption ratio varies between 76 in the upper most 2 cm. and 39 in the subsoil. Correspondingly, after leaching, a deterioration of soil structure must be expected

Plate XI. Area of saline clay with hexagonal cracking and patchy salt efflorescences.

Plate XII. Saline-alkali soils just to the north of the Dead Sea. Widespread salt encrustations at the soil surface, with the Lisan marls in the background.

because of high amounts of exchangeable sodium and magnesium. Gypsum is contained in almost every horizon.

Clay with high salinity in the surface and low salinity in the subsoil occurs in the vicinity of the salt pan and is represented by profile 49 located in the north of the salt pan. The soil of this profile shows a high salinity in the A-horizon with a conductivity of the saturation extract of 21 mmhos./cm. Chlorides predominate only in the highly saline horizon. In the subsoil the importance of the chlorides decreases in favour of sulphates. Soluble calcium exceeds soluble magnesium in the highly saline A-horizon, but in the subsoil magnesium predominates.

Moderate saline silty clay loam soils have a moderate surface salinity but a high salinity of the subsoil. They are represented by profiles 47 and 50 at the southern and eastern fringes of the salt pan. In both profiles, conductivities exceed 16 mmhos./cm. only in the subsoil, whereas they range from 4 to 16 mmhos./cm. in the uppermost soil horizons. In the less saline soil layers sulphates predominate over chlorides while in the highly saline layers the opposite is true. Sodium predominates mainly in the highly saline layers. Amounts of soluble calcium and soluble magnesium are nearly equal in all horizons of profile 47. In profile 50, soluble magnesium is higher than soluble calcium.

Moderate saline silty loam soils are represented by profiles 51 and 52. Profile 51 shows in its upper part a pedogenetic development with a clay enrichment in the B-horizon (B_v). The salinity increases gradually with depth and reaches high concentrations already in the parent material of the solum from 68 to 114 cm. Below the solum several layers of marly material can be differentiated, all of them containing high concentrations of soluble salts. This salinisation is probably caused by the influence of stagnating water during wet periods, of which mottled discolorations give evidence. While SO_4 - ions predominate in the horizons of lower salinity, chlorides, sodium and magnesium prevail in the layers with high salt concentrations.

Association IV : Residual soils from limestone:-

The main distribution of this soil association is on the foot hills along the escarpment of the Jordan Valley. The soils are derived from limestone as a parent material. The only series representing this association is Rendzina soils.

Series IVa : Rendzina soils:- These shallow soils are found on limestones of the escarpment highlands and their layers reach at most a depth of 50-75 cm. Their profile is generally not well developed and consists mainly of AC horizons. Textures are light comprising stony loam and stony sandy loam. Lime is the main constituent of the vast majority of these soils. They are generally rich in organic matter. The cation exchange capacity is comparatively low; the dominant exchangeable cation is calcium.

This series can be subdivided into two phases: Rendzina soils on hills and Rendzina soils on gravel fans. Profile 7, on a hill near the Ghor Kufrinja track, represents the first phase. The A-horizon has a depth of 0-17 cm. and is a stony loam with high humus content. Its colour is very dark greyish brown, the structure is granular, and it is highly calcareous with lime concretions. The C-horizon of 17-70 cm. depth comprises a stony sandy loam of yellowish brown colour. It resembles the A-horizon except that it has a very low humus content. The parent material is a hard and fine crystalline limestone.

Rendzina soils on gravel fans are derived from wadi gravel fans. Their distribution is restricted to the large gravel fans at the mouth of wadis, which enter the Ghor from the escarpment. Their main feature is a well developed sharply differentiated A-horizon of moderate to high humus content followed by a very stony C-horizon. Profile 9 represents this phase showing a very stony sandy loam in Ap-horizon of 0-22 cm. depth, and a gravely sandy loam in C-horizon of 22-60 cm. depth. The structure in the horizons ranges between granular and subangular blocky. The Ap-horizon contains 2.5% humus, the lower horizons less than 0.5%. The carbonate content varies between 28% in the Ap and 37.5% from 32-40 cm. Fine lime concretions are found in the 32-40 cm. horizon. Salinity is not encountered in these soils.

Association V :- Recent Zor Alluvium Soils:-

These soils occur in the flood plains of River Jordan and its tributaries. They are alluvial complexes of clay and sand. Their depth is sufficient for a good root zone for most plants. Soil forming factors have not had sufficient time to produce an aggregate soil structure. This soil association can be divided into two series: Alluvial complex and saline alluvial complex.

Series Va : Alluvial complex soils:- The main distribution of these soils are in the northern Zor of the River Jordan and the Zors of the main side wadis (fig.5.9). They are composed of sandy, loamy and clayey soils derived from holocene, fluviatile sediments. Profile 220/2 representing this soil series shows that the silt content is the highest averaging 46% followed by clay 37% and sand 17%. Sand increases slightly with depth (10 to 27%) and there is an associated decrease in the silt and clay fraction. Saturation percentage is high averaging 59%. Correspondingly, the moisture holding capacity is high. Infiltration rates are low being 15.2 mm./hr. The average of dispersion percentages is 56%, being high due to the heavy textures. Conductivities are less than the critical point, the average of electrical conductivity is 2.6 mmhos./cm., while the total soluble salt percentage is 0.2%.

Cation exchange capacity is medium averaging 25 me./100g. Since the ratio of Mg. to Ca. is 1:2, and Na. percentage is 29%, there is no alkalinity hazard resembling the Reddish-Brown soils of association 1. Gypsum content is less than 1 me./100g. The value for pH is 8 on average, increasing slightly with depth. Exchangeable sodium percentage is 6% on average, emphasising that these soils are free from alkalinity.

According to the land classification photo maps of Master Plan, this series can be subdivided into four phases based on texture: Impeded clay, clay loam, loamy, and loamy sand soils. Since the impeded clay soil is predominant in the area, it is considered as a representative soil of the foredescribed series. Similar soil phases occur in the lowlands formed by the River Zarqa, but there, the soil pattern is less complicated. The characteristics of these phases, which are the same as that occurring in the River Jordan Zor, are as follows*:-

Clay loam soils are derived from translocated marls having heavy textures and yellow colour. The A-horizons have a moderate humus content causing a very dark grey colour, while the C-horizons have low humus contents with grey colour. Structures differ from granular cloddy in the A-horizons to very compact in the C-horizons. All of the profiles are highly calcareous.

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* The soils of Zarqa flood plain are representative of the soils of all the main side wadis.

Loamy soils derived from holocene river deposits are predominant in the lowlands of River Zarqa. The A-horizon at 0-40 cm. depth is a dark grey loam with a granular to cloddy structure and moderate humus content. The C-horizon at 40-100 cm. depth is a dark brown loam with moderate humus content and angular blocky to compact structure. All of the profile is highly calcareous.

Loamy sand soils derived from alluvial sands are located on the banks of River Zarqa. They have, in general, a dark reddish grey A-horizon of 30-35 cm. thickness. The A-horizon is often covered with material containing less humus. Sometimes the soils have a stratified appearance with a series of textural layers. Salinity is no problem in these soils due to their good drainage. The cation exchange capacity is very low, due to the high sand content and low humus supply.

Series Vb : Saline Alluvial Complex:-

This soil series is located in the southern Zor, i.e., south of River Zarqa having arid climate with rainfall ranging from 100-250 mm. (fig.5.10). There is a clear variation between this series and the former one. Profile 137/24 can be taken as a representative of this series as well as an index of the contrasts between the soils of Zor south and north of River Zarqa.

The analytical characteristics of the profile show that it has a sandy loam texture reflecting the fact that the lighter textures are seen towards the south. It is rather difficult to recognise the percentages of the textural fractions due to the flocculation resulting from the salts in the soil. However, saturation percentage is less than that of the former series, averaging 32% only, due to the lighter textures.

Accordingly, the infiltration rate is very high being 125 mm/hr.

The average conductivity is 88 mmhos/cm. and the total soluble salt percentage is 1.7% on average. It is to be noted that the average of these values throughout the upper 30 cm. thickness, is 139 mmhos./cm. and 3% respectively. Consequently, it can be concluded that whereas the former series is non-saline soil, this series is saline soil with high accumulation of salts in the plant root zone.

Light textures have induced the low cation exchange capacity averaging 9 me./100g. The ratio of magnesium to calcium is high being 1:1; moreover, the sodium percentage is 50%. This means that the soils tend towards alkalinity. Fortunately, gypsum content is medium being 24 me./100g. on average, leading to a natural soil protection against the alkalinity hazard. The basic fertility is relatively high with the exception of nitrogen and phosphorus . Values for pH are 7.6 on average, whereas the average of exchangeable sodium percentage is 21%. It is noteworthy that high alkalinity takes place at 30-45 cm. thickness of the profile where the percentage of exchangeable sodium is 32%.

According to the land classification photo maps of Master Plan, this saline soil series can be subdivided into four phases:- sandy loam, sandy clay loam, clay loam, and clay. Sandy loam soils, located on the banks of River Jordan, are derived from alluvial sands. Profile 12 represents these soils where it is bordered by good growth of brush. The A-horizon is composed of dark grey loamy sand with a high content of humus. The C-horizon is composed of silty loam with higher values of soluble salts and pH than the A-horizon.

Sandy clay loam soils are represented by profile 8 situated in an irrigated area. It is composed of clay loam at the upper and bottom horizons, with sand at 30-60 cm. depth. Since the area is irrigated by pumping brackish waters of River Jordan, the percentage of soluble salts is more than 0.2%.

Clay loam soils are represented by profile 6 occurring in an area of heavy brush vegetation. The upper horizon contains dark grey clay loam with a high content of humus, while clay is predominant in the bottom horizon.

Clay soils are represented by profile 3 whose pit was dug in bare ground. It is composed of clay with high indications of salt probably due to outwash from the Ghor.

Conclusion :-

It can be concluded that the valley includes saline and non-saline soils. The saline soils are concentrated in the southern valley and extreme south of the northern valley in a strip of badlands and sebkhas (mud flats) situated between the alluvial fans of side wadis and the River Jordan. Salinity in these soils is due to geological, climatological and pedological factors in this part of the valley. The heavy textures of the soils have induced a level of alkalinity which is very slight as a result of the occurrence of gypsum in the area. As can be seen in the following chapter on land classification, lands of saline soils will be classified as Class IV lands when they are level or Class VI. lands when they are sloping and rough. Successful agriculture is impossible without leaching of the soils.

Non-saline soils occur in most of the northern valley and the eastern part of the southern valley on the alluvial fans of Shueib and Kufrein Wadis. These soils are suitable for agriculture and can be classified from Class 1 lands to Class III lands.

References:-

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Chapter 6.

LAND CLASSIFICATION AND CAPABILITY.

Methods and Factors of Land Classification:-

A land class is a category of land having similar physical and economic characteristics which affect the suitability of land for irrigation.(1) To achieve the objectives of the land classification according to U.S. Department of the Interior (1953), Baker and Harza(2) corporations made a distinction between various classes of land and delineated their specific characteristics in the field through consideration of the prime physical factors of soil, topography, and drainage. The effects of physical factors on crop adaptabilities, crop yields, and costs of production were evaluated. Land potential, which is the payment capacity of lands, was made by estimating of the degree of suitability for irrigation agriculture and comparing the characteristics of the lands with the minimum land class specifications.

Field mapping was done on aerial photographic mosaics that have a scale of approximately 1 : 2,500. Topographic sheets with 1 metre contour intervals were used in conjunction with the photographs. The areas covered by the photographs were traversed systematically with such deviations as necessary to determine the boundaries of the different land classes. On the more uniform areas, 8 to 10 holes per square kilometre were dug with a soil auger to a depth of one and a half metres. On the more complex areas, the investigation was much more intensive. The soil borings were spaced at sufficient intervals to determine as accurately as possible the delineations between land classes and sub-classes.

Numerous holes were also examined to evaluate the deeper sub-soil and drainage conditions. After field and laboratory information were correlated, definition lines for land class and sub-class areas were placed on the photo maps. In this manner the total area of the Jordan Valley was summarised by individual land classes grouped as arable and non-arable lands. Sub-classes within each major land class were grouped into categories of similar characteristics.

The factor of soil with its many tangible physical, chemical and biological characteristics is one of the primary criteria for evaluating lands for irrigation. The general soil conditions required for profitable sustained irrigation agriculture are numerous. The soil must have a reasonably high available moisture capacity; it must have, on the other hand, a slow enough infiltration rate to prevent excessive percolation and drought. Good aeration and sufficient depth are necessary. Furthermore, adequate supply of plant nutrient with absence of injurious amounts of sodium are important factors.

The factor of topography in land classification reflects the need for and cost of land development, the ease or difficulty of conveyance of water over the farm and application to the cropped land and, to some extent, the crop adaptability, permanency, and drainage. Consideration is given to the three major topographic features:- degree of slope, relief, and position.

Drainage is an important factor in land classification because of its effect on productive capacity, costs of production, and the costs of land development when drainage must be performed by the farmer. Removal of excess water from the root zone is essential in preventing salt accumulations, which are toxic to crop plants and which impair the physical characteristics of the soil by deflocculation, and in preventing waterlogging of the soil, since most plants require an aerated root zone and a stable structure.

Economic factors considered in establishing the specifications for the land classification include productive capacity, costs of production and costs of land development. Consideration of these basic factors, including their agronomic aspects, is essential for determination of the suitability of land for irrigation.

The total area of land in the Eastern Jordan Valley has been assessed by Baker and Harza (1955) as 605,840 dunums of which 364,084 dunums (60%) are arable land and 241,756 dunums (40%) are non-arable land. Classes I,II, and III are immediately suitable for arable cultivation. Class IV land requires reclamation, but should be as good as the other classes after leaching and levelling. Class VI land is non-arable.

Class I land:- From land classification map (figs.6.1, 6.2, and 6.3), it can be seen that the class I lands are located primarily on the recent flood plains of the perennial streams on the Ghor terraces with small scattered areas occurring on the Zor. There are 73,615 dunums in the northern valley and 42,761 dunums in the southern valley (Table 6.1 (App.6).

The soils include deep, permeable clay loams and significant areas of sandy loams and loams. Their depth is not less than 150 cm., whilst residual marls occur on a depth of 90 cm. from the surface and modified marls on a depth of 75 cm. The heavier textured profiles are primarily located north of the River Zarqa, whereas the lighter textured soils take place in the fans of Wadi Hisban and Wadi Kufrein. The waterholding capacity is good and the inherent fertility of these soils is relatively high. Values for pH are 9 at the surface and 9.2 at the subsoil.* Total soluble salt

* pH values are based on one to five dilutions.

percentage is not more than 0.2 percent (Table 6.2 (App.6).

Surface is regular enough to require only small amounts of levelling. Cover is composed of loose rock and vegetation. Cost of clearing is too small or insufficient to modify cultural practices or reduce productivity. Slopes are very gentle reaching up to 4 percent in same plane and less if complex slopes. Soil and topography require only normal drainage with maximum permissible drain spacing as established from infiltration tests.

Land capability is according to U.S. Department of Agriculture,[3] "a grouping of one or more individual soil mapping units having similar potentials and continuing limitations or hazards. The soils in a capability unit are sufficiently uniform to produce similar kinds of cultivated crops and pasture plants with similar management practices, to require similar conservation treatment and management under the same kind and condition of vegetative cover and to have comparable potential productivity". Capability class I is the best of all land classes since it contains the best soils of the valley. There are no significant limitations for cropland use, beyond those farming measures that should normally be undertaken to maintain productivity. This land is nearly level, has low susceptibility to erosion and has deep soils, well drained with good texture and workability. As a result of intense irrigation agriculture which has taken place in the valley during the last ten years, it can be expected that the area of Class I land will shrink to such an extent that soils with above normal yield potential will not be more than 75,650 dunums in all of the Jordan Valley with its eastern and western parts. This area will represent 14 percent of total suitable area of Jordan Valley.[4]

Soils with above normal yield potential in the Eastern Jordan Valley are estimated to be about 62,300 dunums divided between

TABLE 6.1. Land Classification summary in the Eastern Jordan Valley (Area in thousands of dunums).

Land	Class	Northern Valley				Southern Valley			
		Area according to the survey of Baker-Harza (1955)	Percent %	Estimation of Area at present	Percent %	Area according to the survey of Baker-Harza (1955)	Percent %	Estimation of Area at present	Percent %
Arable	I	73.6	63.2	39.5	63.4	42.8	36.8	22.8	36.6
	II	71.1	62.0	176.5	62	43.5	38.0	108.2	38
	III	25.9	53.2	6.6	52.8	22.8	46.8	5.9	47.2
	IV	4.2	4.7	1.1	2.2	80.3	95.3	47.8	97.8
Non-arable land	VI	271.9	44.9	271.9	44.9	334	55.1	334	55.1

Source: Baker and Harza (1955) and East Ghor Canal Authority (1966).

northern valley with 39,500 dunums, and southern valley with 22,800 dunums.[5] (Table 6.1).

It is to be noted that the Class I lands will be suitable for all crops with no limitations if moderate limitations, due to flood hazard, are discounted. Although Baker and Harza Master Plan (1955) predicted an increase of the Class I lands, it is apparent that much of them have been changed to Class II lands. This transfer is due to intensive irrigation in the area and using some saline well waters for irrigation of cultivated lands in the southern valley.

Class II Land:- Most of the Class II lands occur on the outer fringes of the recent flood plains where deep soils with moderately heavy profiles are found. Some of the Class II lands are located along the edge of the upper scarp having moderate rock cover. Also included in Class II are lands with coarse textured soils on the recent flood plains, lands relatively shallow in depth to marl and areas with soils of slight alkali or saline condition. There are 71,053 dunums in the northern valley and 43,546 dunums in the southern valley.

The soils include deep loamy sand to permeable clay. Their thickness from the surface to the bed rock is about 90 cm. depending on position and slope. The depth of residual marl is approximately 60 cm. while that of modified marl is 45 cm.

The major problems which may be anticipated are heavy textured soils particularly those located in Adasiyeh area of the northern valley. In addition, there are saline-alkali lands which occur generally on the upper fringe of lower lying areas. Fortunately, the major portion has soils that are deep, permeable and capable of holding a moderate amount of water for plant use. There is a slight alkali problem indicated by high exchangeable sodium, but in most cases gypsum content is correspondingly high. The pH values of the soils are generally within the range of 9.2 in the surface and 9.4 in subsoil. Soluble salt percentage is not more than 0.5 percent.

Land surface is in need of moderate levelling and grading. The quantity of earth movement differs from one part to another,but generally, it ranges between 200-500 m^3/dunum. The required clearing of cover may be equivalent in cost to levelling. Slopes range from 1-4% in the case of complex slopes and from 4-8% in smooth slopes. The extent of topographic deficiencies most of which are concentrated in Class II lands, in the valley are shown in the table as follows(6):-

From the table, it can be concluded that the majority of lands characterised by cover or gradient are concentrated on the area between the East Ghor Canal and the escarpment of the Jordan Valley. These deficiency factors, particularly gradient, make irrigation patterns difficult since these areas quite often lie adjacent to smoother slopes. It is notable that these deficiency factors, below the canal, range from negligible in Zor to 5-10% in Ghor. Nevertheless, Zor lands are in need of levelling since there are numerous old abandoned channels of the River Jordan and its tributaries, local pockets of cover, and ridges of landslides outwashed from badlands by streams to the Zor. The Southern Ghor both above or below the canal is in need of levelling (14% of the lands) more than the northern Ghor (5%). This is due to the small ridges formed on the Ghor by wave action as the old inland lake receded.

Although most of soil profiles in this category are permeable, additional drainage is required. Conditions indicate slightly closer drain-spacing than that established for Class I. Drainage deficiency is concentrated on the lands in shallow

TABLE 6.2. Extent of Topographic Deficiencies.

	Northern Valley			Southern Valley		
Deficiency	Above Canal	Below Canal		Above Canal	Below Canal	
		Ghor	Zor		Ghor	Zor
Cover	About half of area affected particularly near the alluvial fans.	Minor importance about 5%	Negligible	About half of area affected	Locally important, about 7% of total area	Local pockets-negligible.
Levelling	Minor importance About 5%	Minor importance, less than 5% of area.	Of major proportions. Nearly all lands need.	About 15% needs levelling.	About 12% of this area needs levelling.	Of major importance is principal deficiency.
Gradient	About one third of area is affected.	About 10% of area is affected.	Some of minor importance.	About 10% of area is affected.	Of minor importance about 5%	Negligible

Source: Baker and Harza (1955) Vol.III.

depressions and the lands of heavy textured soils.

With relation to land capability, it can be expected that the area of this class will increase in all of the Jordan Valley from 138,474 dunums to 343,000 dunums as a result of reclamation and betterment.(7) Eastern Jordan Valley will have about 284,690 dunums (83 percent of total of the Jordan Valley) divided between the northern valley with 176,514 dunums (62% of total of the Eastern Jordan Valley), and the southern valley with 108,176 dunums (38%). It is noteworthy that the soils of this category are distinctive with a normal yield potential and they are suitable for most crops. Most of these soils have no limitations (60%); even those with limitations (40%), vary from slight limitations (stoniness) to moderate limitations (relief and stoniness).*

Class III Land:- These lands are predominantly found adjacent to the upper reaches of the Ghor and the immediate fan areas of stream channels. There are 25,870 dunums in the northern valley and 22,765 dunums in the southern valley. Soils are characterised by their very coarse texture being predominantly fine sand. Their depth to bedrock is 60 cm. depending on position and slope. Residual and modified marls are located on the depth of 45 and 30 cm. respectively. The pH values vary from 9.4 at the surface and 9.6 at subsoil. Soluble salt percentage increases towards subsoil being 0.5% at the surface and 0.75% at subsoil. Moderate alkali conditions and very coarse textures are the primary soil limitation. Lands of this deficiency are smooth to gently sloping in which moderate amounts of alkali and soluble salts have accumulated. Current irrigation practices with an inadequate water supply have permitted

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* Personal communication with Engineers of Irrigation Office of EGCA.at Deir Alla in summer of 1966.

accumulation of salts from the subsoil, particularly in those areas underlain by marl at a relatively shallow depth.

Land s of this class have fairly rough topography, which requires heavy levelling and grading. It is estimated that each dunum requires earth movement ranging from 500-800 m^3. Heavy clearing of loose rock and vegetation is necessary. The gradient of complex slopes is less than 8%, while that of smooth slopes is up to 12%. Topographic deficiencies are concentrated in lands of uneven topography or relatively steep gradient. On the other hand, there are lands which combine topographic and soil deficiencies and require grading and clearing.

Owing to the occurrence of some soil profiles having slowly permeable clay, additional drainage is required. Conditions indicate closer drain spacing than that required for Class II. Lands having drainage deficiency are relatively minor and they normally occur as very small depressions with evidence of a shallow watertable.

As a result of reclamation and betterment processes undertaken by the East Ghor Canal Authority and farmers, much of the Class III land has been upgraded to Class II. It is expected that there will be 6,552 dunums only of Class III in the northern valley and 5,880 dunums in the southern valley.* In relation to the capability of Class III lands, it is noteworthy that these lands have a normal yield potential. Nevertheless, they are less suitable for fruit trees and salt-sensitive vegetables. In addition to these limitations, there are lands having some other limitations also. These limitations vary from slight (stoniness) to moderate limitations (relief). The practices required on Class III lands are

* Personal Communication with Irrigation Division of EGCA. Amman, spring of 1966.

more complex and costly to install and to maintain than on Class II lands. Terraces, special crop rotations including more use of close-growing crops, better use of crop residues, and other practices are necessary.

Class IV Land:- The majority of these lands are located in the southern valley where there are 80,268 dunums. They occur in large bodies primarily on the lower edge of alluvial fans where they are not irrigated. These lands are so limited in the northern valley that they are only about 4200 dunums (4.7%).

Soils are characterised with texture ranging from sandy loams to clay loams or permeable clays. They are similar to those of Class III lands with relation to depth to bedrock, residual, and modified marls. Having equal pH values with Class III, they exceed their limits of salinity, but are susceptible of leaching to at least Class III percentages. Soluble salt percentage may range from 0.5 percent to greater than 3 percent in cases where soil, topography and drainage characteristics are favourable for leaching. Salinity and moderate alkalinity are the dominant factors in soil deficiency. Leaching is required to correct alkalinity. Fortunately, there is an appreciable amount of gypsum present which will materially aid in the leaching process.

Topography of these lands is generally favourable when compared with Class III lands. They are in need of levelling and clearing more than Class II but should not be the maximum allowable for Class III. Gradient, like that of Class III, is less than 8% in complex slopes, and up to 12% in smooth slopes. Heavy undulating lands represent the topographic deficiency in this category.

Since leaching is an important process to correct alkali of this category, it becomes necessary that drainage should accompany this process. On the other hand, some lands may face a watertable hazard which is considered as a drainage deficiency.

This condition can be remedied by subsurface drainage.

According to Baker-Harza report (1955), all of Class IV lands will be divided between Classes I,II, and III as a result of reclamation and leaching as is shown in the following table.

TABLE 6.3. Anticipated conversion of Class IV lands to Class I,II,III lands.

Area	Class IV			Total
	Class I dunums.	Class II dunums.	Class III dunums.	Class IV dunums.
Northern Valley:-				
Ghor above Canal	-	-	-	-
" below "	1,060	2,063	315	3,438
Zor " "	200	314	254	768
Total Ghor and Zor below Canal	1,260	2,377	569	4,206
Grand Total northern valley	1,260	2,377	569	4,206
Southern Valley:-				
Ghor above Canal	298	317	470	1,085
" below "	33,808	27,554	13,677	75,039
Zor " "	1,732	2,212	200	4,144
Total Ghor and Zor below Canal.	35,540	29,766	13,877	79,183
Grand Total southern valley.	35,838	30,083	14,347	80,268

It can be concluded, according to the prediction of Baker-Harza, that all of Class IV land will be converted to Classes ranging from Class I to Class III. But field observations show that this conversion will occur for some parts of Class IV land and not for all of it. This is due to the fact that after leaching and reclaiming the land by the present saline well waters, they are susceptible to deterioration again. Even though the East Ghor Canal will be extended in future to irrigate these lands, salinity of the soils cannot be absolutely obliterated because of high values of evapo-transpiration, in the southern valley, which raise the water table again to the root zone. Consequently, it is expected that there will be some 1126 dunums only (2% of totals of the Eastern Jordan Valley) of Class IV in the northern valley and some 47,834 dunums (48%) in the southern valley.*

Concerning land capability of this category, it has soils with a normal yield potential. Before leaching and reclamation, some 10,000 dunums had been cultivated by dry farming. The majority of these lands produce cereals; nevertheless, where suitable irrigation water is available, it becomes possible to cultivate fruit and vegetables. Soils in this class may produce a good yield in years of above average rainfall, a low yield during years of average rainfall, and failures during years of low rainfall, but the soil must be protected against blowing in all years, if severe wind erosion is to be avoided. Soils are less suitable for deep rooting and moderately salt-sensitive crops. Relief limitations occur in limited small areas, and vary from moderate to severe. Consequently, in using these lands, they must have very careful management to preserve their productivity and to avoid serious loss.

Class VI Land:- The majority of Class VI lands are located as badlands between the Ghor and the Zor. In addition, they occur along the sides of stream channels, in the areas of shallow soils with strong alkali and high salt content, and in undulating areas of very heavy textured soil with high salt content. There are some 271, 876 dunums in the northern valley and some 333,964 dunums in the southern valley.

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* Personal communication with Irrigation Office Engineers - Deir Alla.

As regards capability of Class VI lands, they are not suited for cropping; this is due to the fact that they are in scattered rough and stony lands. They may range up to steep or very steep, may have severe erosion hazard, be subject to frequent and serious overflow, be shallow, and may have salts or sodium accumulation. All these deficiencies are hindrances to land cultivation, and they limit their use largely to pasture or wild life.

Conclusion:- All lands within the Eastern Jordan Valley were classified as part of all the Jordan Valley as to their suitability for sustained irrigation agriculture. The gross land area is approximately 605,840 dunums. Of this total, about 279,610 dunums are currently suitable for crop production, and about 84,474 dunums are capable of varying degrees of crop productivity after reclamation.

Lands in Class I and II are suitable for all crops, except soils of fine textures in Adasiyeh area and some parts of Zor which belong to Class III. They have above normal and normal yield potential respectively. Most of them have no limitations due to the fact that they are not inhibited by stoniness, unfavourable relief or hazard of flooding. The minority have slight limitations owing to the presence of stones which result in an estimated JD. 0.5/dunum* per annum reduction in farm benefits, compared with that of no limitations.

Lands of Class III have normal yield potential, but are less suitable for fruit trees and salt-sensitive vegetables. They have moderate limitations particularly on the Ghor with steeper than normal slopes or with rolling relief, and in the Zor exposed to the hazard of flooding.

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* JD. is a Jordanian Dinar which equals £ 1.17.

Lands of Class IV have normal yield potential and are less suitable for deep-rooted and moderate salt-sensitive crops, because of the presence of salinity at depths less than 90 cm. They have severe limitations since they are on hilly relief. These soils cannot feasibly be irrigated by surface methods.

All lands of Class VI have very severe limitations on use imposed by heavy stoniness, steep slopes, severe erosion or poor drainage. Upgrading of these lands is judged to be unfeasible.

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Chapter 7.

SOIL PROBLEMS AND CONSERVATION.

The foregoing chapters reveal that the soils of the valley suffer from problems and limitations which impede agricultural production. It should be stressed that these problems deserve relevant detailed analysis to show the difficulties inherent in their utilization. Efficient agricultural techniques need to include measures for the reclamation and continued conservation of the soil. The basic soil problems which need to be considered are those connected with the salinization and alkalization of soil profiles and those concerned with the susceptibility of the soil to erosion.

The valley has not been the scene of efficient soil problem studies up to the present. Although Baker-Harza and the German Geologic Mission made investigations which demonstrated some aspects of the soil problems, such as salinization and alkalization, they have neglected the other sides, such as wind and water erosion. Moreover, they have not tackled these problems by mentioning the fundamental measures of controlling these problems. On the other hand, the soil laboratory, attached recently to Deir Alla experimental station, has contributed in analysing soil samples taken from the farms. However, its service is too limited when compared with the services of the station as a whole, in the field of experiments dealing with the most adaptable crops or livestock of the valley.

The erosion problem is very important and striking in the valley; nevertheless, there is a lack of direct instrumentation and, moreover, no experiments have yet been done to show the most suitable techniques to alleviate the dangers of erosion in the area.

The information dealing with soil problems was obtained basically in the field by direct observations and answers from either farmers or members of the Extension Service at the valley. Comparisons with sophisticated works elsewhere were helpful. These works were done in similar parts of developed countries and have important results which can be taken as a model for implementation in the valley.

Saline and Alkali Soils.

Saline soils are soils that have been harmed by soluble salts which increase the salt concentration of the soil solution, and alkali soils are soils with a high percentage saturation of the soil adsorption complex with sodium. At present there are some 70,000 dunums in the valley requiring leaching of salts from the soil before a satisfactory degree of crop production can be expected (fig.7.1). This area is almost entirely located in the southern valley. The soluble salt percentage of these soils ranges upward from 0.2% with the average percentage somewhat greater than 3%. It is noteworthy that this area has decreased by some 17,000 dunums during last ten years due to soil leaching. This small decrease is due to the fact that most of the saline soils are located in the southern valley which has not yet been included in the present East Ghor Canal project. Consequently, reclamation works are not more than limited individual schemes impeded by water deficiency in the area.

The accumulation of soluble salts and adsorbed sodium in soils impairs their productivity in several ways. Because of the presence of much dissolved salt and the absence of significant amounts of adsorbed sodium, saline soils generally are flocculated. Their tillage properties and permeability to water therefore are equal to or higher than those of similar non-saline soils. The abnormally high salt concentration of the soil solution of saline soils, however, reduces the rate at which plants absorb water and nutrients, and consequently growth is retarded.

For appraising the tolerance of crops to salt, Scofield[1] used a scale based on the electrical conductivity of the solution extracted from the saturated soil paste (scale of conductivity - millimhos per cm.). According to this scale, the effects of salinity on growth are largely negligible when the electrical conductivity reading is less than 2. At readings in excess of about 16, only a few very salt-tolerant crops yield satisfactorily. The yields of very salt-sensitive crops may be restricted at readings as low as 2; moderately salt-tolerant crops grow satisfactorily below readings of 8; only salt-tolerant crops grow satisfactorily when readings range between 8 and 16.

Alkali soils remain flocculated and their properties usually are similar to those of saline soils as long as considerable amounts of soluble salts are present. As the concentration of the salts in the soil solution is lowered by leaching, the adsorbed sodium present causes undesirable characteristics to develop. The particles of the soil disperse and cause an unfavourable structure for the entry and movement of water and air and for tillage. Adsorbed sodium also may be toxic and cause various nutritional disturbances in plants. Nevertheless, because of the high gypsum content of a large portion of the soils in the southern valley, the detrimental effects of alkalinity, brought about by salt leaching, are reduced.

Numerous observations have proved that a large number of plant diseases in the valley are caused not only by micro-organisms, but also by disturbances due to the conditions of plant nutrition. It follows therefore, that the absence of certain minerals indispensable for the thriving growth of a plant, or their presence in the soil in insufficient or in too abundant quantities may cause diseases such as chlorosis in citrus trees.

No experiments have been done in the study area to show the effect of salinity on citrus trees. However, observations conducted in a grapefruit plantation in the Jericho area, both in a plot growing normal trees and one where the trees were chloritic, have shown that plants grown in a soil, the chloride content of which was high, and the ash of the leaves of which contained a comparatively large percentage of chloride, enjoyed good health. On the other hand, trees grown in soil, the chloride content of which was low, and the ash of the leaves of which contained a comparatively small amount of chloride, were chlorosis stricken.(2)

The danger of salinization can be shown by the investigation carried out by Reifenberg (1947)(3) in the neighbourhood of Jericho. It was apparent that an orange grove irrigated by water, the chloride content of which amounted to 593 mg.Cl^- per litre, displayed all the symptoms of intense chlorosis. The chloride content of the substratum of this ruined plantation has risen to 0.629 percent. In the immediate neighbourhood of Jericho, there was another orange grove irrigated by water having a chloride content of 27 mg.Cl^- per litre. This grove has developed quite normally since it has also a substratum having a chloride content of 0.007 percent.

Numerous cases of disease and death in plants in the Kinnereth area are caused by the presence in the soil of a high proportion of sodium chloride, bicarbonate of soda and excessive moisture.(4) The accumulation of sodium chloride in the soil is the causeof the death of bananas. It should be added that apart from the sodium chloride, the rise in the level of the subterranean water caused damage to the banana plantations. This rise is due to the non-porous and saturated subsoils affected by seepage of water coming from Lake Tiberias. An additional complication is that the irrigation practice in Kinnereth is extraordinarily intensive. The average volume of irrigation water given per dunum in this area is 2500 m^3. per annum. Since 1 cubic metre of water contains 323 gr.Cl., each dunum receives 807 kg.Cl., or each square metre about 0.8 kg.Cl. The same factors were the cause of the death of eucalyptus trees which formerly flourished in the area.

In addition to sodium chloride and bicarbonate of soda, there is a third factor of considerable importance which retards the development of the plants and destroys them, excessive soil moisture. This factor operates especially in heavy soils, and in general in soils lacking permeability which are located in Adasiyeh area and in scattered patches within the Zor. As a result of excessive moisture the colloids in the soil swell and stop up the capillary micro-pores which then fill up with abundant water causing an interruption in the action of the roots.

Reclamation of Saline and Alkali Soils

Saline soils are improved by establishing artificial drains if a high groundwater table exists and by subsequent leaching with irrigation water to remove excess soluble salts. The improvement of alkali soils involves, besides drainage and leaching, the replacement of adsorbed sodium by calcium or magnesium and the use of practices that develop good soil structure. Adequate drainage is essential for the permanent improvement of saline and alkali soils. Leaching operations and the application of amendments for the replacement of adsorbed sodium will be largely ineffective unless the ground-water table remains deep enough to prevent appreciable upward movement of water.

Drainage:- Drainage must be established before alkali-soil reclamation becomes feasible. Good management of the water is a part of good management of the land. It has already been mentioned that the valley has suffered from the periodic flooding of lands by overflow from the River Jordan and its tributaries. Furthermore, there are waters accumulated on depressions (Bassat) as a result of seepage from springs or canals. These seepage zones suffer from a high watertable which is located in the root zone. The movement of artesian water due to hydrostatic pressure in the Lower Kufrein area induced a development of a high watertable.

In order to carry out hydrotechnical reclamation of saline soils in the valley by drainage, farmers must maintain the groundwater level on irrigated fields at depths below critical. The critical depth of saline groundwaters depends upon evaporation in the valley. As a rough approximation, and on the basis of empirical data, V.A.Kovda (1961)[5] assumed it to be proportional to the average annual temperature; $Y = 170 + 8\ t^{o} \pm 15$, where Y is the critical depth in cm., and t^{o} the average annual temperature of the area. Applying this equation on two selected areas of drainage problem representing the northern and southern valley, the result will be as follows:-

Northern valley: Adasiyeh area:-

$Y = 170 + 184 + 15 = 369$ cm.

$Y = 170 + 184 - 15 = 339$ cm.

Southern valley: Dead Sea North:-

$Y = 170 + 189 + 15 = 374$ cm.

$Y = 170 + 189 - 15 = 344$ cm.

It can be seen that the critical depth of the level of saline groundwater ranges in Adasiyeh area from 369 cm. to 339 cm. while it ranges in the Dead Sea North area from 374 cm. to 344 cm.

According to Baker and Harza (1955)[6], about 7 percent of the arable area in the northern valley and 1 percent in the southern valley have drainage problems. They are indicated by the presence of a watertable within the top 150 cm. of soil profile. At present, due to the recent drains of East Ghor Canal project, groundwater occurs mostly at 5-15 metres below the soil surface. Only small scattered wet spots occur in the northern valley having a depth to groundwater of less than 200 cm.

Generally, the drainage needs in the valley are closely related to irrigation practices which are subject to control. To maintain watertables at depths sufficient to control salt accumulation, drains should be installed to depths of 200 cm. Suffice it to say that improved irrigation practices and other farming procedures which control the use of excess water have considerably lessened the need for numerous drainage installations in the East Ghor Canal project area. It is notable that increased pumping of well groundwater in the southern valley has lowered the saline watertable. Therefore, it will be beneficial when using pumping as a means of drainage in the seepage areas having hindrances in their drainage.

According to N. Ahmed (1961),[7] this method of drainage has been used in West Pakistan successfully. A table well with a 30 m. long baked-clay strainer causes a movement of the subsoil water up to a depth of 36 m., and with continuous pumping a deep formation of this kind can be cleared of brackish water, which is replaced by fresh water from infiltration sources.

The use of pumps for drainage is common in U.S.A. besides other methods. For open ditch drainage in Florida, the engineering board of review developed the following formula[8]:-

$Q = \frac{69.1}{M} + 9.6$ in which Q is runoff in cubic feet a second per square mile of drainage area, and M is drainage area in square miles.

Eaton (1953)[9] has given some formulae which can be helpful in assessing the amount of drainage needed when using different qualities of irrigation water. The salinity status of the soil solution is maintained at a level at which 70-80 percent of the crop yield can be obtained. Required drainage (tentative) can be calculated keeping in view the original salinity of the irrigation water, while drainage (final) can be ascertained by including the calcium content of the water. The two formulae are:-

$$\frac{Sw \times 100}{2 \times Mss - Sw} = \% \text{ drainage (tentative)} \qquad \ldots (1)$$

$$\frac{Sw - \frac{1}{2}\text{ total Ca}}{2 \times Mss - (Sw - \frac{1}{2}\text{ total Ca})} = \text{drainage (final)} \qquad \ldots (2)$$

where Sw is meq./l of Cl + $\frac{1}{2}$ SO_4, and Mss is the mean salinity of the soil solution.

Applying these two formulae on the valley, two drainage areas were selected; the first area is located on the grid lines 220N - 208E in the northern valley; it is represented by soil profile I and irrigated by good waters from River Yarmouk. The second area is located on the grid lines 137.5N - 204E in the Zor of southern valley, it is represented by soil profile 24 and irrigated by pumping of saline waters from River Jordan*. The results were as follows:-

$$\frac{[2.90 + \frac{1}{2}(2.14)] \times 100}{2 \times 0.58 - [2.90 + \frac{1}{2}(2.14)]} = -133.7 \text{ \% drainage (tentative).}$$

The first area:-

$$\frac{[2.90 + \frac{1}{2}(2.14)] - (\frac{1}{2} \times 2.40)}{2 \times 0.58 - [2.90 + \frac{1}{2}(2.14) - \frac{1}{2}(2.40)]} = 1.5 \text{ drainage (final).}$$

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* These two profiles were selected from Baker and Harza soil analyses (1955).

$$-\frac{[25.76 + \frac{1}{2}(5.45)] \times 100}{2 \times 71 - [25.76 + \frac{1}{2}(5.45)]} = + 25\ \%\ \text{drainage (tentative).}$$

The second area:-

$$-\frac{[25.76 + \frac{1}{2}(5.45) - \frac{1}{2}(4.73)]}{2 \times 71 - [25.76 + \frac{1}{2}(5.45) - \frac{1}{2}(4.73)]} = + 0.22\ \text{drainage (final).}$$

It can be concluded from these formulae that the second area has higher figures (positive) than the first area (negative). Therefore, where irrigation waters of higher saline content (River Jordan) are used, higher drainage has to be provided to maintain a normal yield of crop.

Leaching:-

Leaching has to be used in soils in which the salt concentration is high. Unless it is accompanied by drainage, leaching will not be effective on the soil. Very often, owing to lack of drainage, the salts cannot be leached away but only leached down to deeper levels and the danger of re-salinization exists. Leaching is most efficient when it is possible to pond water over the entire soil surface. Water can be ponded on nearly level land in shallow basins formed by the construction of earthen dikes or borders 60 to 120 cm. high. Normally the difference in elevation at the high and low points of the basin should not exceed 15 cm. It is often convenient to conduct leaching operations during the winter, when water may be more plentiful and the watertable and drainage conditions may be more favourable than during the regular irrigation season.

The choice of irrigation water for leaching is important for improving water transmission through soils and for providing calcium for reclamation. When different qualities of water are available, initial leaching may be helped by using moderately saline water. Later the water quality can be gradually improved by substituting water of lower salt content. This can be available either from reservoirs of Shueib and Kufrein Wadis after completion of the dams construction, or from the anticipated extension of the East Ghor Canal.

In some cases secondary salinization may be caused by a high mineralisation of irrigation waters as previously mentioned. According to Kovda,[10] it is necessary to leach at least once each year to remove the salts remaining after irrigation, when mineralisation of irrigation water is 2-3 gm./l. ; when it is 4-5 gm./l., it is necessary to leach after 4-5 normal waterings; when it is 7-8 gm./l., each second or third watering must be a leaching; when it is 10-12 gm./l., it is necessary to introduce the practice of increasing the frequency of waterings, using quantities exceeding the water-holding capacity of the soil, and assuring evacuation by the use of a closely situated and deep working drainage system.

Results of the trials conducted by Baker and Harza (1955) show that salts can be leached from the soil (figs.7.2 and 7.3). An application of 15 cm. of water followed by subsequent applications of the same amount (each applied immediately after the previous one has been absorbed by the soil, until a total of 80 to 100 cm. has been applied) had removed the salts to a safe level for shallow rooted crops and additional applications of water maintained this level when adequate subsurface drainage has been provided. Table 7.1 shows the total soluble salt displacement, the amount of water applied and the infiltration rate during water application.

It can be concluded that the infiltration rate of the soils ranges from low (1 mm./hr) to high (124.5 mm./hr). This differentiation is reflected on the salinity of soil after the infiltration process. It is notable that soluble salt displacement in the soils of low infiltration is higher in the soil surface than in the subsoil. Salts are transferred slowly and with difficulty from the higher horizons towards the lower horizons of the soils because the capillary fringe occurs near to the surface. Paradoxically, the soils of high infiltration have a similar low

TABLE 7.1 Soluble Salt Displacement Resulting From Infiltration Studies of Eastern Jordan Valley Soils.

Coord-inate.	Hole No.	Layer Depth cm.	Infilt-ration Rate mm./hr.	Water Appl-ied, $m.^3$	Conductivity $ECx10^3$ Before Inf.	Conductivity $ECx10^3$ After Inf.
139N-206E	10	0- 15	1.0	2.47	117	3.8
		15- 30			99	4.8
		30- 45			66	(3.2
		45- 60			56	(
		60- 75			51	(17
		75- 90			53	(
		90-120			55	18
		120-150			54	15
137.5N-204E	24	0- 15	124.5	7.68	161	7.6
		15- 30			117	11
		30- 45			70	6.1
		45- 60			46	5.9
		60- 90			19	6.6
		90-120			14	6.5
134.5N-208E	20	0- 15	25.4	1.01	188	6.6
		15- 30			113	3.8
		30- 60			92	4.4
		60- 90			61	4.3
		90-120			49	4.6
		120-150			31	5.8
		150-180			38	6.6
140.5N-206E	22	0- 15	10.2	2.19	44	6.2
		15- 30			50	4.1
		30- 60			52	3.7
		60- 90			61	4.4
		90-120			65	6.6
		120-150			83	25

Source:- Baker and Harza (1955).

salinity within all of the horizons, but more water is needed in order to decrease salinity. Nevertheless, the proportion of salt removal before and after infiltration differs in the profile according to depth; surface horizons show a greater decrease than subsoil horizons. Generally, salts are carried out from a layer not deeper than 100 cm. in the soils of low infiltration and low applied water, and not deeper than 180 cm. in the soils of high infiltration and high applied water. This movement of soluble salts under leaching is similar to the movement of soluble salts under leaching carried out on the Kizyl-Arvat station and on Tashaouz station in the region of Kunia-Urguench and on the Kara-Kalpak station in the centre of Chimbay oasis in the delta of Amudarya river. Salts in the soils of these two Russian regions are carried out from a layer not deeper than one metre.[11] Similar to the soils of the valley, the transfer of salt during waterings of these soils takes place more efficiently when salt solutions migrate in dry ground. When the groundwater table occurs near to the surface, it is more difficult to remove the salt. In such cases waterings can give a positive effect only with the help of drainage.

Leaching Requirements:- It is important to know how much additional water should be allowed with low-quality waters to prevent salt accumulation. The percentage of water applied that must leach through the soil to maintain the drainage water at the bottom of the root zone can be calculated. According to the equation proposed by the U.S. Salinity Laboratory (1953)[12]:-

$LR = \frac{Ddw}{Diw} 100 = \frac{ECiw}{ECdw} 100$ in which LR is the "leaching requirement" expressed in percentage of the water applied that must leach through the soil; Diw is the depth of irrigation water applied in inches; Ddw is the depth, in inches, of drainage water leaving the soil; ECiw is the electrical conductivity of the irrigation water; and ECdw is the average electrical conductivity of the drainage water leaving the bottom of the root zone. ECiw and

ECdw must be expressed in the same units. In applying the equation, a value is usually assumed for ECdw to represent the maximum soil salinity that can be tolerated.

If irrigation water has a conductivity of 2,800 micromhos and the maximum concentration of salts considered permissible in the soil solution is 4 millimhos, then the leaching requirement would be 2.8/4 x 100 = 70 percent. Hence, if an application of 100 mm. of water is required to replenish the soil moisture, by bringing it to field moisture capacity, a total of 170 mm. of water would be needed for proper leaching. It is notable that the leaching requirements for saline waters are usually high. From leaching practices by the farmers in the valley, it has been found that in the case of highly saline soils, 30 cm. of water for each 30 cm. depth of soil will usually provide enough leaching.

In an approximate form, the relationship existing between the salinity of soils and the quantity of water to be used for leaching out the salts might be shown by the following equation of Kovda[13] :-

$$Y = n^{400} x \pm 100$$

$$n = 0.5 - 2$$

In this equation, Y is the quantity of water to be used for leaching expressed in millimetres of depth of water; X is the average of salinity of the soil expressed in percent for the depth of 1-2 m. in this particular section of reclaimed field; n is the coefficient depending on the permeability of the soil and on the depth of occurrences as well as on the degree of salinity of groundwater in this particular section of the reclaimed field. On the average, the coefficient n is 0.5 - 2 ; for sandy soils 0.5 ; for loam 1 ; for clay 2 ; for deep-located ground-water 1 ; and for high located saline groundwater 2.

Applying this equation on profile 28 of loamy soils located on grid lines 145N-206E. in the valley, the quantity of water to be used for leaching salts will be as follows :-

$$Y = 1^{400} \times 3 \pm 100 = +103 \text{ mm. and } -97 \text{ mm.}$$

This result means that the depth of water must be 103 mm. over the surface of this soil and 97 mm. below the surface in order that the salts may be dissolved by leaching. It can be concluded also that the depth of leaching water must be higher in the case of clayey soils than in sandy soils.

Field observations show that soils have to be leached by one of two methods according to their salinity. Firstly, slightly to moderately saline soils can be leached by normal farming methods. The procedure is to have winter cropping with 20 percent over-irrigation and heavy pre-irrigation prior to the next crop. Secondly, strongly saline soils can be leached by basin flooding. The average depth of flooding must be 150 cm.; winter cropping must have 30 percent over-irrigation.

Chemical Amendments:- Alkali soils may be improved or reclaimed by the replacement of the harmful exchangeable sodium by beneficial calcium and magnesium. That is generally accomplished by the addition of chemical amendments, the kind and the amount depending upon the soil characteristic and the desired rate of replacement and economic considerations. Chemical amendments for the replacement of adsorbed sodium are of three types[14]: Soluble calcium salts (calcium chloride and gypsum); calcium salts of low solubility (limestone); and acids (sulphuric acid, sulphur, and iron and aluminium sulphate). Since the choice among these materials depends on availability, cost and soil conditions, it is important to know the chemical composition of both soils and irrigation water in order to use the prerequisite amounts of chemical amendments. Owing to the occurrence of sufficieint gypsum and limestone in the soils of the southern valley, the sodium hazard is only slight. Nevertheless, a potential hazard is present as a result of using saline well waters for irrigation. Therefore, it is worthwhile to determine the amount of gypsum which is necessary in some farm units. This amount depends on the amount of exchangeable sodium that is to be replaced and the proportion of this that can be obtained from natural sources such as irrigation water and gypsum already in the soil. If application rates are based on the assumption of 100 percent efficiency in replacement of sodium and on a soil depth of 30 cm., the following is a convenient formula[15] to use in estimating gypsum requirements (GR) in tons per acre-foot of soil.

$$GR = 1.7\ NaX$$

in which NaX represents the number of milliequivalents of exchangeable sodium to be replaced by calcium per 100 grams of soil.

Applying this formula on profile 26 located at gridlines 145N-206E in a saline-alkali soil, it is apparent that this soil contains 6 m.e. of adsorbed sodium per 100 grams, the cation exchange capacity is 16 m.e./100g. and the exchangeable sodium percentage is to be reduced to 10. Then NaX as used in the formula is

$GR = 1.7\ NaX = 1.7 \times 4.4 = 7.48$ tons/acre. The gypsum requirement is then equal to 7.48 tons per acre. As a general rule it is suggested that the gypsum requirement as estimated by equation be multiplied by 1.25 to allow for a 25 percent loss of calcium in the replacement reaction. It is notable that this profile contains 38 m.e. of gypsum per 100 grams in the upper 30 cm. of the soil. This amount can approximately meet the needs of gypsum requirement with little need for amendments. It is notable also that up to the present time, adding gypsum to the soils of the southern valley is very limited due to the fact that these soils contain as much gypsum and sulphur as is required for an adequate replacement of sodium during the leaching of salts. Most of the farmers use superphosphate as a fertilizer and amendment for the soil.

The rate of reaction of gypsum is limited only by its solubility, which is about 0.25 percent. Under field conditions, the application of 3 to 4 acre-feet of irrigation water is required to dissolve 4 or 5 tons of the high grade agricultural gypsum. Sulphur must first be oxidized to sulphuric acid by soil micro-organisms before it is available for reaction. In order to increase these micro-organisms which are beneficial also for the stability of the soil aggregates and the formation of good humus, farmers should manure the soils after leaching to increase the organic matter and micro-organisms. This is important since saline soils usually have poor biological activity. Most of the soils of the southern valley have coarse particle size; consequently, the rate at which limestones, as well as sulphur and gypsum, react in soil is slow. This reaction between acids and limestone leads to the release of soluble calcium which replaces the adsorbed sodium. Alkali soils should be leached immediately following the application of amendments since leaching dissolves the amendment and carries it downward.

<u>Management Practices</u>:-

Controls of salinity and alkalinity include selection of crops or crop varieties that will produce satisfactory yields under moderately saline conditions. Particular attention should be given to the salt tolerance of the crop during germination. Some crops that are salt-tolerant during later stages of growth are quite sensitive to salinity during germination. Among the highly tolerant crops are barley, sugarbeets, cotton, Bermuda grass, spinach, and tomatoes. Crops having low salt tolerance include radish, beans, clovers and most fruit trees.[16]

Certain irrigation practices may increase plant growth on saline soils in several ways. The water may be applied to keep the salt concentrations in the soil more dilute. Irrigation may bring about a partial leaching of salt to areas below the rooting zone. It may also reduce salt concentration from a limited zone around the furrow and provide a region favourable for the rooting of plants and for water absorption by them.

Careful levelling of land makes possible a more uniform application of water and better salinity control. Poor areas in otherwise productive fields often are high spots that do not receive enough water for good crop growth or for leaching purposes. Unless the soil is well drained, the application of irrigation water in considerable excess over that required for the crop and for leaching can be as detrimental as underirrigation. Overirrigation increases the amount of water that the drainage system must convey and leads to the rising of the watertable to an unsafe level. Seepage losses can be reduced by lining canals with cement. Shelter belts or hedges may reduce air movements and evaporation. Finally, the use of mineral fertilizers and organic manuring improves the soil structure by reducing capillary action.

Selected experimental works of reclamation.

Lower Jordan Valley:- Ravikovitch (1943)[17] had selected one of the worst areas, at the north end of the Dead Sea, to undertake his experimental works of reclaiming soils having salinity as high as 16.5 percent. The area was flooded for five to six months with an average application of 4000 m^3. of water per dunum. The salt residue was reduced greatly, mainly to gypsum, not considered injurious to crops. Soil structure was greatly improved, and the capacity for development of micro-organisms. The plots were planted to irrigated crops grown in rotation - for instance, potatoes and cucumbers, clover and African millet, tomatoes and maize, and lucerne. After four years the salt content had not increased to any extent, and crop yields were good.

Northern Part of the Nile Delta:-

Some of barren soils in the northern Nile Delta had been reclaimed since 1902 and many changes in the chemical properties of these soils have occurred as a result of reclamation and cultivation. Zeinel Abedine et al. (1965)[18] clarified these changes by investing ten profiles in five localities, one from a cultivated area and the other from an adjacent barren area. From the analytical results of seventy soil samples and ten groundwater samples, it became apparent that cultivation decreased the salt content in the crust from 8.19 millimhos/cm. (in soil extract 1:20) in barren soils to 0.58 millimhos/cm. in cultivated ones. Unlike the gradual decrease in salt content from surface downwards in barren profile layers, there is an accumulation at about 20 cm. below the soil surface in cultivated soil profiles, after which the salt content decreases until the watertable is reached. The removal of salts under cultivation without the addition of any amendment makes soils alkali. All values obtained for pH, ESP., and SP. are higher in cultivation profiles than in barren ones.

San Joaquin Valley (California):-

Kelley (1937)[19] initiated reclamation experiments in the San Joaquin Valley of California. The first procedure was to install drains to lower the watertable; the second, to treat the soil with experimental quantities of different soil amendments; and finally, to carry out a leaching procedure. This enabled the soil to be reduced in pH from 10 to 7.3. Sodium carbonate had been removed from the upper 60 cm. within a period of seven years. Kelley found that alkali soil at Fresno was improved simply by growing Bermuda grass (Cynodon dactylon) and irrigating frequently for two summers.

Erosion Potential.

Soil erosion is primarily the result of the removal of the soil's protective vegetation cover. Two main kinds of erosion can be distinguished in the Jordan Valley, the first caused by wind and the second caused by water.

Wind Erosion:- The wind erosion process has several major phases[20]: Initiation of movement of the soil and its transportation, sorting, abrasion, and deposition. Each phase is influenced by the condition of the air, the ground surface, and the soil. The movement begins with the most erodible grains on the most exposed positions of the surface.

Erodibility is influenced by the proportion, size, and bulk density of the erodible soil particles. It is convenient to relate erodibility with the equivalent diameter of the particles. The equivalent diameter[21] is equal to OD/2.65, in which O is the bulk density of the particles and D is their diameter. The most erodible soil particles are about 1 mm. in equivalent diameter.

A Monthly Climatic Factor for the wind erosion equation:-

Chepil et al. (1962) devised a means of computing an annual factor C_a^1 which represents the influence of wind velocity and surface soil moisture on wind erosion. This annual factor had been applied on selected stations, as mentioned in Chapter 4. Woodruff and Armbrust (1968)[22] have devised a method of computing a monthly wind erosion climatic factor which was calculated with the following equation:

$$C_m = 34.483 \frac{Vm^3}{(P-E)_a 2}$$

wherein C_m is the monthly wind erosion climatic factor, and V_m is the average monthly wind velocity. The annual precipitation-evaporation index was used because monthly precipitation to evaporation ratios did not give meaningful monthly climatic factors.

Furthermore, the Thornthwaite indices were not precise enough to evaluate soil moisture conditions for periods as short as one month.

Applying this equation on the valley, climatological data for the calendar year (1965) were chosen for the calculations. Table 7.2. shows monthly wind erodibility indices for selected stations in the valley.

It can be concluded that Deir Alla which represents the northern valley has a very low erodibility. Paradoxically, Jericho and Dead Sea North which represent the southern valley have indices ranging from intermediate to very high erodibility. Although Deir Alla has a very low annual index, some months such as December, January, and February have high indices; i.e., the highest wind erodibility occurs during these months as is shown in figs.7.4. and 7.5. Similarly, Jericho has an intermediate annual index, and monthly indices ranging from low erodibility in months of November, December, February, to very high in June and August. Dead Sea North has very high erodibility indices during all months of the year with maximum values in July and August.

Field observations show that wind erosion is one of the primary factors which impedes citrus cultivation in the Deir Alla area. It is believed that easterly winds, blowing on the area during winter at the front of each atmospheric depression, cause the fall of tree blossom. Wadi Zarqa represents a continuous corridor in which local east wind currents blow during winter as a result of a difference in pressure between the desert and the valley. On their confluence with the northern wind currents blowing through the valley during this season, the easterly wind currents cause such disturbances in the area that plants in blossom such as citrus, tomatoes and beans are damaged. Although the yield average of the valley from citrus is some 2 tons per dunum, the Deir Alla area yields on average only one ton per dunum. This is due to the fact

TABLE 7.2. Monthly wind erodibility indices for selected stations in the valley (1965).

Station	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual
Deir Alla	34.8	31.3	19	9.9	9.9	2.4	1.8	8	5.6	3	9.9	17.5	9.9
Jericho	44.3	33.7	39.8	44.3	82.1	157.7	118.1	198.9	78.7	39.8	31.8	31.8	65.8
Dead Sea North	558.9	396.5	536.6	680.1	654.6	654.6	760.5	706.2	514.8	453.1	414.8	433.7	558.9

that winds cause orange fruits to fall before they are mature.

In summer, the Deir Alla area is exposed to wind currents blowing from the south. Since the gradual elevation of the valley floor is from the south towards the north, currents have to ascend gradually towards Deir Alla; hence they will have not enough velocity to affect the plants.

Jericho and Dead Sea North are distinctive with their high erodibility indices all the year round. The peak of the wind erodibility occurs during summer for two reasons. Firstly, this area is influenced by the Dead Sea breezes of summer days which blow up the valley northwards as far as the confluence of River Zarqa with River Jordan. It was observed that the effect of these breezes is greater owing to the intense heating of the arid lands under the summer sun. Secondly, the area is affected by Mediterranean Sea breezes which reach it in the afternoon as a very dry and hot wind. The meeting of breezes causes disturbance and turbulence in the area. Gusts are always accompanied by dust which is evidence of wind erosion during this period of the year.

Field observations show that bananas grown in this area are of Cavendishi type which has a short stem and large broad leaves. Although the broad leaves are responsible for the greater portion of the evapo-transpiration, farmers prefer this type of bananas because it is more resistant to strong winds of the area than the taller varieties. It is a common observation in the area that any banana farm exposed to strong wind may lose some 50 percent of its crop.

Briefly, wind and water erosion potentials are highest during winter in the northern valley, whereas, generally, in the southern valley, wind is the dominant factor of erosion during the dry period of the year and water is the dominant factor during the wet period. Accordingly this difference in the values of erosion potential from one position to another and from certain time to another within the valley is of primary importance. These results should be taken into consideration when undertaking conservation measures.

It is worthwhile mentioning that Woodruff and Siddoway (1965)[23] have used a wind erosion equation at Midland, Texas by methods and techniques to estimate the potential average annual soil loss, to determine vegetative cover and width of strips needed to control erosion at a tolerable level.* It will be very useful in future to apply this equation on the valley when data are available.

Damages from wind erosion:- The effects of wind erosion are clear in the valley particularly the southern valley and the Katar lands. In the southern valley, there are ample areas of gravels and sands. Coarse soil textures are caused by the loss of fine soil fractions (silt, clay, and organic matter) which are gradually sorted from the sands and carried to distant places. The remaining sand of the southern valley often is much more erodible than was the original soil and its coarse fractions are infertile. Most of the Katar lands have wind eroded soilswhich have lost their A-horizons. On the other hand, wind erosion has played an important role in creating the hummocky terrain of the southern extremity of the valley.

Field observations show that tomatoes, which form the main crop in the valley, fail in some years due to the wind velocity which breaks the stems and drops the leaves. Fallen tomato fruit is sometimes seen scattered on the ground as a result of strong winds. In the Kufrein area, it was observed that some leaves of banana trees are dissected and wilted by winds. It was observed also that a recently cultivated grove of bananas includes trees having wilted leaves. After some discussions with its operator, it

* A tolerable loss depends on the crop, economic choice and soil reserves. Five tons per acre is an arbitrary value based on present knowledge of erosion effects.

it was understood that this grove takes some 3000 $m.^3$ of irrigation water per dunum, which is the required amount of water necessary for bananas in this area. In addition to the considerable irrigation water lost through deep percolation caused by present irrigation schedules, wilting is attributed to wind and insolation which increase evapo-transpiration and induce a limited supply of soil moisture. This is true when it is known that the banana plant under observation by the Irrigation Department(24) in Southern Shuneh showed in May 1955 a sudden decrease in the rate of evapo-transpiration following the burning up of the leaves caused by the dry and hot Khamsin winds. Dust storms, which are known to all inhabitants in the valley, are disagreeable and sometimes unbearable to the farm family.

Water Erosion:- The erosive actions of water are the effects of the energy developed by its movement in the form of rainfall or as runoff. Rain drops strike the soil from a vertical direction whereas flowing water moved horizontally over it. Water erosion is conditioned by factors of slope, soil type, landuse, and amount and intensity of rainfall.

Splash erosion is the first effect of a rainstorm upon the land. The falling drops gouge and splatter the exposed soil lifting it into the air and splash it back and forth. Erosive capacity of raindrops results from three factors: amount and intensity of rainfall, the diameter of the drops, and the velocity of the drops as they strike the soil.

Scour erosion, based on runoff, is the second erosive agent of the rain. The former, coupled with raindrop actions produces sheet erosion. The concentrated scouring action of the channelized flow causes rill and gully erosion.

Sheet erosion by water acts on broad expanses between the rills and gullies. Its effects are gradual and often go unnoticed until most of the top soil is removed. The main problem areas are the steep lands representing escarpments of the Ghor and the Zor where rainwater flows across unprotected ground. In this connection, the inherent erodibility of the soil itself is an important factor. The origin of colluvial deposits along the foot of the valley escarpment is primarily due to sheet erosion. They represent a lag-type deposit, which has travelled only a relatively short distance from the eastern side of the rift valley from which they were eroded and deposited when the flow becomes insufficient to transport them farther. In many places they are intermingled with materials from mass movement down the slopes. The alluvial fans of the side wadis are the result of sheet erosion where sudden changes occur in the transport capacity of their flow. The changes are usually associated with abrupt changes in the gradient of the streams descending to the Ghor. These fans include sediment of all textures, from clay and silt to coarse gravel.

The amount of sediment carried out of side wadis varies from one watershed to another. The ratio of sediment yield to gross erosion is the delivery rate. It was observed that the delivery rate of most of these watersheds was high because they are small, steep and highly channelized. More than one-half of the eroded materials from this type of watershed may be transported out towards the valley. Sheet erosion of the alluvial fans can be observed by the difference of soil textures within the same fan where coarse textures occur at the apex of the fan, while fine textures occur at the borders. Moreover, topographic changes occur upon the fan as a result of sediments piling in some channels forcing them to change their courses.

The annual floods of the River Jordan cause a strong and tremendous sheet erosion through its flood plain (Zor). It was observed that when the river inundates its valley, due to successive strong storms, its waters submerge the fields up to the Zor escarpment removing and sweeping out great amounts of material accumulated at the base of the slopes.

Gully erosion can be observed trenching some parts of the valley into the soft Lisan marl (fig.7.6). All side wadis cut deep gorges having numerous gullies and rills. Minor rills coalesce downslope of the Ghor and the Zor to form larger ones. They grow down slopes into larger channels. As the cutting and transporting proceed, rills grow into gullies too large to be crossed. Not only are large volumes of soil removed from the beds and walls of the channels and carried downstream, but the landscape itself is dissected and agricultural operations are impossible.

Over the ages gullies have developed through the process of geological erosion. They are part of the erosional cycle represented by the incised side wadis which cut deep gorges into the floor of the valley trying to adapt their beds with the River Jordan as their base level. It has already been mentioned that these side wadis have two breaks caused by the difference in the level between highlands and the Ghor from one hand, and between the Ghor and the Zor from the other hand. Accordingly, having still cut back their courses, side wadis represent a destructive factor in this cycle of erosion. Since each of these wadis is considered a base level of all attaching gullies, the same process is done by gullies which play the same role of side wadis towards the rills.

Field observations show that in areas with steeper slopes the A-horizon of the profiles are lacking completely and the C-horizon or even the underlaying marl is exposed to the surface. On the other hand, it was observed that the content of humus in the top of 10-cm. layer is absent from some parts of the area, whereas it amounts to some 2% in some others. Undoubtedly, gully erosion, with its sweeping process, causes a disturbance and unsettlement for the soils which become deprived of their surface horizon.

Estimating Potential Erosion:-

It has been already mentioned that erosion is one of the two basic problems facing the soils of the valley. This problem faces also arid zones in general and Jordan in particular. The lack of runoff measurements and of experimental data make it difficult to estimate potential erosion in the valley. The cost in tons of soil lost per year, if one were to wait for installing these measurements and the result of their methods of erosion prediction, would be too expensive.

Consequently, use must empirically be made of research done in developed countries since the universal soil loss equation enjoys a high degree of confidence. The Fournier (1960) equation,(25) "$\log.S.D. = 2.65 \log. \frac{p^2}{P} + 0.46 \log. \frac{H^2}{S} - 1.56$", was selected to be applied in the valley since it can be used for the semi arid zone, and for small watersheds of 100 to 200 $km.^2$ Fournier has correlated the rainfall-intensity of watersheds and their slopes in his equation to estimate potential erosion. Fournier has found that the river basins situated on semi-arid regions have orographic coefficient ($\overline{H}$.tga) + 6 and $\frac{p^2}{P}$ coefficient + 20. Paradoxically, those situated on sub-humid or humid regions have - 6 and -20 respectively. Specific degradation of some basins situated on semi arid middle latitudes has been found to be ranging from 243-853 $tons/km^2./yr.$, while those on semi arid subtropical range from 350-654 $tons/km^2./yr.$, those on subtropical and tropical climate range from 320 to 1400 according to rainfall seasons, and those on continental Mediterranean climate have 473 $tons/km^2./yr.$ Analysing the sediment-load values of more than 140 rivers in Europe, Asia, and the United States, he found a strong correlation between what he called specific degradation, or total annual erosion in metric tons per square kilometre, and a rainfall distribution coefficient

$C = \frac{p^2}{P}$ wherein p is the mean monthly rainfall in the wettest month of the year and P is the mean annual rainfall. On the other hand, a correlation was found also between this specific degradation and orographic coefficient $C_M = \bar{H}.tg\alpha$ wherein $\bar{H}$ is the mean height of the terrain above its base-level, and tgα is its massive coefficient $\frac{H}{S}$ of which $\bar{H}$ is the mean height of terrain above its base-level divided by its projected area S in square kilometres. In his final equation, Fournier found it necessary to add some constants as follows:-

$$\log. S.D. = 2.65 \log. \frac{p^2}{P} + 0.46 \log. \frac{H^2}{S} - 1.56$$

Applying this equation on the valley, data for each station were analysed as follows: altitude of the station above sea level, mean monthly rainfall in the wettest month, p in mm., mean annual rainfall P in mm., rainfall distribution coefficient $\frac{p^2}{P}$, orographic coefficient $\frac{H^2}{S}$ and specific degradation S.D. in tons per square kilometre per year.

The orographic coefficient was determined as follows. On a 1:250,000 contour map, a circle with a radius of 1.25 km. was established around each station, giving an area of approximately 100 km^2. The base level was read on the map. Mean altitude above this level was computed. This value H, was then squared and divided by the area 100 km^2. The appropriate equation of the Fournier series was then applied to obtain S.D., specific degradation. Table 7.3. gives the area corresponding to each range of values of S.D. plotted on the map in figure 7.7. and the respective percentages of the total.

It can be seen that the mean erosion value of the valley is 415 tons per square kilometre per year.*

* The mean erosion value of the northern valley is 443 tons/km^2./yr., and the southern valley is 358 tons/km^2./yr.

TABLE 7.3. Total erosion rates and areas in the valley.

Erosion (Tons/Km.^{2}/yr.)	Area (Km.^{2})	Percent of total area
300 - 350	130	20.8
350 - 400	243	38.9
400 - 450	18	2.9
450 - 500	135	21.6
+ 500	99	15.8
Total	625	100

This value ranges between 300 tons and more than 500 tons. Undoubtedly, the tendency of rainfall to be concentrated in relatively short periods during the year, the long gradual sloping of the valley floor, and its being the field of part of numerous watersheds, all these factors contribute in these high values of erosion. It is observed that the highest erosion rates are in the central part of the valley, particularly, the zone located between Ghor Damia south and Ghor Farah north. It can be assumed that where erosion values are low, the cost of conservation measures will also be low and restrictions upon land use will be less severe.

Comparing the valley with some other parts of the world, it becomes evident that erosion potential is a universal problem. According to Tsi An'[26], the erosion rate in the loessial province of China is 7 to 9 mm. a year. The mean annual rate in the Italian provinces of Emilia, Romania, and Marca ranges from 0.2 to 1.4 mm. a year. According to Burykin,[27] the Yakh-Su, Vakhsh, and Kzyl-Su Russian rivers which flow in the most arid southern zone of the Tadzhik republic, are the leading Central Asian rivers in erosion activity. Every year they erode (5104),(2609), and

(2502) metric tons/Km^2. of soil respectively. It is notable that watersheds of these rivers are located in mountainous regions with steep slopes. Therefore, they have values of erosion higher than the Jordan Valley and perhaps similar to those of mountainous watersheds of the side wadis.

Rainfall patterns at the various locations of the valley differ with respect to the distribution of erosive rains during the year. It is observable that about 60% of the year's erosive rainfall occurs during November, December, and January which are the first three months after seedbed preparations for winter crops. Moreover, the ground during this period is still bare or with limited cover. Undoubtedly conservation measures which afford the greatest possible protection during the seedbed period are very important in the valley. Compared with the valley, the South Central States of U.S.A.[28] have as much as 20 percent of their year's erosive rainfall during December, January, and February.

The quantity of soil eroded from a field depends to a large degree upon the kind of rainstorms and the extent to which the soil is protected at the time erosive storms occur. That this is true is evident from the large year to year differences in soil losses from fields on which the cropping system and management remain unchanged. No experimentation has yet been executed in the valley to show the real time in which erosion occurs. Nevertheless, according to the study of the rainfall data during the period of 1961-1967, it can be concluded that at the northern valley, 18 percent of the total soil loss occurred in 56 days of the seven years. Only 52 percent of the total rainfall occurred during those 56 days. At the southern valley, 9 percent of the total soil loss occurred in 21 days of the seven years. Only 38 percent of the total rainfall occurred during those 21 days.

Damage by water erosion:- Side wadis have developed pronounced alluvial fans as they enter the Ghor or the Zor. These fans keep spreading year after year causing damage to farmlands, canals, laterals ... etc., in their track. Damages to the main canal have resulted in insurance payments of J.D. 124,500 during 1960-1963.* The East Ghor Canal Authority reports expenditure of J.D. 10,000 during the period for maintenance of the main canal. Estimates prepared immediately after a single flash flood on 28.5.1963, showed that direct repair costs to stage 1 of the canal and road systems would cost J.D. 3,500. The overall loss in stage 1 of the East Ghor Canal project during the period from June 1960 up to June 1963, is estimated at J.D. 250,000.

Most of the side wadis are active torrents. During any sharp fall of rain, water appears in unexpectedly large volumes running towards the valley and carrying sediment-loads. These torrents differ from active with strongest movement of debris and silt, to relatively gentle with just an amplified movement of materials. Data of the quantity of sediment transport are absent. However, according to Godek[29] (1967), the transport of debris and alluvium of Wadi Sammu, one of the tributaries of Wadi Ziglab is estimated at 900 $m.^3$ annually, of which 85% is silt materials and 15% gravel and stone.

Deposition of erosional debris in the valley is one of the major damages. Fertile soils below upland slopes are often covered with the less productive fractions of the materials that are carried down by runoff. Crops are damaged by soil deposited on them by flood waters. In many parts of the northern valley, silt is injurious when it is derived from the subsoils of eroded areas and is deposited on the surface of its rather productive soils. In some

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* J.D. = £1.17

cases, silt accumulation may lower the permeability of soils and make irrigation more difficult. Nevertheless, the gradual accumulation of silt on the soils of the southern valley has a directly beneficial value. It adds appreciably to the productivity of the irrigated soils.

The soil properties change sharply depending on the degree of soil erosion. The severely eroded soil layer from 0-10 cm. contains 2-3 times less humus than the non-eroded soil. It has already been mentioned that the mean annual erosion of the valley is some 400 tons/Km^2., then with a content of 2% humus in eroded soil, 0.1% nitrogen, and 0.12% phosphorus, the annual losses from 1 Km^2. of ploughed land come to 8 tons of humus, 0.4 tons of nitrogen and 0.48 tons of phosphorus. Accordingly, it is not surprising to observe that the yield of winter wheat on very severely eroded soils decreases about 28 times the yield on non-eroded soils.

Measures for soil erosion control.

To maintain the productivity of the basic soil resources, it is necessary to hold soil erosion to a level where the formation of new soils from basic material at least balances soil loss. Increasing soil productivity as a result of its conservation induces increasing the income, which is the final goal. The valley has distinctly good agricultural potential. Retaining the soils in good condition necessitates execution of corrective measures of conservation. That the valley is attached with higher reaches of side wadi watersheds, should be considered when dealing with conservation. To help conservation works in either the valley or the watersheds, long term experimentation has to be done.

The Ministry of Agriculture has executed an important scheme of slope terracing and olive tree cultivation. The scheme is based on distributing young seedlings freely to the farmers on condition that they build stone terraces on the slopes of their fields. Consequently, the tremendous task achieved at present by local population in terracing the slopes has yielded very positive results. On the other hand, loans have been given to the farmers to meet the expenses of farm unit reclamation, particularly, levelling works of units and preparing them for irrigation. Those loans are part of the encouragement wages scheme, giving the right to any farmer, who is a member of Co-operative Society of the East Ghor Canal project area, to benefit from it. According to the scheme, in addition to the loans, J.D.2 are paid to the farmer for each farm including 1-10 dunums of alfalfa, clover, or hybrid corn. At present, 750 farm units in the northern valley are in need of reclamation. The scheme has allocated a sum of J.D. 75,000 for the process of reclamation and development with J.D.100 on average for each unit. The Land Development Division has helped farmers in levelling processes, opening and cleaning laterals, and protecting cultivated lands from River Jordan floods by erecting earth dams. It is notable that the southern valley has not benefited from any of the foregoing facilities given to the northern valley due to its location outside the East Ghor project area. A dam was constructed on Wadi Ziglab and two other dams are being constructed on Shueib and Kufrein Wadis. In addition to their advantage as water reservoirs, those dams protect the valley from continuous damages of side wadi floods.

The valley needs more development in future in the field of conservation. With the exception of the southern valley which needs urgent reclamation by the East Ghor Canal extension, the facilities given to the northern valley are not sufficient. Allocating farm units and delivering irrigation water should not be the final stage of work; perhaps it will be the beginning of hard work in levelling the unit and preparing it for receiving the water by lining canals and laterals. Farmers should be trained on the correct use of irrigation water. To protect soils from erosion caused by irrigation, the Development Division has planned for a continuous educational programme by which farmers can learn the new techniques of irrigation agriculture. This programme is based on two aspects: firstly, land development which is subdivided into farm development, extension, and research. Secondly, farm improvement which is subdivided into cooperation system and marketing.

Research should be considered, particularly that having a close connection with conservation measures. The valley is in need of experimental stations specialised in soil research in general and conservation research in particular. Cooperating with American experts, Jordanian experts have prepared three typical farm units in the valley at present in order that farmers may learn from them new techniques of irrigation and agriculture. Since these farms occur at Northern Shuneh, Tel el-Arba'in, and Deir Alla, it can be suggested that using them for conservation research will be very useful. More basic information concerning the water balance in particular can only be obtained by longer periods of instrumental measurement of soil moisture, evaporation rates, temperature, and stream flow. The precision of conservation work will depend on the future availability of such data.

The following are a few practices which need to be adopted to reduce the dangers of soil erosion.

Cover of Vegetation:- The valley was not always as bare of vegetation as it is today. Those parts of the valley which are situated within the Zor area were once covered by woodlands. Travellers* who visited Ajlun and Belqa highlands in the nineteenth

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* Some of those travellers such as Ritter (1866), Hull (1886), Buckingham (1821), Burckhardt (1848), Robinson (1865) and Huntington (1911).

century were struck by forests which gave the area a landscape similar to that in Central Europe. Today, however, most of the forests have disappeared; even scrub growth and grasses whose roots hold the soil together and prevent erosion, are no longer as dense as before. Overgrazing, tree-cutting for fuel by Turks during the First World War and by the local population since, and clearance of land for agricultural purposes, have led to the destruction of forests. One of the principal aims of the Forestry Department is to protect the natural forests, in addition to reafforestation of suitable areas and regulating pastoral zones according to scientific bases.

The Forestry Department has prepared different species of trees and shrubs in nurseries such as Zizyphus lotus, Rhetama rhetam a Acacia cyanophylla, to be sold at very cheap prices to the farmers. Similarly, in the higher reaches of the side wadi watersheds, elements of a Mediterranean vegetation have been sold. Those species are cultivated along the banks of canals in the valley as well as around plantations of citrus and bananas. Moreover, they are cultivated on the slopes of mountains to take part with terraces in a process of soil conservation.

There is a trend towards expansion in reafforestation of suitable areas in most of watersheds as part of the planning for conservation. Although the consequences of this long term policy will be the corner stone of valley protection from damages by side wadi floods, the valley is still in need of a vegetational policy based on the cultivation of trees and grasses in suitable areas, such as seeps and banks of canals and side wadis. Special care should be taken towards cultivating the River Jordan banks with trees of the same natural species, and cultivating the escarpment of the Zor with grasses. It may be pointed out, however, that protecting vegetation within side wadi catchments, and controlling overgrazing are necessary works. Conservation works in these watershed areas have become matters of great urgency in view of the fact that irrigation projects and land development works already executed in the valley are badly in need of protection against erosion and flood damage.

A vegetation cover helps to reduce runoff by breaking the fall of raindrops and reducing the pounding action on the soil which often tends to seal the surface. Cover also slows down the runoff water, each stem anchored in the soil acting as a miniature dam. This gives the water longer time in which to infiltrate into the soil. Each stem so anchored provides a channel into the soil through which rainwater can enter rapidly. According to Burnell Held and Clawson (1965),[30] soil is lost about 95 times as rapidly from clean tilled areas, as from corresponding areas with dense vegetation cover. According to Stepanov[31] (1966), raindrops cause practically no runoff of solid material when the soil is covered with vegetation to more than 60 percent area.

Cover Crops:- After the Palestinian influx to the valley and subsequent growing pressure of population on the land, all cultivable land in the area was brought into production. Instead of being farmed one year and left fallow for several years, land came to be cropped every year and irrigated land was often double-cropped. Execution of the first stage of the Yarmouk-Jordan Valley project has introduced intense irrigation agriculture. In 1965, the total cultivated area was 360,000 dunums in the whole of the Jordan Valley, whereas, total cropped area* was 380,000 dunums. This means that the 20,000 dunums which were fallow in the past have become cropped at present. Accordingly, the opportunity of soil protection from erosion is stronger now than before.

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* Cropped area is the acreage of cultivated crops during the year. In irrigated lands, cropped area is more than cultivated area since the land is cultivated with more than one crop; in non-irrigated land, it is vice-versa.

Completing the first stage of the Yarmouk-Jordan Valley project, the Government of Jordan decided to begin the second stage by extending the East Ghor Canal for 8 Km. and allocated a sum of J.D. 750,000 in the 1967 budget. Nevertheless, execution of great project of the Yarmouk-Jordan Valley, with its five stages, is vital and necessary to increase the area of cropped land and subsequently to have more intense cover of crops and more protected soil from erosion.

Planting of cover crops, either in strips or as solid plantings, can effectively control soil blowing. To protect young tender seedlings of banana or citrus plantations in the valley wheat or barley should be planted between rows of trees. Such resistant strips not only control soil movement, but they also protect the young plants from damage by hot, dry winds.

Analyses of the effect of landuse on the loss of soil at Pullman, Washington, indicate that cover is one of the most important elements that influence the amount of erosion. It also is one of the most variable. A plot that loses soil at the rate of 100 tons an acre under fallow might lose only 10 tons if it is planted to small grains, 2 tons if it is in good pasture, and less than 1 ton if it is in good forest cover.(32)

Strip Cropping:- This method is necessary in the valley to control wind erosion. It is based on a systematic alternate arrangement of erosion-susceptible and erosion-resistant crops in relatively narrow strips whose lengths run perpendicular to the direction of prevailing erosive winds. It is used extensively in wheat/fallow, wheat/sorghum/fallow and similar cropping systems in semi-arid areas in the U.S.A. and elsewhere. The major benefit, is, however, trapping of saltating soil particles and thereby controlling soil avalanching.

No experiments have been done in the valley to show the importance of strip cropping in protecting the soils from erosion.

It is rare to see strip cropping in the same farm. However, some neighbouring farms of small area represent a strip cropping particularly when they are elongated strips of different crops. Most farms are generally cultivated with one crop or two crops of the same resistance to erosion. It was observed in some new plantations of citrus or bananas that wheat or barley have been cultivated between the rows of young seedlings. In addition to its exploitation for land until trees can yield in future, this aspect is a means of soil protection. In fact, farmers need to know the great advantages obtained by implementing strip cropping in their farms. This knowledge cannot be realised without establishing plots of lands for this purpose in order that farmers may watch the useful results of adopting this measure of conservation. The results of experimental work may convince the farmers much more than the repeated advice of extension officers.

According to Drullinger and Schmidt(33)(1968), field experience in the Great Lakes Region shows that a strip of grain at least 2.1 m. wide with no more than 21 m. of open or cultivated land between strips is necessary to control soil movement. Skidmore et al.(34)(1966), have made experiments in Dalhart, Great Plains, to see the influence of row spacing and direction on wind erosion. The results showed that soil loss was reduced by narrow row spacing, high plant population, and rows perpendicular to wind direction. Nearly three times as much erosion occurred with wind blowing parallel as perpendicular to row direction. The combined advantage of narrow row spacing (52.5 cm.) and rows perpendicular to prevailing wind erosion on direction reduced soil loss from 55 to 29%.

Crop Rotation:- Since 15 years ago, crop rotation has not been known for most of the farmers in the valley. Lower yields of crops were only attributed to climatic factors or deficiency of manure. Realising the importance of crop rotation, the farmers began to implement 3 and 4 year rotation. It has already been mentioned that J.D.2 are paid to the farmer in the East Ghor project area for each farm including 1-10 dunums of alfalfa, clover, or hybrid corn. This procedure is aimed at encouraging farmers to use a crop rotation which maintains soil fertility and controls pests and diseases. Moreover, forage crops can also increase the amount of animal husbandry in the valley. Nevertheless, there are numerous farmers, particularly, at the southern valley, who continue to cultivate crops belonging to the Solanaeae family such as tomatoes, eggplants, potatoes. Although this sort of crop is highly profitable, it creates harmful consequences with time such as diseases and deficiency in organic matter inside exhausted soils. Field observations show that only these farmers do well, whose land is not used too long at a time for this kind of intensive cropping. A great number of farmers have found that their land shows signs of exhaustion and production figures are dropping with reference to the older parcels of land.

Wheat, fodder crops and a certain degree of fallow should be included in the cropping pattern, not only with a view to protecting soils from erosion, but also for controlling pests and supplying organic matter. Although the importance of crop rotation is known to planners of the valley, no experiment has yet been done up to now to show the index value of this factor.

On cropland, the rate of erosion varies with different crops and their sequence in the rotation. Measurements at American experimental stations have shown the relative amounts of soil losses from different crops in various rotations.[35] These are shown below in comparison to a standard 3-year rotation of row crop (R), spring grain (O) and hay (H) - that is, R-O-H has the index number of 100.

Rotation	Percentage of R-O-H
R - O - H	100
R - O	242
R - R - O - H - H	125
R - O - H - H	65
R - O - H - H - H	52

Indications from certain work show that the inclusion of crops such as lucerne or grasses does reduce erodibility. In Nebraska, U.S.A. for example, the inclusion of lucerne with sugar beets and potatoes in rotation or the application of manure reduced soil erodibility. Russian workers have observed that fallow and melon fields are the least resistant to erosion within the rotation.(36) Further, 3 years of using alfalfa on non-irrigated land rotation in Tadzhikistan increased the humus content of the ploughed layer by 0.2 to 0.3%, and in the irrigated southern regions of Central Asia by 0.4 to 0.5%.(37)

From these instances, it can be emphasised that crop rotation is very important to conserve the soil, and farmers should expand using this rotation in the valley.

Windbreak and Shelterbelts:- Windbreak plantings of adapted trees or shrubs, properly spaced, provide the most permanent protection. They represent an obstacle which obstructs the flow of the wind. A zone of shelter is created, mainly on the leeward side, but to a lesser extent on the windward side as well. The wind is abated over a distance equal to about forty times the height of the barrier, a quarter of the protected area being on the windward side and three-quarters down-wind of the barrier.(38) For instance, a nine metre high shelterbelt affects wind speed for ninety metres in front of the trees and 270 m. down-wind.

The direction of the winds has considerable influence on barrier effectiveness. The protected area has been found to be triangular in shape, and the protection varies with the length of the belt. This stresses the importance of long belts and of so orienting them that the most frequent and strong winds will be caught broadside.

No local experimental work has yet been done pertaining to the role of wind break and shelterbelts in conservation. However, Government nurseries contribute in supplying farmers with young seedlings at cheap prices. Orchards are already occasionally surrounded by shelterbelts of poplars, casuarinas or cypresses and it is anticipated that this practice will be extended also to vegetable farms in the future. The establishment of windbreaks for protection against hot and cold winds is necessary to safeguard a high production level. According to the Extension Agents, the valley was exposed in 1964 to a terrible wave of cold wind which caused damage to 4562 dunums of tomatoes, 72 dunums of beans, 2616 dunums of marrow (Kousa), 2587 dunums of eggplants, 610 dunums of potatoes, 532 dunums of green pepper, and 1987 dunums of bananas. Consequently, the Extension Service of Ministry of Agriculture allocated some 446,000 young seedlings of tomatoes to be given to harmed farmers of the valley as compensation.

Some farmers of the valley object to windbreaks, or even temporary barley strips, because land is taken out of cash crop production and water used for the growth of trees is regarded as lost to agriculture. Some others plant shelterbelts in some parts of a farm or in all its parts. Interviews with some of these farmers show that the yield of sheltered plantations of bananas and citrus increased some 30 and 20% respectively. It was observed also that the yield of trees near the shelterbelts was more than that of trees in the centre of plantation. This is due, of course, to the fact that shelter protects crop from hot, drying winds, and it reduces evaporation rates and fallen blossoms in trees.

Plate XIII.

Orchard of citrus irrigated by the East Ghor Canal and protected by a shelterbelt.

Plate XIV. A three-year old citrus plantation without shelterbelts or windbreaks.

Most of the vegetables in the valley and tomatoes in particular are in need of protection against damage by wind and water. The cost of windbreak planting, however, is low compared to the cost of replanting a crop such as tomatoes. Field observations show that most of farm units, in area 23 of Section III south of River Zarqa were exposed to damage of tomatoes by wind on December 1966. Procedures were taken to plough these farms immediately after the failure of the tomato crop and to replant them with wheat instead of tomatoes. The consequences were a loss in income from tomatoes, and obtaining very few grains from wheat farming which was too late. It was observed also that a bean crop is seldom cultivated in this area due to the falling of its blossoms by wind. This means that the area is deprived of a leguminous cash crop which is also beneficial to the soil as a source of humus and nitrogen and to the crop rotation.

Crop Residue Management:- Residues of crops following harvest continue to protect the soil against wind erosion, just as does the growing crop. Such residues, if properly managed, can provide excellent control during periods between crops. The relative effectiveness of different kinds of crop residue for erosion control has not been evaluated by experimental work in the valley. However, experimentation in the U.S.A. indicates that finer textured ones, such as the small grains, afford greater protection than equal quantities of coarse stalked crops, such as sorghum or maize.

Crop residues were not known in the valley 15 years ago. Nevertheless, as a result of using recent harvesting tractors, it became possible to leave crop residues on fields during early summer. Undoubtedly, these residues are very beneficial for soils as a source of humus in addition to their protection for the soil against wind erosion. It has already been mentioned that a hazardous period of wind erosion in the southern valley occurs during summer. Accordingly, these residues are very important for the valley in general and the southern valley in particular. Unfortunately, as soon as the grain crops have been harvested there is very little stubble left by the goats, sheep and camels which feed off it. Therefore, a more intensive system of animal husbandry is needed and a change from the attitude prevalent in many areas where it is thought that domestic animals only require what is left of crop residues and a little barley.

No data can be obtained to show the benefits of crop residues in the valley. However, American workers have elucidated the correlation between wind erosion and different tillage practices in Ohio (1966) as is shown in the following table[39]:-

TABLE 7.4. Wind erosion and maize yields with different tillage practices. Ohio, 1966.

Tillage treatment	Crop residue cover		Wind erosion Tons/acre	Maize stand Plant/acre	Corn yield Bushel/acre
	% cover	Pounds/acre			
Ploughed	0	0	130	16,700	73
Strip-tillage	30	3500	-	16,300	102
No-tillage	67	7800	2	19,100	116

Source:- Jour.Soil.Wat.Cons. March-April (1968).

The control of erosion along irrigation channels:-

The farmers in the valley base their selection of a method of irrigation on relative costs without consideration to the importance or necessity of any of them to their farms. Since it is known in the valley that the surface methods of irrigation are generally cheaper than sprinklers and channels are cheaper than asbestos-cement pipes in the same surface method, irrigation channels are implemented at present time. The Natural Resources Authority lays stress upon irrigation in the valley, and continues its work in construction, completion, and protection of irrigation projects. Some J.D. 70,000 were allocated for casing of laterals, levelling, and drainage in budget of 1967.

Field observations show that serious erosion damage has been done by the flow of irrigation water in earth channels. Each westerly flowing irrigation channel ends in a deeper erosion gully at least 200 m. before it reaches the Katar. Moreover, all lateral channels have developed into such erosion gullies that valuable soil is washed into the Dead Sea. On the other hand, the principal channels, either those taking their waters from the perennial streams of side wadis or those taking their waters from the East Ghor Canal, are concrete-lined. However, some of them such as the irrigation channel which runs along the road south of Muaddivillage at a high elevation, are apt to formation of very deep gullies due to dam breaks. In such cases, it is necessary to enlargen the concrete area at sites of the dam breaks where the outlets of these channels begin.

Lateral earth channels are affected by topography and soil type. At Deir Alla area, it was observed that the slopes of the fields when accompanied by large amounts of waters in earth channels cause rill erosion particularly in parts of channels which do not coincide with contour lines of the fields. With regard to soil type, it has been forementioned that the structure of the soil helps in increasing erosion by sealing the soil surface. In such a case, the water is forced to erode the sides of channels and the course of water becomes so extended upon a broad bed that it is exposed to more evaporation; subsequently, its volume will be less. Occasionally, eroded sides of channels cause uprooting of tomato seedlings as observed in the Kufrein area.

Plate XV. Crop residues are one of the measures controlling soil erosion.

Plate XVI. Lining operations on laterals.

The lining with concrete of these channels will be very advantageous. Maintenance of the outlets of channels and preventing the danger of their undermining are urgently needed. Modern irrigation practices of less water consuming methods should be considered. Channels should be lined along the contour lines; grasses and some trees should be cultivated along them to prevent erosion and evaporation hazards.

Gullies and Flood Control:- In order to protect water behind the dams from silt and sedimentation, side wadis watershed management will be necessary. The immediate requirements are to arrest erosion processes in the watershed areas and prevent movement of the debris and silt material down the Ghor. A first stage of the requisite works has been implemented by the Forestry Department since 1964. This work is due to be completed in 1968. As part of such work, in the Wadi Sammu catchment itself, 36 gully plugs have been constructed. The Government allocated a sum of J.D. 150,000 in 1967 budget for maintenance and flood protection of the East Ghor Canal including a distribution system in Wadi Ziglab dam area.

To prevent the valley from flood dangers, all side wadi catchments should be managed as the Wadi Sammu catchment. Floods of big gullies and tributaries of side wadis can be controlled by erecting numerous debris dams along their courses in order to decrease sediment movement. For instance, a detailed demonstration programme of torrent training works in Wadi Sammu has been designed to decrease this sediment movement to 300 m^3. of silty material instead of 900 m^3. of debris and alluvium transported annually. This programme includes a proposal to construct of five debris dams. As regard the side wadis themselves, a repeated suggestion to build dams on their entrance to the Ghor should be stressed.

One of the simplest and cheapest ways, to arrest the advance of small to medium-sized gullies having small drainage areas in the valley, is to fence them, exclude livestock, and revegetate them by grass, shrubs, or trees used separately or in combination. Cedar, poplar, and willow trees can be suggested because of their adaptation to the area.

Terracing and Contouring:- Terraces help control erosion by reducing the length of slope over which runoff water has a chance to pick up speed and erosive power. Terracing is important in the hills located along the side wadis. After terraces have been constructed, cultivation must continue on the contour. Up to the present, all of terracing and contouring works have been individual schemes with the exception of Wadi Sammu catchment management where 2700 dunums of cultivated lands have been covered with contour ridges. It is essential that other catchments of the side wadis will be managed in future as Wadi Sammu catchment and under the control of Forestry Department.

Field studies on many farms show, by comparing contour lines on the 1:10,000 map with the disposition of ploughing lines in fields, that there is no coincidence between them. Since the ground of the valley is distinguished with a long gradual sloping, it appears as such a level ground that ploughing is done in every direction. Most of times, down slope ploughing is so common, that the soils are attacked by sheet erosion. To be able to plough and plant on the contour, a farmer needs one or more key contour lines marked on each field.

At present, the method of dry reservoirs, recommended by F.G. Kisriyev, has been developed and introduced in Dagestan.(40) According to this method the terraces on gentle slopes are replaced by log barrier water-collecting basins for directing water in furrows for accumulating water and protecting soil from erosion.

Plate XVII. Terracing slopes protects the soil of this farm as well as the Jordan Valley.

Plate XVIII. Extension Agents at work in the project area.

Conclusion :-

The valley has a combination of physical and human factors which make the problems of soil serious. Unless measures of conservation are introduced to tackle these problems, land deterioration and agricultural decline will inevitably ensue. At present, there are 70,000 dunums of saline soils in the valley requiring leaching of salts before a satisfactory degree of crop production can be expected. Results of the experiments conducted by Baker-Harza (1955) showed that salts can be leached from the soil. Nevertheless, leaching work is very limited due to the fact that most of saline soils occur in the southern valley which suffers from a deficiency of water.

The erosion problem in the valley needs to be tackled by both farmers and Extension Services. Experimentation should be done to reveal the extent of erosion aspects and the proper means of controlling them. Proper farm management is prerequisite in order that damage from runoff and floods is held at the lowest point practical. The valley has seen an agricultural development as a result of introducing intense irrigation agriculture. Some difficulties undoubtedly occur due to the fact that farmers have not yet got accustomed to the new techniques of irrigation. Interviews with some 750 farmers, in the East Ghor project area, showed that 30 percent of the farmers always irrigate their farms (full irrigation) with little experience in irrigation agriculture; 40 percent of them irrigate occasionally their farms (partial irrigation) without experience in irrigation agriculture; and 30 percent irrigate for the first time without experience in irrigation agriculture and most of their experience is concentrated on the dry farming.

Field observations show that farmers without the help of the Authority could not undertake reclamation and development of their farm units allocated to them in the project area. In fact, some of the farm units are still invalid for agriculture due to their saline soil or to their need of levelling. For instance, there are still some 45,750 dunums in the northern valley which need levelling before a satisfactory degree of irrigation agriculture can be expected. The amount of earth-moving varies from 40 to 200 m^3/dunum. These procedures should be considered by Farm Development Division in the Ministry of Agriculture.

Much of the success for any conservation scheme will undoubtedly depend on full co-operation with the Extension Service of the Ministry of Agriculture. The help of agricultural field officers in hastening and easing the various changes will be a pre-requisite for their success. According to Extension Agents, the total annual average of their activities in the project area of the valley is as follows: 3600 visits to the farm units, 230 shows undertaken before farmers to elucidate the new techniques in controlling the pests and using chemical manures, new machines and selected seeds, and 90 meetings held with farmers and co-operative agricultural societies to discuss the problems of agriculture and the measures of tackling these problems. Comparing the number of farm units in the project area (3435 farm units) with that of visits (3600 visits), it becomes apparent that the share of each farm from the visits of Extension Agents is about one visit per year. This point emphasises the fact that farmers still ignore the new techniques of intense irrigation.

The farmers are often mistaken about the causes of poor yields: insects are confused with rust and over-irrigation is confused with a shortage of water. Such confusion between the causes of crop failures leads to harmful consequences in the case of implementing remedies. It is the responsibility of Extension Agents who must let the farmers know what are the real causes of failure and what are the known remedies. The farmers of the project area claim that Extension Agents have not enough experience in irrigation agriculture services; moreover, Agents do not stay a long period in the valley, and as soon as they gain the practical experience in this irrigated area, they are transferred to another part of the Jordan. The best way is to appoint specialised Agents with practical experience in management of irrigated farms and to let them stay as long a period as possible in the valley. Practical experience and long stay are the most important factors of creating the conviction and credit of the farmers in the importance of Agents.

On the other hand, questionnaires answered by 50 farmers at Ghor Nimrin in the southern valley showed that 50 percent of them did not meet any Extension Agent during 1966; 20 percent met them just one time without learning any new techniques; and 30 percent met them two times and learnt some methods of controlling diseases.

Briefly, co-operation between the farmers and Extension Agents should be increased and be more positive. To get the credit of farmers, Agents should not depend on theoretical advice. Taking two samples of soil and water of any farm and analysing them at experimental station of Deir Alla to know the real problems of a farm, is a vital work on which the connection between the farmers and Agents must be based to strengthen this credit.

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Chapter 8.

HISTORICAL LAND USE.

Land Use Pre 1950.

Along the entire length of the Jordan Valley, ruins of pre-historic settlements can be seen represented by scattered hills (Tells), e.g. Tell Deir-Alla and Telleilat el Ghasul[1]. The valley was the first and oldest place to be settled in ancient times. In the nineteenth century B.C., it was so prosperous that Lot had settled in it with his tribe. Jericho which is the oldest settlement is 8970 years old.[2] It is noteworthy that the valley has seen successive periods of prosperity and deterioration. The Roman era (2000 years ago) represents the period of prosperity where cultivated area was ample due to use of good irrigation methods (fig.8.1). Some of these ancient works have been discovered and restored to use. During the Roman rule, a canal had been constructed in the same site of the present East Ghor Canal to irrigate the lands of the valley from the Yarmouk River. In addition "fuquaras" were underground canals which were used to develop and carry the water to gravity canals called "Kanats" . Topography played an important part in locating the fuquaras which started near the foothills and extended toward the valley. At present, it is the fuquara part of the system that has created the drainage problems. The static head created by waters from the artesian aquifer has proved to be the source of water causing high water tables in many areas where fuquaras have been blocked, particularly in the southern valley.

The valley was watered by side streams particularly the River Zarqa which reached the Jordan at Adam city (Tell Damia); along its course were small cities such as Succoth (Tell Deir Alla), Zarethan (probably Tell Umm Hamad) and farther to the east Penuel and Mahanaim (eastern and western Tellul edh-Dhahab).[3] North of Succoth was Zaphon (probably Tell-es-Sa'idiyeh) on the Wadi Kufrinja. Still farther north, on Wadi Malawi, was ancient Pehel, the Pella of the Decapolis. There were other mounds, situated on the various smaller rivers, like Yabis, without names. South of the River Zarqa were Beth-nimrah (Tell Shunet Nimrin) on the waters of Nimrin (Wadi Nimrin or Shueib), Abel-shittim (near Kufrein) on Wadi Kufrein, Beth-haram (Rameh) on Wadi Rameh, and, near the Dead Sea, Beth-jeshimoth (near Sweimeh) on Wadi Azeimeh. The region around these latter is called "the plains of Moab".

The valley was famed, throughout the ancient world, for its maize, dates, balsam, flax and other products.[4] The clay of the valley was good for moulding. Between the Yarmouk and Pella, sufficient streams had broken from Gilead (Ajlun) to irrigate the whole region; the remains of ancient aqueducts are still visible today.

In the centuries after the division of the Roman Empire, there was a general deterioration of agriculture, interrupted only by brief periods of recovery under the Umayyad and Abbasid Caliphs. Gradually, the irrigation works of the Romans fell into disrepair and silted up; some were completely abandoned. The area under cultivation shrank with the disappearance of most towns and villages. A semi-nomadic type of farming replaced the settled agriculture. Tristram[5] who travelled in Palestine in the years 1863-64, speaks of the utter absence of villages. He adds saying that even a few years before his visit to Palestine the lands of the Jordan Valley were in possession of the farmers (Fellaheen)* themselves and were used for the most part for

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* Fellaheen are the villagers who settle in the area and till the land.

the cultivation of maize, but at the time of his tour they were already under the control of the tribe of Sukhour el-Ghor, and all agricultural work had ceased except in a few plots of land which were left to be tilled by the slaves of the tribe. In this valley, two powerful tribes of the Bedou* were in control, the Beni Sakhr and the Beni Hassan. The Beni Sakhr used to destroy the villages of the Fellaheen and turn their crop lands into pasture. In the areas which were not seized by the Bedou, the land became the property of any one who occupied it and tilled it in any sort of fashion.

By the end of Turkish rule there were signs of an agricultural revival. This was based to some extent on the tribes which had been occupying the area for some centuries in addition to an influx of new tribes from neighbouring regions. To the tribes already claiming parts of the area as their land, (fig.8.2), such as the Beni Sakhr and the Ghazzawiyeh, were added the Bashatwah, the Balawineh, the Ghabbad, and the Dayyat, as well as others.(6) In 1874, a group of Turkomans arrived from Turkey and were later given land in the valley. Conditions were not wholly favourable, however, for a large scale development of agriculture. The Turkish system of taxation, based on tax-farming, was scarcely an incentive. Irrigation works were neglected; title was not granted to land and indeed large tracts, as Baqoura, Ghor Farah, and Ghor el-Arba'in, were all state domain. The whole area including the present villages of Ghor Balawineh, Deir Alla, Tawal, and Ghor Damia-Al Shaqaq, was waqf property,** though by the end of Turkish rule dues were no longer collected. Water rights were not clear and were claimed by force. As a result, the development in this period was limited. Yet certain areas came to be known as the preserve of certain tribes and claims to water, though sometimes disputed, were made and often enforced.

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* Bedou are the unsettled people who wander with their animals towards grasses and water.

**The revenues collected by the Government from these lands were appropriated to religious or charitable institutions.

In 1929, the Government of Transjordan had taken further steps towards development when the law for the disposal of State Lands was enacted. This law gave authority to the Executive Council of the Government or to the Director of Lands to sell State Domains. In 1930, there were four cases in which Fellaheen instituted claims to the ownership of State Lands.(7) In that year, an agreement was concluded concerning an area of 6,673 dunums in the valley, the state ownership of which had been disputed since 1920. The Fellaheen admitted the Government's title to the land, and the land was transferred to them on payment of 300 mils* per dunum. In 1931, a dispute was settled regarding the ownership of an area of 108,153 dunums north of the Dead Sea. The Government agreed that the land should be transferred to the possession of the Odwan tribe which agreed to pay the registration fees over seven years. In the same year, 46,016 dunums were sold in Ghor el-Arba'in north of the land of the Odwan tribe, to the members of the Ghazzawiyeh tribe, who claimed ownership over 60,000 dunums, at a price of 300 mils per dunum, payable in ten annual instalments. The remaining stretch of 14,000 dunums was leased to neighbouring Fellaheen in return for a fixed rental, and it was agreed that the area should be sold to them if they could cultivate it adequately. A similar agreement was made with the tribe of Beni Sakhr-el Ghor, which was camping more to the north.

As regards the disposal of 57,000 dunums of irrigable land in the northern valley, it was bought by its cultivators, who had previously claimed ownership of it. In 1932, the land was partitioned among those of the cultivators who had agreed to pay a price of 430 mils per dunum. At the same time, in the years between 1928 and 1933, boundaries between villages were fixed by a land settlement programme which based its work on older and less well-defined

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* mil is the past term of fils which is a part of a piastre.

boundaries established in the previous century.[8] For the first time the rights of villages and tribes were clearly defined. As this measure was accompanied by some improvement in the enforcement of law and order, conditions were becoming more favourable to the spread of sedentary agriculture.

According to Ionides (1939),[9] distribution of the cultivated land of this period shows that most of settled and cultivated lands are confined to the northern valley. There was an isolated patch of cultivated lands located in the alluvial fans of Shueib-Kufrein Wadis, and seemed as an oasis in the desert. The valley covers an area of 605,840 dunums including about 364,084 dunums (60%) of cultivable land, and 241,756 dunums (40%) of non-cultivable lands. The last area was confined to salty and badlands. Major categories of landuse during this period are shown as follows. (fig.8.3).

TABLE 8.1. Major categories of land use in the valley, (1939).

Item	Area in Dunums.	Percentage of the total area of the valley.
Total area of the valley	605,840	100 %
Non-cultivable lands	241,756	40
Cultivable lands	364,084	60
Villages and gardens	9,500	1.56
Field crop cultivation	196,365	32.41
Orchards	3,635	0.59
Fallow	60,384	9.96
Rough grass land	60,200	9.93
Scrub and woodland	34,000	5.61
Total	364,084	60

Source:- Department of Lands and Surveys.

It can be seen that field crop cultivation and orchards, which were the cultivated area, occupied one third of the total area of the valley. Some 186,000 dunums (93 percent of the cultivated area) were irrigated.[10] (fig.8.4). However, about 75 percent of irrigated lands were partly irrigated. This point can be emphasised by the fact that the area of orchards which needed full irrigation was very small and limited, and the area of fallow land was large. Rough grass lands occupied some 10 percent of the total area of the valley, most of which were scattered in the southern valley and some small parts of the northern valley. Scrub and woodland covered some 5.6 percent of the valley, most of which extended along the River Jordan in the Zor.

Irrigated lands were almost dependent on the waters of Rivers Yarmouk and Zarqa, in addition to those of side wadis. It is estimated that some 30,000 dunums were irrigated from the waters of River Zarqa. Furthermore, more than half of irrigated lands in the northern valley were dependent on the waters of River Yarmouk and side wadis.

Under the existing system of irrigation great quantities of the available free-flow water supply were already absorbed; the methods used were, however, primitive and a very great percentage of the water had been running to waste. Moreover, with no accurate means of dividing the water and with crude earth channels, where the bank can easily be broken and the water diverted from the rightful owner, disagreement and dispute were common. It is notable that Ottoman legislation for using waters was still implemented during this period, under which the water from springs and streams was distributed in units of time called "Fasl"* and as a matter of fact, goes to the influential cultivator at the expense of his weaker neighbours. Consequently, the area of partly irrigated lands was three

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* Fasl is the local Arabic term meaning season.

times that of fully irrigated lands.

A relatively high percentage of untilled fallow land (Bur) occurs in the map of land use. Bur was the most extensive form of one crop farming, and consisted in leaving the ground entirely unploughed for one or perhaps several years between two crops of winter cereals. The purpose was to let the ground rest in order to render it capable of bearing cereals again; but land which remained untilled for a number of years was usually overgrown with a thick vegetation.

The principal field crops were cereals based on a two-year rotation of winter crops of wheat and barley and summer crops of millet or sesame, sown after repeated ploughing of winter fallow. In the central and southern valley, no summer crop was possible, and barley or wheat, alternating with fallow, was grown by a nomadic or semi-nomadic people who harvested the crop in the spring and then took their animals to graze on lands elsewhere. Although in the valley the per capita consumption of cereals was high, the yield exceeded the requirements of the inhabitants and considerable quantities of cereals were exported to Palestine, Syria, and Saudi Arabia.

Transjordan had to import vegetables from Syria up to 1930. A change happened after land settlement had taken place in the valley and it began not only to supply the country's own requirement, but also to export fresh vegetables to neighbouring countries. The area under vegetable cultivation in the valley was estimated in 1933 to comprise some 10,000 dunums of irrigated and 4,000 dunums of unirrigated land.(11) Tomatoes, eggplants, cabbages, cucumbers, marrows, and melons were the principal varieties. A first attempt made in the valley to grow potatoes on a commercial, other than subsistance, scale had succeeded with yields increasing between six and tenfold on previous returns.

Orchards of citrus and bananas were confined to small areas in the north and south of the valley. They proved to be successful in the valley due to their adaptability to the local climate. The banana crop was absorbed in the markets of Palestine. Reeds and canes of the woodlands in the Zor were used in the manufacture of mats and as roofs of mud huts or as poles of hair tents. Dead wood along the bank of the River Jordan yielded a sufficient supply of wood for utilization for fuel, charcoal burning.

Grasslands were used for grazing by animals of nomadic tribes. Following the seasonal pastoral round, tribes used to move in a transhumance into the hills in summer and back to the valley in winter. In dry years, grasses were so poor and rough that sown lands were exposed to attacks of Bedou animals overgrazing the unsuccessful crops. The raising of livestock was a major function of the nomadic tribes, beside their primitive agriculture. Camels were the principal means of conveyance, transport, and ploughing. Sheep and goats were cared for by inhabitants for their milk, meat, wool and hair. Primitive local dairy manufactures were based upon these animals. Moreover, movable houses of nomads, their luggage and dresses were made from the hair of animals. Exporting animals was a major source of income,(12) Transjordan exported 12,000 camels, and 39,000 goats in 1928 to Palestine.

Land Use during the period 1950-1960:-

It has already been mentioned that a development of agriculture occurred at the end of the last period of land use. During World War II, high prices and shortages of goods and of shipping encouraged the further expansion of the crop area. The pioneers of the post-war development of the valley were largely the Palestinian Refugees. Leaving Palestine in successive waves, some of them resided in the valley and took up farming.

According to UNRWA.,(13) some 85,885 Palestinian Refugees were living in the Jordan Valley in 1952; of these an estimated 29,833 lived in the eastern side of the valley. By 1953, those refugees in the Eastern Jordan Valley have grown to a total of 33,767 persons. Adding the number of original population, estimated at 13,500 persons, the total population is 47,267 persons. Refugees influx was so tremendous that it caused a pressure on the valley's resources. This is evident when calculating the shares of cultivated land per person of the original and refugee population; there were about 4 dunums of irrigated land and 7.5 dunums of non-irrigated land per person. Nevertheless, inhabitants of the valley seemed in better condition when compared with the whole of Jordan; according to the 1954 agricultural census, there was less than half a dunum of irrigated land and 6.5 dunums of non-irrigated land per person.

To alleviate the growing pressure of population on the land, new lands were cleared of brush and many thousands of dunums were opened up in the Zor, along the banks of River Jordan. Not only had areas under cultivation expanded horizontally, but they also expanded vertically. The refugees brought about changes which greatly increased the agricultural output of the valley. Instead of being farmed one year and left fallow for several years, land came to be cropped every year and irrigated land was often double cropped. New crops were also introduced into the cropping pattern.

This period saw the rise of tenant farming. Landowners became conscious of the rising value of their land as population grew and farms were made more productive; they were, therefore, seldom willing to sell their land to refugees who also had not money for the purchase. There arose in many cases a form of partnership between the landowner and the immigrant whereby the landowner supplied the land and often some of the factors of production, the tenant supplied the labour and whatever else was needed. With good management and development of the valley, crop surpluses became available, and agriculture changed from self-sufficient farming to an undertaking directed largely to the market. In 1953, the area under annual crops amounted to about 34 percent of the total area of the valley.

Aerial photographs of this period reflect the change of land use in the valley which can be seen in the following table.

TABLE 8.2. Major categories of land use (1953).

Item	Area in dunums	Percentage of the total area of the valley %	Item	Area in dunums	Percentage of the total area of the valley %
Villages and gardens	10,984	1.81	Fallow	60,000	9.90
Field crop cultivation	204,200	33.70	Rough grass land	54,690	9.02
Orchards	9,900	1.63	Scrub and woodland	24,310	4.01

Source:- 1) UNRWA. (1953), Agricultural economic survey, Jordan Valley.
2) Baker and Harza (1955), Yarmouk-Jordan Valley Project.

The total irrigated lands increased by 5.5 percent, from 186,000 dunums in 1939 to 196,312 dunums in 1960. It is notable that increase of irrigated lands was slow; whereas the irrigated area was 190,000 dunums (1953) at the beginning of this period, it reached to 196,312 dunums (1960) at its end. The slow increase is attributed to the fact that irrigation projects had not yet been executed in the area.

It can be concluded that the River Zarqa irrigated the largest area in the valley, followed by the River Jordan. On the other hand, the River Yarmouk and wells had a very limited contribution during this period, which can be considered a transitional period in which it was prepared to execute the East Ghor Canal Project and to expand digging new wells in the area. As with the previous period, partial irrigation still represented the dominant type of irrigation.

TABLE 8.3. Irrigated area (1960) by source of water.

Source of water	Dunums Irrigated		
	Full irrigation	Partial irrigation	Total
Stage 1 :-			
Yarmouk river	2655	475	3130
Jordan river	18329	1353	19682
Wadi Arab	524	12040	12564
" Ziglab	1507	11293	12800
" Jurum	1183	12260	13443
" Yabis	550	8062	8612
" Kufrinja	51	10365	10416
Zarqa river	4408	33038	37446
Wadi Rajib	8	8879	8887
Others	1115	13189	14304
Wells	270	189	459
Springs	437	10532	10532
Total all sources	31037	121675	152712
Stage II :-			
Shueib, Kufrein, Hisban Wadis	5000	20000	25000
Pumping from wells and River Jordan	15000	4000	19000
Total all sources	20000	24000	44000

Source:- 1) Dept. of Statistics (1961).

2) Harza Eng.Comp.Int. (1962).

The relatively unleached condition of soils in many irrigated areas further emphasised the fact that full irrigation was practiced on only a small part of the valley.

The increase of irrigated lands during this period was on the expense of grasses and woodlands which decreased some 16 percent of their former area. At this period, grasses and woodlands covered an area of 79,000 dunums which represented 13 percent of the total area of the valley (4% woodlands and 9% grasses). These scattered patches of scrub-type, brush and annual grasses were utilized for grazing purposes. The shrinkage of the area of grasses and woodlands was a principal factor in increasing also the non-irrigated cropped lands from 14,000 dunums at the past period to 24,000 dunums at this period. Some 9 percent of the valley area was left fallow per year. (figs.8.5. to 8.9).

Under the existing system of irrigation by which in many cases water was available in relatively large quantity for a short period of time with no regard for water intake rate of the soil or topographic features of the land, a degree of erosion takes place particularly at unlined field head ditches.

Perennial crops occupied only about 1.6 percent of the valley area. Most of the orchards consisted of bananas which are confined to areas where a reliable source of water was available. Citrus fruits were also produced in currently irrigated areas. Other fruits such as pomegranates, figs and grapes were found in small, scatteredplantings. The main productive fruit areas were located in the Adasiyeh and Southern Shuneh areas.

With regard to agricultural practices during the first five years of this period, it is to be noted that about half of the dry farming areas were sown annually while the other half was left fallow. In irrigated areas which were not used for fruit trees the land was partly planted with vegetables, partly with wheat or barley (winter crops) and partly with summer crops or left fallow (figs.8.10 and 8.11). Neighbouring fields, even when owned by different persons were generally planted with similar crops. Since most of the cultivated lands were partly irrigated, Harrawiya and Hamra villages

(Ghor el-Arba'in) were selected to represent the land use in the valley in 1954/55 in addition to the farmers' agricultural practices. Their land use maps (figs. 8.12 to 8.15) reflect the nature of dominant partly irrigated agriculture during this period. From these maps, it can be concluded that cereals constituted about 50 percent of the total crops grown on the irrigable area of those two villages. Wheat comprised more than three-fifths of this category, followed by barley with one-fifth. One reason of the large wheat planting was the country's heavy consumption of bread caused by catastrophic increase of population. The other principal reason is that the wheat with its taking advantage of winter rains and with its low consumptive use coefficient could save the limited irrigation water amounts to meet the needs of other crops of high consumptive use coefficient such as vegetables and fruit.

Vegetables and fruit occupied about 13 percent of the crop area. For the most part, vegetables were produced during summer. Tomatoes, watermelons and eggplants were the main vegetables, representing 70 percent of the total vegetable areas.

The survey made by the Department of Statistics in the agricultural year 1959/1960 (14) shows the use made of holdings in a total area of 207,941 dunums.* It was noted that almost the entire area of holdings was cropped. Only 6.7 percent of cultivable land was left fallow for the whole year, only 1.5 percent was classified as uncultivable, and some 91.8 percent as cultivated land. Out of this cultivated land, some 18.4 percent was classified as rain-cultivated, 58.5 percent as partly irrigated and 14.9 percent only as fully irrigated. No land in holdings was classified as permanent pasture or woodland, though some pasture was planted in permanent forage crops,

* The survey covered the Stage 1 of the East Ghor Irrigation Project which occupies all of the northern valley and the Ghor Damia-Al Shaqaq in the southern valley. The survey considered only land which formed part of holdings and not all land in the area. Land not owned or rented by farm operators have been omitted in this survey.

and small area was planted with trees grown as cash crops.

An extensive cropping pattern was generally dominant in the fifties and intensive agriculture was only possible in the small part of the cultivated area which received sufficient irrigation water. According to the agricultural survey of UNRWA.(1953), there were three types of farm. The vegetable farm was the most intense and profitable. It included fruit trees beside vegetables which were mainly summer crops. Farms of this type were concentrated in such a way that they could benefit from waters of the perennial side streams. The field crops farm was generally the least intense of all three farm types; it was mainly cultivated with winter cereals, but it could cultivate some summer crops such as sesame, sorghum and vegetables. Two or three crop rotation was undertaken, and considerable areas of cultivable land were left either fallow or idle in order to give rest for the land or because of water deficiency. The general farm yielded numerous crops and had more livestock. It was the least important farm of all the farm types which are shown in the following table:

TABLE 8.4. Farm types in the valley in 1953.

Farm type	Northern Valley		Southern Valley	
	Number of farms.	Percentage of farms %	Number of farms	Percentage of farms %
Vegetables	162	10	269	39
Field Crops	1249	77	400	58
General	211	13	20	3
Total	1622	100	689	100

Source:- 1) UNRWA., Agric.Econ.Survey in the Jordan Valley (1953).
2) Baker and Harza (1955), Vol.VIII.

It can be concluded that during the fifties, the field crop farm was the dominant farm in the valley, emphasising the fact that extensive and not intensive agriculture was common in the area. The general farm had the lowest percentages revealing that the mixed farming was little known.

Changing types of farming during the period 1950-1960:-

To elucidate the changes during the fifties in the cropping patterns, it is instructive to compare land use and crops in the years 1953 and 1960. These are shown in the following two tables:-

TABLE 8.5. Landuse in the valley - 1953.
Use of land in % of total cultivable area.

Item	Northern valley	Southern valley	Total valley
Irrigated Crops:-			
Wheat	37	17	27
Other cereals (barley, sorghum, maize, sesame).	26	5.5	16.
Tomatoes	1.5	3.5	2
Other vegetables and non-tree fruit.	10	4	7
Fruit trees	4.5	1	3
Total irrigated	79	31	55
Unirrigated Crops:-			
Cereals (wheat,barley,sorghum).	14	-	7
Vegetables and others.	-	-	-
Fallow, grazing, waste	7	69	38
Total unirrigated	21	69	45
Total	100	100	100
Total cultivable area in thousand dunums.	170	184	354

Source:- UNRWA., Agricultural Economic Survey, Jordan Valley,(1953), pp.7-8.

TABLE 8.6. Cropped areas in Stage 1 area (Project area including all of the northern valley plus Ghor Damia of the southern valley) - 1960.

Cropped area in percentage of cultivable area.

Crop	Cropped area in percentage of cultivable area.	Crop	Cropped area in percentage of cultivable area.
Irrigated crops*		Unirrigated crops	
Wheat	35	Cereals (wheat,barley)	18
Other cereals (maize, sesame)	10	Vegetables and others	1
Tomatoes	13	Fallow	7
Other vegetables and non-tree fruit	20	Total unirrigated	26
Fruit trees	6	Total	110
Total irrigated	84	Total cultivable area in thousand dunums	205

Source:- Department of Statistics, the East Jordan Valley, A social and economic survey, (1961).

* The cropping intensity of the irrigated area (cropped area over irrigated area), amounted to 110.

From these two tables, it can be concluded that the cropping patterns have changed since 1953 up to 1960. On both irrigated and rain-fed lands there seems to have been a distinct shift away from low-income crops to crops which yield higher returns. On irrigated lands, this was manifested in a reduction of the area given over to cereals, and an increase in the area given over to vegetables. Comparing figures of 1953 with those of 1960 in the northern valley,**

** It is the only part of the valley which is covered in the two surveys of 1953 and 1960, however, the areas covered do not correspond exactly.

it can be seen that the area planted in wheat has shrunk from 37 percent of cultivable land to 35 percent, while other cereals such as barley, sorghum, maize, sesame, have dropped from 26 to 10 percent. In place of these crops more irrigated vegetables and non-tree fruits are being grown; the proportion of land given over to these crops has increased greatly from 11 to 33 percent. Within this category the most striking increase has been that of tomatoes (from 1.5 to 13 percent), while the area given over to watermelons and certain minor vegetables has declined relatively. There has also been a very much smaller but important increase of 2 percent in the area of fruit trees.

On unirrigated lands, cereals in general and wheat in particular, have increased from 14 to 18 percent. Nevertheless, the area given over to barley and millet has declined. There also appear to be a number of new crops introduced into the cropping pattern such as lentils, vetch and vegetables. However, vegetables cover 1 percent only of the cultivable area; this area is very much smaller than that of vegetables on irrigated lands. Introduction of such new crops shows that a tendency towards implementation of crop rotation became stronger

Two basic factors are considered to interpret this clear shift of crops. Firstly, crop return played an important role in shifting from crops which, when sold, yield a relatively low return per dunum to crops which are more profitable. The production of the valley is thus becoming more sensitive to the needs of the market. Secondly, water was an orientation factor, the crops which yield the highest revenues are also the crops which require the most water. Therefore, on the irrigated area, vegetables increased at the expense of cereals, whereas, on unirrigated land, cereals covered the largest cultivated area due to their low consumptive use coefficient. Even on irrigated land, in spite of decreasing the area of cereals, they have still accounted for an area larger than that of vegetables. This is due to the fact that the amount of water which is available to the average dunum of land irrigated from the side wadis is in most areas insufficient for growing higher revenue crops such as fruit trees and vegetables. Moreover, cereals are necessary for the crop rotation and can bear the shortage of water more than vegetables.

Analysing crop yields of the years 1953 and 1960, one is struck by the fact that most of the yields of 1953 per dunum are higher than those of 1960 as is shown in table 8.7.

The less yield capacity of land in 1960 than that of 1953 emphasises the fact that the majority of irrigated land was still partly irrigated and greatly dependent on rainfall as an integrated source for irrigation. Although the area of cultivated land was in 1960 larger than that of 1953, the yield was lower. Up to 1960, the valley was seriously effected by rainfall fluctuations which not only affect the agricultural yield by making it unstabilised, but they also affect erratic irrigation sources which supplement the valley with water. The mean annual rainfall of the northern valley in the year 1952/53 was 372 mm. whereas in the year 1959/60, it was only 184 mm. In other words, since the rainfall amount of the dry year 1960 was less than 50 percent of that of the wet year 1953, it is therefore, naturally, reflected on the yields of these two years.

Livestock:- Animal husbandry and the raising of fowl have not developed to the same extent as the growing of crops. The number of farm operators owning animals is relatively small. According to 1960 survey, some 25 percent of farmers own goats, 16 percent own cattle, and 12 percent own sheep. In fact the total number of animals in the valley is greater, as some animals are owned by persons who are not farm operators, either permanent residents of the valley or grazers who bring their flocks to the valley at certain times of the year. The traditional transhumance of nomadic grazers has been disrupted by the appearance of national boundaries and of settled agriculture, and their movements no longer have the same regularity. Generally,

TABLE 8.7. Crop yields in kilograms per dunum and average revenue in J.D. in the northern valley (1953 and 1960).

Irrigated Land				Non-irrigated Land			
Crop	Yield 1953 Kg./Dunum	Yield 1960 Kg./Dunum	Average Revenue per dunum 1960 J.D.	Crop	Yield 1953 Kg./Dunum	Yield 1960 Kg./Dunum	Average Revenue per dunum 1960 J.D.
Wheat	90	49	1.610	Wheat	80	5	0.226
Barley	100	66	1.495	Barley	90	8	0.194
Sesame	60	28	1.707	Sesame	30	-	-
Tomatoes	620	557	9.804				
Eggplants	1000	983	10.900				
Watermelons	470	396	4.032				
Bananas	1300	1316	43.048				
Citrus	1300	435	13.801				

Source:- 1) UNRWA. (1953) and Baker-Harza (1955).
2) Dept. of Statistics (1961).

however, they appear in the valley in the winter and may remain until after harvests are in and stubble-grazing is finished. They are joined towards the harvest season by other animals from the uplands, often belonging to settled farmers, who bring their flocks to graze on stubble.

Forage crops for farm animals are practically non-existent and feed is obtained by herding on non-cropped land or waste land in a wet year until June. After harvest, animals can be grazed for several weeks on stubble. In dry years as 1960, when the crops fail, farmers cut their losses somewhat by letting animals onto the failed farms.

According to 1960 survey,[15] the greater part of the output of animal products is not sold, because it is necessary to meet the consumptive need of the farmers' families. Nevertheless, the gross income from animals and animal products was 5 percent of the gross income from crops.

Incomes of farmers:- Gross incomes from operating holdings were calculated from their components reported by farmers. According to the 1960 survey, these components fall into four broad categories: Firstly, income from the sale of crops represents 91 percent of the total income. Secondly, the sale of animals and animal products represents 5 percent. Thirdly, miscellaneous agricultural income represents 1 percent. And fourthly, the imputed value of wages and rents paid in kind represents 3 percent. The net income per dunum varies from village to another according to the sort of irrigation or rain-fed agriculture. It ranges from J.D. 7.435 per dunum in Adasiyeh village to J.D. 0.021 per dunum in Azziyeh village, averaging J.D. 2.242 for all villages. In the former village, the land is amply irrigated and much of it is planted in bananas; in the latter, almost all farming is rain-fed. It is notable that incomes in the dry year 1960 were lower than those of the wet year 1953. According to UNRWA. survey (1953), the net farm income in the valley was estimated at J.D. 4 per dunum on average.

Conclusion

The Jordan Valley has a long history of limited irrigation. However, it can be divided into two primary periods of land use during the period from 1901-1960. The first period includes the first half of this century; it can be subdivided into two secondary stages: the first stage is called the semi nomadic stage extending from the beginning of this century up to 1930; the second stage is called the settlement stage extending from 1930 up to 1950. The first stage, preceeded by a nomadic stage, was distinctive with a pastoral or animal economy, whereas, the second one was distinctive with a mixed type of a primitive agricultural and pastoral economy.

The second period includes the fifties of this century; in spite of its shortness, it can be subdivided into two secondary stages of land use: the first stage, including the first five years of the fifties, is called a subsistence agricultural stage; cereals are the principal cropping pattern in order to meet the food needs of population who increased greatly as a result of Palestinian influx into the area. The second stage, including the second half of the fifties, is called a market agricultural stage; the shift of cropping pattern towards vegetables and crops of high revenue was the dominant type of this stage.

The following chapter will deal with the present land use in the valley. The primary distinction between present and past land use, as it will be mentioned, is that the present land use, beside its market agricultural economy, is based on intense irrigation agriculture due to the execution of irrigation schemes in the valley.

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Chapter 9.

PRESENT LAND USE (1961-1967)

The valley has seen a progressive development during this period. The East Ghor Canal is the prominent aspect of the East Ghor Irrigation Project, and is regarded indeed as one of the primary development schemes in the country. It is designed in such a way that it can divert and hold all normal flow waters of Yarmouk River most of the year. It aims at exploiting the lands by intensive agriculture and expanding the irrigated agricultural area. The project aims at a redistribution of agricultural ownership in such a way that will suit intensive irrigated farming and the huge expenses it requires. It sets the maximum limit of ownership at 200 dunums, and the minimum at 30 dunums.

Work on the project, which is the first stage of the Yarmouk-Jordan Valley Project, started at the end of 1958. For execution, the project was carried out in three sections during a period of seven years, and work was accomplished by the end of 1965. Furthermore, two storage dams on Ziglab and Abu Ziad Wadis, together with the construction of ten earth dykes on side wadis were completed. Not only is the distinction between this period and the former period (1950-1960) observed in the expansion of irrigated areas, but it is also observed in the intensity of irrigation water use. For instance, the 120,000 dunums of present intense irrigation lands of the first stage of the East Ghor Project were classified, before construction of the East Ghor Canal, as follows:

Dry state domain lands : 30,000 dunums.

Dry private lands : 36,000 dunums.

Saki, i.e. partly irrigated land with annual effective area of only 1/5 to 1/4 compared to perennial irrigation : 54,000 dunums.

This Saki in terms of effective area under continuous irrigation means only about 13,500 dunums. Therefore, the actual effective increase is from 13,500 to 120,000 dunums or about 9 times or 900% increase.

In the southern valley, irrigated lands have expanded at the expense of rain-fed lands. This is due to the digging of numerous wells and exploiting their waters in irrigation. Most of these wells are concentrated on the lands which are too far from the lined irrigation channels of Shueib and Kufrein Wadis. Nonetheless, irrigation has not such an intensity as that of the northern valley. Most of the irrigated lands have such a partial irrigation that they resemble those of the northern valley before the construction of the East Ghor Canal. The projected extension of this canal in Stage II is pre-requisite for leaching the salty lands in the southern valley.

The total area of the valley is some 605,840 dunums, divided into arable lands (364,084 dunums) or (60%) and non-arable lands (241,756 dunums) or (40%). According to Baker-Harza,[1] arable lands are distributed in the valley as is shown in the table 9.1.

TABLE 9.1. Arable land in the valley.

Location	Arable land (in thousand dunums).	Location	Arable land (in thousand dunums).
Northern Valley		Southern Valley	
Ghor above main canal	42	Ghor above main canal	33
" below " "	115	" below " "	140
Zor " " "	18	Zor " " "	16
Total northern valley	175	Total southern valley	189
		Total area	364

Source: Baker and Harza (1955).

Allowing some 3 percent for roads, canals, etc. the total net arable land becomes about 354,000 dunums. Although the area cultivated under rain-fed conditions varies from year to year according to the rainfall fluctuations, the total cultivated area in the valley has shown a steady increase during the past 13 years. Whereas this area was some 214,000 dunums in 1953, it is some 248,000 dunums in 1966 i.e. the total cultivated area has increased 16 percent during 13 years. The increase is due to the increasing of irrigated areas, particularly during this period, and to the conversion of grazing lands into farming lands (fig.9.1). The eastern valley comprises some 65 percent of the cultivated lands in the whole of the Jordan Valley and some 1.6 percent of that of the whole of the country in 1966. When we know that the study area of the valley is 0.6 percent of the total area of Jordan, and its cultivated land is 1.6 percent of cultivated lands of Jordan, then, this point emphasises the fact that the valley is one of the main agricultural regions in Jordan.

The total irrigated area in the valley has increased from 190,000 dunums in 1953 to 233,000 dunums in 1966; i.e. the irrigated area has increased 23 percent during 13 years. (figs.9.2. and 9.3). Moreover, the increase of the total irrigated area, in the whole of the country during the same period, has been estimated at 130,000 dunums,* or 41 percent. The increase of 43,000 dunums in the valley represents more than half the increase in the whole country. The construction of the East Ghor Canal, the extension of irrigation from side wadis, and the increasing use of groundwater for irrigation, are the dominant factors in the expansion of irrigated area during this period. Comparing the figure of irrigated area in the valley with that

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* It has been estimated that the total irrigated area in the whole of Jordan increased from 320,000 dunums in 1953 to 450,000 dunums in 1966, while in the whole of Jordan Valley, the area in the same period increased from 230,000 dunums to 300,000 dunums.

of cultivated area, the difference is not more than 15,000 dunums. This means that there are some 15,000 dunums of rainfed lands. In fact, the real figure of rainfed lands ranges approximately from 25,000-35,000 dunums. It was observed that a lot of farms are classified as irrigated farms although they are watered just one time per year to help in growing the crops. These farms are cultivated mainly with wheat and are dependent mainly on rain because of water deficiency particularly in the southern valley. Field observations show that all of wheat and barley farms in Ghor Kebid are so far from the irrigation sources that they are dependent totally on rain.

Major Categories of Land Use.

The data for designing the land use map of this period were mainly recorded in the field with the help of the 1965 aerial photographs and are shown in table 9.2. (figs.9.4 to 9.7).

TABLE 9.2. Major categories of land use (1966).

Item	Area in dunums.	Percentage of the total area of the valley.
The total area of the valley	605,840	100
Arable Land	364,084	60
Field crop cultivation	226,856	37.44
Orchards	21,144	3.49
Fallow land	46,200	7.62
Rough grass-land	49,944	8.24
Woodland and scrub	8,956	1.47
Villages and gardens	10,984	1.81
Total	364,084	60

Source:- The 1965 aerial photographs and the field work information.

The area under annual crops amounts to about 37.4 percent of the valley. It is estimated that some 65 percent of the field crop cultivation occurs in the northern valley, and 35 percent in the southern valley. The East Ghor Canal has contributed in the expansion of the cultivated land in the northern valley and the introduction of intense irrigation agriculture. Field observations show that some parts of non-arable land have been cultivated after levelling the land. Farms of these lands are still unsuitable for cultivation since they have not yet been reached the optimum level of topography and they are deprived of the benefit of the East Ghor Canal according to the laws of the East Ghor Canal Authority. These farms are not suitable for crops according to land capability of this area. Afforestation of these lands can be suggested as the best use from the view point of economics and conservation. It is evident, as we shall see later, that planting these lands with tree species (Poplars) under irrigation is more profitable than crops of marginal agriculture. In the southern valley, marginal agriculture occurs as scattered patches of lands cultivated mainly with wheat and barley. Most of the salty lands are cultivated without taking sufficient quantities of irrigation water which must be used for leaching and watering the soils. Such areas are not cultivated as frequently as the main arable fields and are often allowed long fallow periods. It is estimated that some 46,200 dunums (7.6 percent of the total area of the valley) are left fallow to give rest for the soils during the crop rotation. In the valley, cropped lands occupy some 15,000 dunums more than cultivated lands. This increase has remained practically constant since 1953, emphasising the fact that some of the old farms are exhausted and need to be either left fallow or cultivated with one crop per year. Moreover, some farms still suffer from a shortage of irrigation water during summer months which is the critical time of crops. Such shortage of water is caused by the absence of storage dams on the Yarmouk River and other side wadi streams.

Perennial crops occupy about 3.5 percent (21,144 dunums) of the total area of the valley. Most of the orchards consist mainly of citrus and bananas. In addition to these, occasionally eucalyptus, pomegranate, and olive trees occur scattered in small areas. It is observed that the vast majority of orchards are concentrated in the northern valley, particularly in the area located between the Yarmouk River and Wadi Yabis. It is estimated that the northern valley occupies about 85% of the orchards of the valley, whereas only 15% of the orchards occur in the southern valley. This is due to the fact that orchards need plenty of waters which can be found in the northern valley. Although the orchards in the northern valley have increased some 137 percent from 1953 to 1967, the orchards in the southern valley have increased only 39 percent during the same period. Nevertheless, the expansion of orchards in the southern valley is more remarkable than that of the northern. This is clear when comparing the land use maps of 1959 and 1967. It can be seen that only very small patches of orchards were found in the map of 1959 in the southern valley, whereas considerable patches have occupied the northern valley in the same map.

Scrub and woodland cover small scattered patches in some parts of the banks of River Jordan which are not suited for agriculture or apt to river floods, particularly located inside the meanders of the river. Moreover, there is scrub still along the beds of dry small side wadis and in some patches north and north east of the Dead Sea particularly in areas of mud flats. Sebkhas, which are swampy salty lands, include some scrubs of halophytic vegetation especially Tamarix association which is scattered here and there on the borders. Since agriculture has expanded in this period, many areas which were covered with scrubs in the past have been converted to cultivated land. Woodland and scrub, thus defined, amount to 1.5 percent of the total area of the valley.

Rough grassland still covers a relatively large acreage and includes areas of very limited seasonal grazing. It includes places where badlands reduce the vegetation cover. However, a grass cover is also found in gravel lands of the Ghor particularly in the southern valley. Additional patches of grass are found between minor patches of cultivation in Ghor Kebid and Ghor Rameh, and on marginal land near Katar which is infrequently put under crops. As has been already mentioned, the grassland area has shrunk as a result of agricultural encroachment. However, it occupies about 8.2 percent (49,944 dunums) of the total area of the valley.

Most of the badlands are non-arable land. Nevertheless, parts of them located along side wadis, and some other parts in the northern valley are cultivated in a marginal agriculture. It is observed that some southern parts of badlands in the southern valley are completely devoid of any vegetation, while the remainder of them are covered with rough grass. The badlands, generally ,include screes and gullied areas where rapid erosion precludes soil development and plant growth.

Most of the important villages are situated on the main elongated road running along the eastern border of the Ghor. The villages with their gardens, the roads, and the canal with its channels and drains, all occupy about 3 percent of the arable land or 1.8 percent of the total area of the valley. Most of these villages have been founded since the beginning of this century, but they were farmsteads and small settlements up to 1948 when the Palestinians settled in the area and established new settlements in addition to these growing villages. Therefore, all of the present villages have been founded since 1950, with a distinctive difference in their population and growth in each of the two periods.

Present Cropping Pattern:- The data and information of the cropping pattern in the valley have been supplied by the Extension Agents, Irrigation Office of the East Ghor Canal Authority and field samples. The recent cropping pattern is shown in the following tables.

TABLE 9.3. Recent cropping patterns in the East Ghor Irrigation Project area (1966):-

Crop	Summer (July 1966)						Winter (December 1966)					
	Section I		Section II		Section III		Section I		Section II		Section III	
	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%
Cereals	3737	21.77	5715	38.39	54	1.05	5859	25.32	10615	44.17	9897	51.65
Vegetables	2375	13.84	3553	24.29	3469	67.67	6362	27.50	8040	33.45	5278	38.70
Citrus and Bananas	10576	61.63	5308	36.29	1603	31.27	10603	45.83	5279	21.96	1785	9.30
(Berseem)	106	0.61	-	-	-	-	234	1.01	82	0.34	-	-
Miscellaneous.	364	2.12	150	1.2	-	-	76	0.32	14	0.05	60	0.31

Source:- Irrigation Office of EGCA. and Extension Agents.

TABLE 9.4. Recent cropping patterns in the southern valley, south of the project area. (1965/66).

Crop	Winter (December 1965)						Summer (July 1966)					
	Ghor Kebid		Ghor Nimrin		Ghor Kufrein		Ghor Kebid		Ghor Nimrin		Ghor Kufrein	
	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%
Cereals	6100	24.29	5600	23.72	5100	29.98	300	13.36	265	8.43	140	11.72
Vegetables	18550	73.87	16100	68.20	11565	67.98	1485	66.17	970	30.89	708	59.29
Citrus and Bananas	459	1.82	1905	8.07	346	2.03	459	20.45	1905	60.66	346	28.97
				Ghor Rameh						Ghor Rameh		
Cereals					10,000	48.70					220	11.88
Vegetables					9917	48.29					1015	54.83
Citrus and Bananas					616	3					616	33.27

Source:- Ministry of Agriculture.

From these tables, it can be concluded that in winter the cereal percentage is the highest of all percentages of crop acreages in the project area, followed by vegetables, citrus and bananas. In the southern valley, vegetables have the highest acreage, followed by cereals, citrus and bananas. In summer, citrus and bananas have the highest acreage in the project area followed by maize and vegetables. In the southern valley, vegetables have the highest acreage, followed by citrus, bananas, and maize. In other words, the project area includes the highest acreages of cereals in winter and citrus and bananas in summer, whereas the southern valley includes the highest acreages of vegetables all round the year. It is worthwhile mentioning that berseem has a very low acreage of the project area, while it is rare in the southern valley. This point emphasises the forementioned fact that vegetables as a profitable cash crop in the southern valley dominate other crops to such an extent that crop rotation is neglected. Since cereals have the highest winter acreage in the project area, crop rotation is successful. The cooperation between the East Ghor Canal Authority and other Ministries has made the control and management of the project area so beneficial that it is reflected on the monthly cropping patterns. (figs.9.8. and 9.9).

The percentages of crop acreages differ from one section to another within the project area. It is notable that citrus and bananas have the highest percentages in Section 1 all round the year, since most of the orchards are concentrated in it. This section is the best part of the valley for cultivation of citrus and bananas. Northern Shuneh area can be considered as the belt of citrus and bananas growing inside Section 1 because it is characterised by level land with clay loam soils, a suitable climate with high temperatures and a medium amount of rainfall, and adequate irrigation water from Wadi Arab lined channels and from the East Ghor Canal. In addition to its superiority in orchards, Section 1 has also the highest percentage of berseem in all of the valley. Forage crops are cultivated in a crop rotation with cereals and vegetables in this section which is the first one to enjoy the benefits of irrigation from the East Ghor Canal, and benefits from the longest period of experience in irrigation agriculture.

Cereals have the primary place all round the year in the acreage of Section II. This point reflects the fact that cereals have still been keeping their importance in the valley in spite of their rivalry with other cash crops for the following reasons: Firstly, water requirements of cereals are less than other cash crops. Secondly, some farmers who have been accustomed to growing cereals are reluctant to rely on perishable crops, which require more attention, and, unlike cereals, cannot be stored or used by the farmer and his family. Thirdly, cereals are still necessary as substantial foodstuffs for the increasing population of the country and for animals; therefore, while cash crops face the problem of their marketing, cereals can easily be marketed. And fourthly, cereals are important for crop rotation which is necessary for the valley, particularly on exhausted soils.

Cereals also take first place in the winter acreage of Section III, whereas vegetables take this place in the summer acreage. It is noticeable that citrus and bananas have the least acreage of all the acreages in Section III. It has already been mentioned that citrus plantations are not successful in the Deir Alla area of this section because of its exposure to strong wind blowing. Accordingly, most of those plantations are found in the Zor area where they have a refuge and more protection than the Ghor area.

With regard to the distribution of crop acreages in the southern valley, it is observed that vegetables, generally, are most important during both winter and summer. Nevertheless, in summer, vegetables leave their place to be taken by citrus and bananas in Ghor Nimrin. On the other hand, in winter, cereals in Ghor Rameh have slightly higher acreage than that of vegetables. Vegetables percentage differs from one part to another within the southern valley; during winter, the percentage of vegetables decreases from the north, where it is in Ghor Kebid 74%, to the south where it is 48% in Ghor Rameh. On the contrary, cereals percentage increases from the north, where it is in Ghor Kebid, 24%, to the south where it is 49% in Ghor Rameh. This is due to the fact that the water requirement of vegetables is higher than that of cereals; accordingly, since Ghor Kebid - Ghor Nimrin area has higher amounts of annual rainfall and ground water than those of Ghor Kufrein - Ghor Rameh area, it is expected to observe this natural shift of vegetables towards north and cereals towards south. This phenomenon is clearer in winter than in summer since both of the two parts of the southern valley in summer depend on groundwater which has not the sharp difference of that of rainfall. The mean annual rainfall in the northern part of the southern valley is 200 mm.with an estimated water quantities of 23.2 mcm. pumped from wells annually; whereas those of the southern part are 100 mm. and 21.5 mcm. respectively.

Paradoxically, contradiction between the percentage acreage of cereals and vegetables is not found in the project area during winter. For instance, whereas the percentages of cereals and vegetables in Section II are 44 and 33 respectively, those of Section III are 51 and 38 respectively. This state of adaptation between crops and natural conditions is less in the project area than in the southern valley since the irrigation project has saved the crops in the area from the dangers of rainfall fluctuations. Inside the project area itself, one can observe that Section 1 differs from Sections II and III in the percentages of cereals and vegetables. It seems that orchards of citrus and bananas, in Section 1, affect the percentages of cereals and vegetables to such an extent that they are not given the chance to increase their acreage which is not much more than that of citrus and bananas.

Comparing the acreages of citrus and bananas in the valley during winter and summer, one is struck by the remarkable change in this percentage. It is clear that percentages of these permanent crops are higher in summer than in winter. This phenomenon of changeable percentages reflects the real image of other seasonal crops which have higher percentages in winter than in summer. It is known that the total acreage of crops during winter is more than that of crops during summer. The southern valley has not yet seen the execution of Stage II of the Yarmouk Jordan Valley Project; accordingly, about 90 percent of its cultivated lands are left fallow. The project area has its critical months, where deficiency of water occurs, during summer. This deficiency in irrigation water in addition to dependence of the southern valley on rainfall are the dominant factors in the remarkable shrinkage of crop acreage during summer.

Table 9.1 (App.9) shows the monthly cropping patterns in the project area in 1966; it is notable that the cereal acreage reaches its lowest value, in all the sections of the project area, in October when the land becomes semi vacant from summer cereals, as most of them are harvested in September. Similarly, since April and May are the harvesting months of winter cereals, the acreage of cereals becomes the lowest one after that of October. The winter cereal (mainly wheat) acreage increases gradually from November up to April, while the summer cereal (mainly maize) acreage increases from June up to September.

During the months of winter, the vegetable acreage begins to decrease, from October up to April, and from June up to July. The largest percentage of vegetables occurs during the period of August-September-October, when the percentage of summer cereals becomes lower. The Berseem acreage is generally low during all months, with its highest values in December and lowest ones in March.

Table 9.2. (App.9) shows detailed percentages of crop acreages in the three sections of the project area during winter

(December) and summer (July). It can be seen that, in Section 1, the wheat acreage is most important during winter, followed by bananas, citrus, eggplants (aubergine), cabbage and cauliflower. On the other hand, the banana acreage is the highest of all during summer, followed by citrus, maize, mallow (Muloukhiyeh) and eggplants. In Section II, the highest percentage of winter acreage is wheat followed by citrus, tomatoes, beans, cabbage and cauliflower; whereas that of summer acreage is maize followed by citrus, eggplants, bananas, and cucumbers. In Section III, the first winter crop is wheat followed by green peppers, eggplants, tomatoes and citrus; while in summer, cucumbers comes first, followed by citrus, green peppers, bananas and eggplants.

It is relevant to know that each of the project area sections includes a number of areas, and each of the areas includes a number of farm units. In order to show the acreage percentage of each crop within each area, the months of December and July have been selected from the monthly cropping pattern and the results are illustrated in fig.9.10.

Selected samples of the crop acreage in the project area:-

The Hamra and Harrawiya villages have been selected as a sample of the crop acreage in the fifties and sixties. In other words, these two villages of Ghor el-Arba'in in the northern valley illustrate the cropping pattern before and after execution of the East Ghor Canal Project.

The Hamra village is located in the Zor having an area of 8145 dunums (8.1 Km^2.). Its lands are bordered by the River Jordan on the west, the Qla'at village on the north and east, and the Harrawiya village on the south. Most of its lands are Class 1 land; however, there are two strips of Class VI land in the northern and south western parts of the village lands. Comparing the land use and the land classification maps of the village lands in 1954/55, one is struck by the fact that there is no coincidence between them. What happened was that the western strip of Class 1 land, located in the river meander, was an uncultivated area, and the two strips of Class VI land were cultivated.

Figures 8.14 and 8.15. show the land use map of the village lands in 1955 and 1966. Comparing the two maps, it becomes evident that a remarkable change occurred in the cropping pattern of 1955 as a result of execution of the East Ghor Irrigation Project. In 1966, all of the lands are cultivated in spite of the two strips of rough lands which have been reclaimed to some extent by levelling. Moreover, irrigation channels irrigate most of the village lands which have been designed and re-allocated to the farmers as blocks containing farm units adapted in their size with the class of the land. Accordingly, a change in the percentage of crop acreage is expected. The trend toward cash crops was induced by the introduction of irrigation agriculture. For instance, in 1955, the percentage of citrus, bananas, and vegetables was not more than 20 percent of the total area of the village lands. In 1966, those cash crops occupy more than 75 percent of the acreage, whereas the cereal percentage has dropped from 50 percent in 1955 to 24 percent in 1966. At present, most of the rough lands, which are in need of more levelling, are cultivated with cereals, particularly, the northern part of the village lands.

The Harrawiya village is located in the Zor, south of the Hamra village, having an area of 1861 dunums (1.8 Km^2.). Its lands are bordered by the River Jordan on the west, the Buseileh village on the east and south, and Wadi Ziglab on the north. The majority of its lands are composed of Class 1 lands; however, the southernmost part of these lands is of Class II lands, and the small strip of rough lands, near the confluence of Wadi Ziglab with the Jordan, is of Class VI land. In 1955, this strip of Class VI land was uncultivated; but in 1966, it was cultivated with the cereals as a marginal agriculture on the banks of Wadi Ziglab. On the other hand, citrus and banana orchards, which were not found in the cropping pattern of 1955, occupy in 1966 some 15 percent of the acreage. The area of vegetables has increased also to such an extent that it occupies in 1966, some 23 percent of the acreage. Cereals still account for the largest acreage (62%) with more dependence on irrigation waters from lateral channels.

Selected samples of the crop acreage in the southern valley:-

The Southern Shuneh and Kufrein villages have been selected as a sample of the crop pattern in the southern valley. Three strips of cultivated lands have been chosen for this purpose. The first two strips represent the cropping pattern in the Southern Shuneh area, extending along the road between Southern Shuneh and Mashrou village from one hand, and the road between Southern Shuneh and Dr.Sati farm on the other. The third strip represents the cropping pattern in Kufrein area, extending along the road between Dr.Sati farm and Kufrein village. The area covered by this field work lies on the alluvial fans of the Wadis Shueib and Kufrein, and is about 8.5 $Km.^2$, (8500 dunums). The crops have been plotted on two sheets of 1:10,000 scale, including the farm units of the two villages. Hence, two land use maps, representing the cropping pattern of the areas in April 1967 (winter crops), have been designed (figs.9.11 and 9.12). The categories of land use are shown in the following table.

It can be seen that the main crop in Southern Shuneh area is vegetables, of which tomatoes and eggplants are the dominant. Wheat and barley rank second after vegetables, followed by bananas and citrus. Field observations show that plots of vegetables are nearer to the irrigation channels than wheat plots due to the fact that vegetables need more water than wheat. Verifying the land classes of Southern Shuneh area, one can see all the classes from Class 1 up to Class VI. The correlation between those land classes and the crops is so clear that the lands of Class VI, located between the Mashrou village and the Zor, are not cultivated. Nevertheless, there is a small patch of Class VI land, located west of the middle of Southern Shuneh - Dr.Sati farm road,

TABLE 9.5. The categories of Land use of the villages Southern Shuneh and Kufrein in April 1967.

Item	Southern Shuneh area		Kufrein area	
	Area in dunums	Percentage of the total area	Area in dunums	percentage of the total area
Wheat	927	13.24	812	54.13
Winter Vegetables	1248	17.82	148	9.86
Bananas	642	9.17	138	9.20
Citrus	401	5.72	112	7.46
Dates	22	0.31	15	1.00
Fallow	3542	50.60	150	10.00
Villages and gardens	182	2.60	125	15.00
Miscellaneous	36	0.51	-	-
Total	7,000	100	1,500	100

Source:- Field work.

cultivated with crops. Other patches of Class VI lands, either west of this road or east of it in the foot hill area, are left fallow. Unless this small cultivated patch of Class VI land is near to the irrigation channels, it cannot be cultivated; the nearest parts of this patch to the channels are cultivated with vegetables, whereas other remote parts are either cultivated with wheat and barley or left fallow. The Class IV lands are known to have saline soils, and their cultivation is not expected without leaching. Therefore, the comparison between the land classification and land use maps of this area reveals that the Class IV lands, extended along the two sides of the Dr.Sati farm - Southern Shuneh road, where they can be leached and irrigated by the channels, these lands are cultivated with different kinds of crops, particularly, bananas and citrus. But those lands of Class IV, located too far from the channels toward the west, are either left fallow, which are the vast majority, or cultivated with wheat and vegetables where they depend on irrigation from well waters.

Comparing the irrigation channels and the cropping pattern, one can see that there is a clear correlation between them. The banana and citrus orchards are usually situated in the eastern part of the area in general and along the irrigation channels of the two strips in particular, while the land to the west is planted with cereals or left fallow.

With regard to the existing canal system in this area (Ghor Nimrin), it is relevant to divide it into two systems according to the source of irrigation. Firstly, Wadi Shueib canal system which comprises a lined head reach canal taking off from a weir across the Wadi Shueib and flows along the northern bank of the Wadi to feed vegetable plots before the canal is flumed down to a pool. Two weirs from this pool divide the flow into two equal parts. One canal is led down to and across the Wadi Shueib to serve the southern bank. The other follows the contours north along the edge of the irrigable land for 2.8 Km. with three branches each about half a kilometre in length flowing to the west. These branches feed water into the unlined distribution system which extends to the edge of the irrigated land. Secondly, well water system, based on the numerous pumps supplying water from boreholes, usually has its own lined canals. It is important to know that in the whole of the cultivated lands of Ghor Nimrin, the vast majority of irrigated lands depend on well waters. For instance, some 80 percent of citrus plantations in Ghor Nimrin are irrigated by the well water system, while some 20 percent only are irrigated by Wadi Shueib canal system.

Field observations show that along the two sample strips, some crops dominate in some parts of the strips (fig.9.13). Generally, the following crop belts can be recognised; Firstly, the banana belt occupies the two sides of the Southern Shuneh-Dr.Sati farm road; this belt includes, beside bananas, other crops such as wheat, vegetables, and citrus. Secondly, the vegetable belt occupies the northern side of the southern Shuneh - Mashrou road. This belt extends towards the north most of which is in the Class IV lands. It is notable that the length of this belt of vegetables, from Southern Shuneh up to north of Karameh, is some 11 Km. and its width from Southern Shuneh to Mashrou is some 3 Km. In addition to the Class IV lands, the south eastern part of this belt comprises the land Classes I,II,III., with some small patches of bananas and wheat. Tomatoes, eggplants, and beans are the main crops in the belt, tomatoes occupy 75 percent of the vegetable acreage, followed by eggplants (10%), beans (10%) and others (5%). In addition to the Wadi Shueib canal system, on which also the banana belt depends, this belt depends on well water system.

The tendency of farmers to expand the tomato acreage, in this belt, is due to the fact that the tomato is a tolerant crop to the salinity of both groundwater and soils. This fact explains why the acreage of bananas and citrus is small when compared with that of vegetables both in Karameh (Ghor Kebid) and Southern Shuneh (Ghor Nimrin). It is natural that citrus and banana plantations are restricted to small scattered patches in sites of good water such as the Wadi Shueib canal system. Climate is the second factor which has led to this expansion of tomatoes; the relatively higher temperatures of the southern valley than those of the northern valley have led to such earlier ripeness of tomatoes in this area that it gains high prices. Soils of this area are the third and very important factor of tomato expansion; the salinity of the soils and their light texture, composed of coarse sands and gravels, create better quality and more profitable fruit. For instance, the tomato box of Karameh area is sold for 70 piastres, whereas that of Muaddi area (area 24 in Section III of the project area) is sold for 60 piastres and that of the northern parts for 50 piastres.

Thirdly, the citrus belt occupies the southern side of the Southern Shuneh - Mashrou road depending on the Wadi Shueib canal and well water systems. This belt of citrus is small and it is found beside other crops such as wheat, vegetables and bananas. Fourthly, the Wheat-fallow belt occupies the internal parts which are far from irrigation channels and near to the Class VI lands in the west. This belt includes some patches of other crops such as vegetables or citrus where they depend on well water system. The belt size is liable to fluctuation according to the amount of annual rainfall; in the good rainy years, the wheat acreage expands to leave limited areas of fallow lands.

Kufrein area:- This is the second sample of cropping pattern in the southern valley represented by the third strip of cultivated lands along the road between Kufrein and Dr.Sati farm. It can be seen that the main crop in Kufrein area is wheat occupying some 54 percent of the total area of the strip. Vegetables rank second (9.8 percent) in the acreage. Villages and gardens with ample threshing floor (Beidar) near Joufeh, occupy some 15 percent of the total area; the two villages in the strip are Joufeh in its northernmost part and Kufrein in its southernmost part both of which are located east of the road. Fallow occupies some 10 percent of the total area; its area is disordinarily small in the strip for the following reasons: firstly, the strip is an elongated land 30 percent of which runs along an irrigation channel. Secondly, the survey was made during the time of winter crops and not summer crops. Thirdly, the year of this survey was a good rainy year. Accordingly, wheat acreage increases in the rainy years such as the agricultural year 1966/67 and fallow area decreases. In the dry years, since about two thirds of this strip depends mainly on the rainfall for its cultivation, the fallow lands become dominant with a shrinkage of wheat areas. It is notable that some 25 percent of the cultivated lands in the west of the road, where they are far from irrigation water, is left fallow. In summer, most of the rainfed area of this strip is left fallow and very small patches are cultivated with summer vegetables such as melons and watermelons. Bananas occupy some 9.2 percent of the total area, followed by citrus (7.4). Such percentages of these two crops are low during winter only; in summer, they have the primary importance.

All of the lands of the strip are of Class 1 or II lands, with the exception of a patch of Class VI land located on the eastern side of the road. Since 1950, this waste land has been used as a settlement, for the Palestinians, which is known as Joufeh village, and the ample space of the threshing floor south of this village has been used as Bayadir.* Since there are no limitations in the cultivated lands of this strip, they are suitable for all kinds of crops. The water is the primary criterion in such areas which suffer from deficient and erratic annual amount of rainfall.

Like the first two strips of Southern Shuneh area, this strip, in its irrigation, depends on the Wadi Kufrein canal and well water systems. An unlined canal at a higher level on the right bank of Wadi Kufrein takes off further up the wadi to serve higher land to the north. From the diversion weir the canal leads into a settling pool with an automatic recorder, and then west following the northern bank of the wadi. The canal bifurcates about 1.8 Km. above Kufrein village, one section passing north and then west for 1.2 Km., the other passing the village to terminate at the road between Kufrein and Southern Shuneh. Before this termination, one section passes north from Kufrein to Joufeh along the eastern side of the road. This later section of unlined canal irrigates the southern third of the strip between the Kufrein and the Joufeh leaving the northern two thirds of the strip dependent on rainfall and well water canal system.

Since the southern part of the strip has more irrigation water than the northern one, it is natural to see crops of higher water requirement, such as vegetables, bananas and citrus, occurring there, leaving the wheat and fallow lands to the northern part. As is the case

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* Bayadir is the plural of Beidar which is the threshing floor.

of Southern Shuneh area, tomatoes and eggplants are the main vegetable crops in this strip.

In the light of the land use map, the strip can be divided into two agricultural crop belts: Firstly, the banana-citrus belt occupies the southern most part of the strip, including other crops such as vegetables and wheat. There is an intimate relation between this belt and the Wadi Kufrein canal system. Secondly, the wheat belt extends between the Joufeh village and the farm of Dr.Sati, including some other crops such as vegetables in addition to fallow lands. This belt depends mainly on the rainfall in its irrigation with the help of well waters.

Agricultural Yields

Not only does the Jordan Valley play an important part in the crop acreage of the country, but it has also the considerable importance in crop yields. This fact can be illustrated as follows:-

TABLE 9.6. Crop acreage and yields in the Jordan Valley and the country (1965).

Crop	Crop acreage in thousand dunums		Crop yields in Kg. per dunum	
	Jordan Valley	Jordan Kingdom	Jordan Valley	Jordan Kingdom
Wheat and Barley	150	3648.2	115	105
Maize	6	69.5	200	119.4
Sesame	1	35.2	-	39.8
Tomatoes	63	205.9	1200	917.4
Eggplants	35	38.2	1400	1246
Cabbage and Cauliflower	13	26.0	1500	1480.8
Onions	3.5	31.2	750	602.6
Potatoes	4.5	16.4	900	963.4
Cucumbers	19.5	86.9	750	698.5
Beens	15.5	23	600	600
Watermelons	14	217.5	700	736.1
Peppers	6.5	-	700	-
Other Vegetables	17	38.9	-	-
Bananas	8.5	10.5	1500	1466.6
Citrus	23	23.8	1000	1974.7

Source:- 1) Ministry of Agriculture.
2) Dar Al Handasah (1967).

The figures show that most of the crop yields, in kilograms per dunum, are generally higher in the Jordan Valley than in the country as a whole. Nevertheless, potato, watermelon, and citrus yields, in the Jordan Valley, are lower than those of the whole of Jordan due to the fact that the relative tolerance of these crops, to the salty soils of the Jordan Valley, is low or low to medium. Higher yields of the irrigated crops of the valley have led to such an expansion in their acreage that, in 1965, the eggplant acreage is some 92 percent of the total area of the eggplants in the whole of Jordan, followed by beans (67 percent), cabbage-cauliflower (50 percent) tomatoes (30 percent) and cucumbers (22 percent). The vast majority of citrus and bananas in the country is almost concentrated in the Jordan Valley where citrus occupies some 97 percent of the total citrus in the country, followed by bananas (81 percent).

Even inside the valley itself, crop yields change from one place to another, and from one time to another, as is shown in the table 9.7.

It can be seen that crop yields, in kilograms per dunum, have increased from 1953 up to 1966. Although the amount of rainfall in 1966 was less than the average, and that of the 1953 was more than the average, the increase in crop yields is clear due to the considerable progress in the agricultural development based on the use of relatively new techniques in irrigation methods, management reclamation and conservation works. However, in the southern valley, wheat and barley, revealed a decrease of the yield in 1966 because ample patches of these crops are cultivated as marginal agriculture in Class VI or IV lands without receiving sufficient amounts of water. In 1965, wheat and barley yields show the same increase of other crops.*

Investigations on improvement of local crop varieties through hybridsation and selection, have aimed at creating good varieties

* Wheat yield increased from 90 Kg./dunum in 1953 to 160 Kg./dunum in 1965 in the northern valley, and from 90 Kg./dunum to 125 Kg./dunum respectively in the southern valley.

TABLE 9.7. Crop yields in the Eastern and the whole of the Jordan Valley in 1953-1966.

Crop	Eastern Jordan Valley				The whole of the Jordan Valley Yield/Dunum Kilograms.	
	Northern Valley Yield/Dunum Kilograms		Southern Valley Yield/Dunum Kilograms			
	1953	1966	1953	1966	1953	1965
Cereals:-						
Wheat	90	90	90	45	90	115
Barley	100	90	90	55	90	115
Maize	200	150	120	200	190	200
Sesame	60	100	55	80	60	-
Sorghum	-	150	-	170	100	-
Vegetables:-						
Eggplants	1000	3000	870	1200	930	1400
Tomatoes	620	2000	430	1200	500	1200
Watermelons	470	2000	430	800	490	700
Cucumbers	400	1000	320	880	420	750
Marrow	640	1000	350	1000	490	-
Cabbage	690	2000	770	1000	900	1500
Cauliflower	720	3000	430	1830	640	1500
Broad beans	330	1000	350	536	320	600
Onions	770	1500	520	1000	750	750
Potatoes	1520	2000	840	206	1100	900
Fruit:-						
Bananas	1300	2000	1250	1900	1295	1500
Citrus	1300	1816	230	350	800	1000
Total	10210	22746	7145	12282	8515	12230
The percentage of increase		122.78%		71.89%		43.62%

Source:- 1) Field work. 2) Baker and Harza (1955).
3) Dar Al Handasah (1967).

of high yielding capacity. The field trials made by Deir Alla Agricultural Research Station since the beginning of the fifties, have led to the high crop yields at the present time. Following the initial trials, the most promising varieties were increased on seed farms and distributions of seed made to farmers. Gabo wheat and Arivat barley were two outstanding varieties that were discovered in the testing and selection procedure. Many farmers have now increased their own supply of seed of Gabo wheat which is cultivated in an area of more than 20,000 dunums of irrigated lands and yields some 30 percent higher than other varieties. Moreover, the Agricultural Research Station has devised four improved varieties of tomatoes, one variety of beans and many varieties of cabbage, cauliflower, water melons, cucumbers, potatoes, onions and peppers; these improved varieties have become widespread since the beginning of the sixties. The station has still been working trials on some varieties which may be more suitable for irrigation and adapted to the climate and soils of the valley.

Crop yield percentages in the Eastern Jordan Valley increased some 97 percent, on average, during 13 years, whereas those of the whole Jordan Valley have increased some 44 percent. On the other hand, crop yield percentages in the northern and southern valley have increased on average, during the same period some 123 and 72 percent respectively. Accordingly, it can be seen that, generally, the Eastern Jordan Valley is in a better agricultural status than the Western Jordan Valley; furthermore, the northern valley has the best agricultural status of all parts of the Jordan Valley. These high crop yields of the northern valley are a result of combined factors reacting simultaneously to create the high yields, and subsequently, the high incomes. The execution of the East Ghor Irrigation Project in the northern valley, where climate and soils are suitable for agriculture, is a fundamental procedure in raising the total amount of output.

Comparing the percentage increases in the cultivated land in the valley during 13 years (16 percent) and in the irrigated land (23 percent) with the increase of the crop yields in the valley during the same period (97 percent on average), one can see that the increase of crop yields is much more than that of the cultivated or irrigated area. This point emphasises the fact that the human factor has played an important role in the increase of yields. Human activity is still represented by the works of levelling the land, leaching the salty soils, fertilising, controlling common pests,

Plate XIX. Cereal breeding trials undertaken by the Deir Alla Research Station.

Plate XX . Onions are a successful crop in the valley.

diseases, weeds and using crop rotations and new selected seeds. In other words, the high yields are the consequences of the continuous hard work particularly those of the southern valley where the struggle is fierce between the farmers and the lands. The Palestinian pioneers in the Karameh area had paid high expenses to leach the salty soils of the area during the first three years of their residence. However, it became apparent to them that leaching was not enough to give high yields; in addition, they should also use fertilisers and crop rotation. Using all the requirements of agriculture in the salty soils, the land has begun to give them higher yields. Consequently, the annual income per person has risen from J.D.10, on average, in 1953, to some J.D.50, on average, in 1966.

Crop yields differ from one section to another inside the project area as is shown in the following table.

It can be seen that crop yields in the project area prior to the execution of the East Ghor Irrigation Project (1959/60) were very low when compared with the present crop yields (1965/66) representing the beneficial consequences of the irrigation project. Since the two years of comparison (1959/60 and 1965/66) are similar dry years having rainfall less than the average, the comparison can elucidate the real process of the progressive evolution of the crop yields. It is notable that Section 1 has, generally, the primary importance in yields per dunum, followed by Section II and Section III. The difference in the yields per dunum is caused by the following reasons: Firstly, the mean annual rainfall amount ranges from more than 400 mm. in the northernmost parts of Section 1 to less than 200 mm. in the southernmost parts of Section III. Moreover, Section 1 has relatively lower values of temperature, evapotranspiration, and wind erodibility index than Section III. Secondly, Sections 1 and II have better soils than Section III which has some patches of saline soils. Thirdly, the percentage of rough lands and non-cultivable lands is higher in Section III than in the northern sections. And fourthly,

TABLE 9.8. Crop yield averages by sections of the Stage 1 of the project area in (1965/66)* compared with those of 1959/60.**

Crop	Project area 1959/60		Project area 1965/66					
			Section 1		Section II		Section III	
	Irrigated Dunums Planted	Yields average in Kg./Du.	Dunums planted	Yields average in Kg./Du.	Dunums planted	Yields average in Kg./Du.	Dunums planted	Yields average in Kg./Du.
Wheat	73238	48.7	6190	95	9300	85	22200	90
Barley	9202	65.7	750	100	100	100	1950	85
Maize	4886	66	985	150	1072	150	563	175
Tomatoes	26734	557.4	842	2500	3771	2000	37950	1600
Eggplants	7244	983.3	1757	3500	483	2500	3816	1600
Cauliflower	6770	1556.4	636	2223	214	2000	890	1400
Cabbage	2812	1362.7	1734	1979	29	2000	330	1000
Onions	1304	504.7	107	1691	164	488	623	1000
Potatoes	1851	819.8	56	2571	311	2000	541	948
Broad beans	3145	206.3	427	3311	1135	2176	2391	900
Bananas	2157	1316.3	4600	2000	710	2000	90	2000
Citrus	660	434.6	3721	2138	3740	1617	350	1714
Cucumbers	2284	352.6	80	1000	470	1000	100	1000
Watermelons	5309	396.2	310	2000	170	2000	1400	2000

* Information collected during the field work by random samples.

** Dept.of Statistics, The East Jordan Valley: A Social and Economic Survey. Amman (1961).

Section 1 has received irrigation from the East Ghor Canal before the other sections and subsequently has seen the earlier experience of irrigation agriculture. Nevertheless, in the case of some crops such as cabbage, yields per dunum in Section II are higher than those in Section 1. Likewise, onions and citrus yields per dunum in Section III are more than those in Section II although they are less than those in Section 1. Of course, the imparity of yields is due to complex factors of physical and human environment beside crop ecology itself,

Since the southern valley is still affected by the amount of rainfall, as a result of its partial irrigation, it is convenient to elucidate the effect of erratic rainfall on the yields by selecting two areas such as Ghor Nimrin and Ghor Kufrein as representative of the fluctuated crop yields of the southern valley during this period (Tables 9.3. and 9.4. (App.9)). This fluctuation is more evident on cereals than on vegetables or fruit which are nearer to irrigation channels. For instance, the wheat yield in the rainy year 1964/65 was 150 Kg. per dunum, whereas it was in the dry years (1962,1963,1966) some (100 Kg.)(100 Kg.)(80 Kg.) respectively. Likewise, barley, maize, sesame, and sorghum have high yields per dunum in wet years and low yields in the dry years.

Paradoxically, vegetables and permanent crops, such as bananas and citrus, have higher yields in the dry years and lower yields in wet years. This phenomenon is observed, for instance, when comparing the yields of the dry year 1961/62 and the yields of the wet year 1963/64. The only exception in this comparison is the tomato crop which suffered from a cold wind in 1961/62. The contradiction between the rainfall amount and the yield per dunum can be interpreted by the fact that in the dry years the amount of water used in irrigation increases by overpumping from the wells on which these two areas depend. The successive dry years lead to the problems of water decline and salinity which have been mentioned earlier in chapter 3. On the other hand, the dry years force the farmers to take care of irrigation water and save it for agriculture without waste.

Livestock.

Animal husbandry:- Not much detailed information on animal husbandry in the valley under present conditions is available, most likely because this activity is of minor importance as compared with crop growing activities. The traditional animal species are mainly sheep, goats and cattle, predominantly kept for home consumption purposes and further horses, mules and donkeys, maintained as a source of animal power for land preparation, harvesting, transport etc. The animals graze on waste land and grain stubble.

The number of cattle in the East Ghor project area was estimated at 1700 in 1960. Based on the Livestock Census 1966, the number of cattle in the whole of the Jordan Valley has been estimated at 4000 divided between the Western bank of the valley (1300) and the eastern bank (2700). It has been estimated that the number of cattle in the project area in 1966 is 1700 and that in the southern valley is 1000. The same number of cattle in the project area in 1960 and 1966, emphasises the fact that no substantial shift in the number of cattle has taken place in the valley during the last 7 years. According to the visit of some farms, the annual milk production of local Balladi amounts to 400-500 litres per cow and of the Holstein-Frisians to 2500-3000 litres.

The dominant breed of sheep is the Awassi, producing carpet wool, mutton and milk. The principal goats are the black long-haired type, producing meat and hair. The smooth-coated Syrian goat is a fair milk producer. Camels are almost scarce in the valley.

Shortage of pastures in the valley, either as natural vegetation or as forage, is the dominant factor impeding the increase of animals. In the project area, the forage acreage is the lowest of all crop acreages; for instance, the average Berseem acreage in 1966 has been estimated at 112 dunums yielding, on average, some 1,120,000 Kg.

Plate XXI[illegible]. A cow grazing berseem on a general farm.

of Berseem. Taking into consideration that the cow, beside, field residues, is in need of some 3400 Kg. Berseem per year, it would appear that the 1700 cows in the project area need some 5,780,000 Kg. Berseem per year. This deficiency in the local output of Berseem leads to a dependence on other sources in feeding the cattle and to importing high price concentrates. The high cost of production are conducive to the high prices of milk, which in its turn has inadequate processing storage, and marketing facilities. The scarcity of credit facilities needed for capital investment in dairy-farming can be added to the factors impeding the increase of animals in the valley.

It is well-known fact that good forage, green or preserved, is the foundation of efficient livestock production. The need for more forage in the valley has been emphasised by the dry years as an urgent matter for all concerned. To increase the number of animals in the valley, fodder crop acreage should be expanded. In addition to their importance as animal diet, they enrich the soil and maintain its fertility when introduced in the rotation. Preliminary experiments on fodder crops grown under irrigation were started at Deir Alla Agricultural Research Station in 1955. The results demonstrated that farmers under irrigation could successfully introduce leguminous forage crops such as berseem, vetches, cowpeas, Sudan grass into a reasonable three year rotation which would include vegetable and cereal crops also. The advantages of such introduction would give a higher food value for animals, improve soil fertility, substitute for the shortage of fodder, ease the pressure on grazing of natural pastures, and draw cash income to farmers. Consequently, farmers are strongly advised to allocate part of their land to annual or permanent forage crops.

<u>Chicken husbandry</u>:- According to the Livestock Census (1966), the number of chickens in the whole Jordan Valley was estimated at 130,000 divided between the western bank (30,000) and the eastern bank (100,000). The vast majority of chicken farms in the valley are concentrated in the

Karameh area where there is some 150 farms in 1967 including more than 100,000. This area has the primary importance in the country since it has 30 percent of the total number of poultry farms in Jordan and 25 percent of the total number of chickens in Jordan. The factors which encouraged the establishment of these farms in the Karameh area are: firstly, there are ample spaces of such non-arable land or UNRWA. land on most of which Karameh Camp is built, that no rents are paid by farm owners. Secondly, the chicken houses are built from such local clay moulds and canes, that the costs are low. Thirdly, the climate of the area with its dryness and warmth is helpful in keeping chickens. And fourthly, Palestinian refugees who have no work can find in establishment of such farms a means of their living.

Chicks are imported from Beirut or Amman and kept for two months, in the Karameh farms, during which they are fed by concentrates imported from Amman. The chicken farms meet the needs of local consumption either to the people or to the army. It has been estimated that Karameh exports some 3000-5000 chickens per day.

Bee breeding:- Bee breeding is not common in the valley although the bee is very helpful in cross-fertilisation process by which agricultural yield increases some 30 percent on average. However, during the period between 1964 and 1967, some 100 bee hives have been established in the project area. The area 1 has the primary importance with 26 hives, followed by the area 10 (25 hives), the area 12 (22 hives), the area 14 (10 hives), the area 7 (7 hives), the area 5 (6 hives), and the area 4 (4 hives). In other words, Section 1 comprises 68 percent of the bee hives and Section II comprises 32 percent. The correlation is clear between the citrus trees of Section 1 and the wide-spreading of bee hives. It is notable that Section III of the project area and the southern valley have almost none of the bee hives. Therefore, the Ministry of Agriculture has to encourage bee breeding by allocating good species of bees to the farmers and elucidate the benefits of bees in honey production and yield increase.

The Farm Economy.

The gross value of farm production (G.P.V.) has been evaluated for the years 1953 and 1965 and is summarised in the following table.

TABLE 9.9. Estimates of total gross production value 1953 - 1965.

Item	G.P.V. in thousand J.D.		Percentage of total G.P.V.	
	1953*	1965**	1953*	1965**
Cereals	470.4	486.8	53.9	12.6
Vegetables	243.9	2703.9	28.0	70.0
Fruit	103.3	597.8	12.0	15.4
Livestock	50	73.2	5.8	1.9
Total G.P.V.	872.6	3861.7	100	100
Total cultivated area in thousand dunums	214.1	248	-	-
G.P.V. in J.D. per cultivated dunum	4	15.5	-	-

Source: * UNRWA., Jordan Valley Agricultural Economic Survey (1953).
** Information collected during the field work.

The G.P.V. has been calculated by multiplying cropped areas with crop yields and with prices of farm produce. Present crop yields and farm prices have been based on the findings of the recent field study, on the available statistical data and on information received from various other sources such as local research stations and local officers of the Extension Department.

The total G.P.V. of the Eastern Jordan Valley increased from J.D. 872,600 in 1953 to J.D. 3,861,700 in 1965. The G.P.V. from vegetables shows a ten-fold increase in 12 years and a rise from 28 to

70 percent as a share in the total G.P.V. The gross value of fruit production shows a six-fold increase while its share in the total G.P.V. rose from 12 to 15 percent. Although the G.P.V. derived from cereals is almost similar in the years 1953 and 1965, its share in the total G.P.V. decreased from 54 to about 13 percent in this period. Livestock production shows some increase, but its share in the total G.P.V. decreased from 6 to 2 percent.

The trend of yields to increase during the last years is accompanied by a similar trend of costs of production. The most striking increase of inputs can be noticed for fertilisers and hired labour as follows:-

TABLE 9.10. Costs of Production and Farm Income, 1953-1965.

	J.D. per cultivated dunum		Percentage of total G.P.V.	
	1953*	1965**	1953*	1965**
G.P.V.	4.0	15.50	100	100
Farm Expenses:-				
Seed	0.45	0.70	11.25	4.51
Hired machinery	0.20	0.60	5.00	3.87
Fertilisers	0.05	1.60	1.25	10.32
Manure	0.20	1.00	5.00	6.45
Plant protection	-	0.50	-	3.22
Hired labour	0.85	2.50	21.25	16.12
Own equipment	0.35	0.20	8.75	1.29
Interest on loans	-	0.10	-	0.64
Total farm expenses (excluding irrigation water).	2.10	7.20	52.50	46.45
Irrigation water	-	1.50		9.67
Grand total of farm expenses	-	8.70		56.12
Total farm income	-	6.80		43.87

Source: * "Jordan Valley Agricultural Economic Survey, UNRWA., 1953".
** Information collected during the field work.

It is worth mentioning that the average income per dunum, without having taken water cost into account, has grown about four times between 1953 and 1965.

In an economic study undertaken in 1962, the Harza Engineering Company[2] prepared the following summary of the estimated projected annual agricultural benefits by sections of the project area.

TABLE 9.11. Summary of the estimated projected annual agricultural benefits of the project area by sections.

Item	Unit	Section I	Section II	Section III	Stage I (the project area
Area of cultivated land	dunums	29,984	33,412	47,847	111,243
The total of agricultural income	J.D.	484,579	510,474	696,976	1,728,140
Income per dunum	J.D.	16.16	15.27	14.56	15.53

Source:- The Harza Engineering Comp.Int., The Yarmouk-Jordan Valley Project Stage 1. Economic Feasibility Amman 1962.

It can be concluded that agricultural income per dunum decreases from the north to the south within the project area with the income/dunum in Section 1 is J.D. 16.1 and in Section III is J.D. 14.5. In the same report (1962), the Harza Company prepared the projected incomes of 30 and 50 dunum farms which predominate in the project area, and selected items for farm budgets by type of farms and land class as follows:- (Table 9.12).

It is notable that the Harza Company has predicted that fruit farm will contribute the highest income of the farm incomes in Class 1 and II lands, followed by vegetables and general farms. In Class III lands, general farms will be first, followed by vegetable farms. On the other hand, the prediction of farm incomes by land class was based on the

TABLE 9.12. Projected farm budgets by type of farms and land classes.*

Item	Class I and Class II Lands				Class III Lands	
	Unit	Vegetables	Fruit	General	Vegetables	General
Land area	Dunums	30	30	30	50	50
Total Crops	"	44	40	39	68	61
Vegetables	"	27	14	12	42	15
Fruit	"	.	9	.	.	.
Cereals	"	10	10	12	16	17
Forage	"	6	6	14	8	27
Roads, channels etc. 3%	"	1	1	1	2	2
Investment	J.D.	1175	1475	1300	1532	1965
Farm receipts	"	907	990	748	994	913
Crops	"	826	909	429	913	391
Livestock	"	81	81	318	81	522
Farm expenses	"	539	571	433	619	485
Gross farm income	"	367	419	314	375	428
Interest on investment	"	59	74	65	76	88
Net income	"	308	345	249	298	340
Cropping percent		147	133	130	136	122

* The Harza Eng.Comp. The Yarmouk-Jordan Valley Project. Stage 1. Economic Feasibility. Amman 1962.

results of the Master Plan report of Baker and Harza (1955) which disclosed that the net income of 15 dunums of Class 1 and II lands was approximately equal to the net income of 26 dunums of Class III lands. In other words, the dunum of Class 1 and II lands is equivalent to 1.7 dunum of Class III lands. On designing the area of farm units in the project area, land classes were the dominant factor in determining the size of the farm unit. Class I and II lands have farm units of 30 dunum area, while Class III lands have farms of 50 dunums.

In its water use study of Shueib and Kufrein alluvial fans, MacDonald Company (1964),[3] has been able to assess the average annual income per dunum in a typical year 1962. This is given in the following table.

TABLE 9.13. Average income. Ghor Nimrin and Ghor Kufrein.

Crop	Ghor Nimrin				Ghor Kufrein			
	Area 1962	Income	Income	Average income	Area 1962	Income	Income	Average income
	Dunums	per dunum	J.D.	per dunum	Dunums	per dunum	J.D.	per dunum
Cereals	7,300	1/720	12,600		6,100	1/720	10,500	
Winter Vegetables	16,019	25/500	409,000		10,781	25/500	275,000	
Citrus	1,330	24/100	32,100		55	24/100	1,330	
Bananas	525	49/800	26,150		120	49/800	5,980	
Total	25,174	-	479,850	19/060	17,056	-	292,810	17/170

Source:- M.MacDonald, Shueib and Kufrein water use study, London (1964).

It can be concluded that fruit in general and bananas in particular have the primary importance in the income per dunum. Cereals have the least income per dunum. Nevertheless, vegetables make the largest contribution to the total income of the acreage since they occupy ample space in the acreage and they are sold with high prices.

Sample farm budgets:- The farm units in the valley may be broadly classified, according to the percentage of crop acreage, into three farm types: the vegetable farm, the fruit farm, and the general farm. To facilitate the process of calculating farm budgets, the farms were divided according to irrigation water into irrigated farms andnon-irrigated farms. They were divided also according to land class into farms of Class I,II lands and farms of Class III lands. Twenty three irrigated farms were selected to represent the farm budgets of Class I,II lands, whereas 15-sample irrigated farms and a 5-sample unirrigated farms, represent the farm budgets of Class III lands. It is notable that Class I,II lands comprise all farm types, while Class III lands include vegetable and general farms only. Most of the chicken farms in the valley are found on the Class IV or VI lands which are not used for cultivation. Fifty sample farms were selected to represent the budget of chicken farms in the valley.

All figures relating to incomes are based on estimates of the average yields of the agricultural years 1965/66 and 1966/67 which are variable from one farm unit to another, and take into account the effects of price flucutuations during the winter and summer seasons of those two years. To account the cost of farm production, farm expenses such as seeds and plants, hired machinery, and own equipment, fertilisers and manure, insectisides and plant protection, hired labour, marketing, irrigation water, and miscellaneous expenses, were considered. The gross income of the farm is the result of subtracting the farm expenses from the gross production value of the farm. The capital investment of the farm includes the value of lands, trees, livestock and equipment which differ from one farm to another. For instance, the price of irrigated dunum of Class I,II lands is some J.D. 60 while that of Class III lands is some J.D. 45 per irrigated dunum and some J.D. 10 per non-irrigated dunum. Interest on investment which is estimated at 6 percent must be added to the production cost in order to obtain the net income of the farm.

The summaries of farm budgets of Class I, and II lands are found in tables 9.5 - 9.7. in Appendix 9, where it can be seen that in relation to the net income of a 30-dunum irrigated farm, fruit farms have primary importance (J.D. 884 per year), followed by vegetable farms (J.D. 670 per year) and general farms (J.D. 190 per year). The summaries of farm budgets of Class III land (tables 9.8 and 9.9. App.9) show that, regarding the net income of a 50-dunum irrigated farm, vegetable farms rank first (J.D. 462 per year), followed by general farms (J.D. 113 per year) and non-irrigated general farms (J.D. 82 per year). The summary of chicken farm budgets (table 9.10 App.9) shows that the net income of small farms (500 chicks) is the least of all farms, being on average some J.D. 125 per annum, whereas that of large farms (2000 chicks) is on average some J.D. 496. It is notable that the winter net income of those meat chicken farms are higher than that of summer in spite of the fact that the winter cost of production is higher than that of summer. This phenomenon can be explained by the fact that the weight of chickens is affected by the climate of the valley to such an extent that it becomes heavier in the winter and lighter in the summer. Moreover, the prices of chickens in winter are higher than in summer owing to the relatively smaller quantities of lamb and beef in the markets during the winter.

The average income of the sample farms per cultivated dunum is estimated at J.D. 11.87 per annum, while the total farm income of the valley in the year 1965 per cultivated dunum is estimated at J.D. 6.80. The difference between the figure of the sample farms and that of the valley is due to the fact that most of the sample farms represent the Class I,II,III lands, and there are some cultivated lands belonging to the Class IV and VI lands. These later classes of lands have lower net incomes per cultivated dunum when taking the valley as a whole.

It is convenient to recognise the importance of each crop in the agricultural income of the valley. From the fruit farm budget found i the table 9.5 (App.9), one can see that bananas have primary importance in the agricultural income of the valley with a gross income of J.D. 65 per irrigated dunum of Class I, II land. Citrus follows bananas in the gross income with J.D. 17 per irrigated dunum of the same farm. In vegetable farms (tables 9.6, 9.8, 9.11, App.9), tomatoes rank first in the agricultural income of the valley with a gross income of J.D. 40 per irrigated dunum of Class I, II lands and J.D. 25 per irrigated dunum of Class III land and J.D. 4 per non-irrigated dunum of Class III and IV lands. Tomatoes are followed by potatoes and cauliflower the gross incomes of which are estimated at J.D. 39 and 17 per irrigated dunum of

Class I, II and Class III lands respectively. Cabbage follows, with gross income of J.D. 32 and 15, then eggplants with J.D.26 and 12, and cucumbers with J.D. 23 and 7.

Wheat is so widespread in the valley that it is cultivated in all of the farm types in rotation. However, its gross income differs from one farm type to another according to the land class of the farm. In general farm, in which wheat is the dominant crop, its gross income is estimated at J.D. 3 per irrigated dunum of Class I, II lands and J.D. 1.80 per irrigated dunum and J.D. 1.40 per non-irrigated dunum of Class III lands. Animal husbandry contributes a small gross income when compared with cash crops; the average gross income of one cow is estimated at J.D. 54 per annum in the Class I, II land farms and J.D. 50 per annum in the Class III land farms.

Problems of Agricultural Yields.

Although the agricultural yield has increased in the recent years, it still faces numerous problems affecting its quantity and quality. These problems differ from one farm to another and from time to time. Soils and irrigation waters have the primary importance in the problems of yield. Field observations show, for instance, that the yield of tomatoes in the Karameh area (Ghor Kebid), where there are saline soils of Class IV lands and brackish irrigation waters, varies from 750 Kg. to 1500 Kg. per dunum; while in the northern parts of the valley, where there are non-saline soils of Class I, II lands and good irrigation waters, it varies from 2000 Kg. to 3000 Kg. per dunum. The fluctuation of rainfall in the southern valley on which the farmers depend, affects the yield. This is evident in the fluctuation of well ground waters, which are apt to decline in their level or to be salty as a result of successive dry years.

With regard to the old parcels of land which have been irrigated for 40 years ago, they show signs of exhaustion and declining production. Such lands need to use crop rotations and to be cultivated with new crops which are economic feasible such as oil seeds of industrial crops. Dependence only on vegetables in general and tomatoes in particular is conducive to vulnerable consequences such as exhaustion of soils and subsequently declines in yield, and increases in yield to such an extent that local and external markets cannot absorb them.

The cold fronts of air, occurring during the winter, are serious problems facing vegetables and bananas. The hazard of cold winds varies directly with their severity, the failure of crops ranges between 30 and 70 percent. For instance, tomato yields in the Ghors Nimrin and Kufrein, as a result of the 1962 frost, dropped from 1300 Kg. in 1960/61 to 500 Kg. per dunum in 1961/62. On the other hand, there is a correlation betweensome aspects of the weather and some crop diseases. The "Early and Late Blight" disease, caused by "Phytophora infestans" attacks potato and tomato crops in the valley when the weather becomes highly humid, warm, and rainy. Most of potatoes and tomatoes, cultivated during the period between September and November are susceptible to this disease, since the nights of the valley during this period are temperate and humid (18^{o}C) followed by warm sunny days (25^{o}C). During the years 1960/61, 1961/62, 1963/64, these two crops have been attacked by the "Early and Late Blight" disease all over the valley and some 75 percent of the crops, in the farms with no control, failed. In 1964/65, the disease spread as an epidemic in the valley, and none of tomato fields were rescued. The losses were estimated at 80,000 tons of tomatoes.

Cold waves affect also onion crops in the valley which are attacked by"Pernospora destructor" disease which is conducive to wilting of the leaves. "Thrips tabica" is the most important pest affecting onion yield. Its danger is great during dry years. Field observations show that banana yields are affected only by winds which dessicate the broad leaves, and banana orchards are clean from any pest or fungus disease.

Common pests and diseases play an important role by affecting crop yields. Wilting disease and root rot are caused by soil fungus and cutworms which are widespread in the valley. Cutworms destroy the seedlings of the nurseries, while spiders are the most important pests causing harm to citrus, eggplants, marrows and squash. Caterpillars attack tomatoes, beans, cabbage, and cauliflower. They are widespread in the soil of areas 8 and 9 within Section 1 of the project area. It is predicted that their danger will be so influential that they will be the limiting factor for a lot of crops in the valley. Citrus trees are attacked by gummous disease caused by "Phytopthora citrophthora" fungi; This widespread disease is caused by increasing humidity all round the wounded stems of trees, in addition to the method of irrigation water. Most of the local varieties of wheat and barley, until five years ago, were deficient in one or more important characteristics which influence yield. These characteristics include susceptibility to rust diseases and to lodging and lacking in drought resistance. At present, as a result of the wheat breeding programme undertaken by the Deir Alla Research Station, Gabo wheat and Arivat barley are widely planted. These two varieties have good characteristics such as high yielding capacity, resistance to diseases especially black stem rust and brown leaf rust, resistance to lodging, drought tolerance and resistance to shedding. Nevertheless, wheat is still exposed to failure due to its susceptibility to yellow and orange leaf rust. Rusts, generally, have caused damage recently, to some 15 percent of the crop yield. In addition to rusts, wheat and other cereals are attacked by "Wheat Leaf Miner" worm (Syringopias temperatella) which causes an annual damage estimated at 1 percent of the wheat and barley crops in the valley.

Weeds affect crop yields since pests and worms, such as Wheat Leaf Miner worm, take weeds as a refuge from which they attack crops. On the other hand, weeds compete with crops for irrigation water. Controlling weeds has become easy owing to the progress so far made in relation tothe experiments executed in the Deir Alla Research Station. The results have asserted that gramphene is the best chemical remedy to control grass. However, all weed control is carried out manually or with an animal-drawn plough.

PlateXXII. A wheat farm attacked by worm.

Plate XXIII. Dusting crops for protection against disease.

The successful selection of the selected seeds, fertilisers and chemical dusting materials, is the corner stone in the construction of agricultural yield regarding its quantity, quality, and its marketing locally and externally. Questionnaires of the owners of the sample-farms show that 60 percent of them complain about the quality and capability of the seeds which fail to produce the anticipated yield, particularly, of tomatoes, marrows, cucumbers, cabbage, and cauliflower. Most of the vegetable seeds, fertilisers, and chemical dusting materials are imported from Europe, America, Syria and Lebanon. It is the Extension Agent who has the first responsibility towards inspecting and advice. Just a small error in diagnosis of the disease or the sort of deficient fertiliser may induce harmful consequences. As in the case of fertilisers, chemicals for plant protection are bought direct from merchants or through the commission agents.

The deficiency of capital makes the farmers surrender to the agricultural companies and commissioners who supply the farmers with loans and monopolise the marketing of their crop production. Farmers have to buy also seeds and chemicals from them in spite of the expensive prices and worse quality. In fact, there are, at present, some 30 agricultural co-operative societies in the valley, 15 of which are active. These societies depend much more heavily on funds made available by the Jordan Central Co-operative Union for re-lending than on their own resources. Co-operative lending is short-term (one year) with interest charges of 7-8 percent per annum. The loans extended are believed to cover about half the short-term needs of the farmers. Although the Northern Shuneh and Wadi Yabis societies supply the farmers with some of their inputs, they could not do a great deal more since their funds are limited. Consequently, farmers incur also debts for production and consumption purposes from village grocers, city traders, money lenders, landlords, bankers, commission agents, fruit and vegetable exporters.

The Government is also a creditor, because of debts owed to it as a result of the East Ghor Canal Project by those farmers who have been alloted new or enlarged farm units. These debts amounted to J.D. 2.3 million by the end of June 1967. They are payable in 20 annual instalments, of which only one or two have been paid. Co-operative loans in the valley amounted to some J.D. 200,000 by the end of March 1966. The Agricultural Credit Corporation (ACC) has debts outstanding in 15 villages under the Wadi Yabis ACC. office amounting to J.D. 223,169 by the end of March 1967. Although the total debt burden on the valley farmers is quite high, it is less serious than that of the rest of the country.

The ACC. is the major source of medium and long-term credit. It obtained a new loan of $3 million from the I.D.A. in the spring of 1967 which, together with its revolving funds, will be used for financing land reclamation, terracing, tree planting, livestock raising, and the purchase of agricultural machinery. The ACC. charges an interest of 5.25 percent per annum to individual borrowers, and of 2 percent to the JCCU.

Development Proposals

Development in the valley is essentially based on an evaluation of the development possibilities of the land and water resources. The projected cropping pattern depends on the projected water use which in its turn is based on the economic feasibility of water schemes in the valley. It depends also on the size of the area available for agriculture, and on the development of the land such as upgrading and leaching of the soils and developing the farms. On the other hand, the demand for agricultural produce is an important human factor which integrates with the last two physical factors on which the projected development is based. It is difficult to forecast the trends of agriculture in the valley. These will depend largely on economic influence, such as price and market availability; and on agricultural influence such as the introduction of better strains and improved methods of cultivation and rotation.

From a national-economic point of view, benefits can be considered in relation to either land or irrigation water. Irrigation water being a limiting factor in the future rather than land, it seems appropriate to use the national-economic benefit per m^3. of irrigation water as a criterion in determining the optimal cropping pattern. The latest estimate puts the total surface water supply likely to become available from the entire Yarmouk Scheme at 536 mcm. It has been assumed that the net irrigated area in the valley will be some 321,250 dunums as a result of the scheme completion. According to the ninth annual report of the Deir Alla station (1960),[(4)] which gives the figures for the annual duty of water for a wide range of crops, the general water requirement for the pattern postulated by F.A.O. (1963) would be about 750 m^3. per dunum. In fact the requirement may be less than 750 m^3. in the northern valley and more than 1000 m^3 per dunum in the southern valley which has higher temperatures and more salts.

In a study of the economic feasibility of the Yarmouk-Jordan Valley Project, the Harza engineering international company (1962) has suggested the projected cropping pattern for the valley as follows:-

It is necessary to see to what extent the Harza proposals of cropping patterns have been realised during the last six years. Comparing the proposed intensities of the crop acreage with the present intensities, it appears that the present cereal intensity (28.2%) is double that proposed (14%). Likewise, the present fruit intensity (27.7%) is one and a half times as much as that proposed (18.5%). Paradoxically, the present vegetable and forage areas (46.6 and 0.8% respectively) have not yet reached the suggested intensities for them (56 and 37% respectively). The comparison is shown in Table 9.15.

The figures of the present and the early proposals of cropping intensities of the Stages I and II (northern and southern valley) reveal the same trend of the average of the valley; i.e. the present cereal and fruit intensities in both of the two stages are higher than those earlier proposed, and the present forage and vegetable intensities are less than those earlier proposed with the exception of the vegetable intensity in the southern valley which is higher than that earlier

TABLE 9.14. Proposed cropping patterns with the project by Harza (1962).

Crop	Stage I (Northern Valley)		Stage II (Southern Valley)		
	Cropped area in Dunums.	Percent of Cropped area. %	Cropped area in Dunums.	Percent of cropped area. %	The whole of the valley
Cereals:-					
Wheat	12000	10	9140	9	
Barley	6000	5	4540	4	
Sub-total	18000	15	13680	13	14.0
Vegetables:-					
Tomatoes	10800	9	12210	11.5	
Others	61200	51	41990	40	
Sub-total	72000	60	54200	51.5	56.0
Fruit:-					
Bananas	12000	10	5520	5	
Citrus	12000	10	5520	5	
Others	6000	5	2210	2	
Sub-total	30000	25	13250	12	18.5
Forages:-					
Alfalfa	18000	15	11020	10	
Berseem	6000	5	12760	12	
Summer forage	18000	15	18720	17.5	
Sub-total	42000	35	42500	39.5	37.0
Industrial crops:-					
Peanuts	-	-	9080	8.5	
Sesame	9600	8	-	-	
Sunflower	-	-	13500	12.5	
Sub-total	9600	8	22580	21	14.5
Grand Total	171,600	143	146,210	137	140.0

Source:- 1) Harza Eng.Comp.Int., The Yarmouk-Jordan Valley Project. Stage I. Economic feasibility, Amman (1962).
2) Harza Eng.Comp.Int., The Yarmouk-Jordan Valley Project. Stage II. Vol.1. Economic development, Amman (1962).

TABLE 9.15. A comparative summary between the present and the early proposals of cropping intensities by Harza, (Percent of cropped area %)

Crop	Stage I (Northern Valley)		Stage II (Southern Valley)		The average of the valley (Stage I+II)	
	Proposed cropped area *	Present cropped area **	Proposed cropped area *	Present cropped area **	Proposed cropped area *	Present cropped area **
Cereals	15	31	13	25.5	14	28.3
Vegetables	60	36	51.5	57.2	56	46.6
Fruit	25	35.4	12	20.1	18.5	27.7
Forages	35	1.6	39.5	-	37	0.8
Industrial crops	8	-	21	-	14.5	-
Total	143	104.0	137	102.8	140	103.4

Source:- * 1 - Harza Eng.Comp.Int., The Yarmouk-Jordan Valley Project. Stage 1. (1962).
2 - Harza Eng.Comp.Int., The Yarmouk-Jordan Valley Project. Stage II.(1962).
** Information collected by fieldwork.

proposed for this part of the valley.

By recognising the present cropping pattern, the problems of agricultural yields, the results of experimentation made in the experimental stations of the valley, and the several cropping patterns, being previously proposed for the whole of the valley by UNRWA.(1953), Baker and Harza (1955), Government of Jordan (1955), International Bank Mission to Jordan (1955), F.A.O.(1957 and 1963) and Dar Al Handasah Cons. Eng.(1967), it becomes possible to determine a tentative future development of the cropping pattern. The main determining aspects are the demand for agricultural produce, the total area available for crop cultivation, the benefits of individual crops, and crop-rotational requirements.

Wheat has to be included in the cropping pattern as the main field crop because of its paramount importance for rotation and for the nutrition of population. It will find an easy market in Jordan as long as it is imported from outside and the population increases. Farmers are familiar with wheat growing and they will most likely continue to produce part of their wheat requirement for home consumption themselves, at least in the near future. They prefer it at present as no other crops are available which have the same rotation advantages and with benefits which are at least of the same level as wheat. Since the income from wheat is low and their is a possibility of its expansion to cultivation on the hills, it will be more advantageous if the wheat acreage is restricted in the valley to a percentage necessary for a sound rotation. It is assumed that, in future, the declining acreage of wheat can be compensated by the high yields from new varieties, resistant to diseases and drought, and favourable management conditions such as irrigation and fertilisation etc.

Vegetables have higher benefits than cereals, therefore they have the largest present acreage in the valley. In spite of their high benefits, vegetable growing will be limited, partly by market considerations and water requirements and also by pest and disease hazards. In the hot conditions of the valley the creation of uncontrollable pest and disease situations, by continuous cultivation or specialised production of the Solanacaeae family (tomatoes, eggplants, peppers, potatoes), is an ever-present danger. Such situations have already arisen in parts of the valley and significant areas of land have been abandoned because of the concentration of nematodes and soil-borne disease organisms. A continuous cultivation of the Solanacaeae family for more than one year is not advisable since rotation can check the incidence of pests and diseases and allow effective field hygiene.

The above-mentioned aspects (high benefits, restrictions with respect to crop rotation and demand) have been taken into account in projecting the share of vegetables in the future cropping patterns. In the long term, an eventual reduction of the total area of vegetables and a limited increase in output due to improved yields will occur. It is assumed also that there will be a shift to fine vegetables, as market demand develops, and a consequent increase in value.

Fruit, predominantly consisting of citrus and bananas, shows the highest benefits of all crops. Bananas have the great advantage that they yield the year after they are planted, and although they require at least twice as much labour per dunum for cultivation and twice as much water per dunum as citrus, and are easily damaged by frost, they will continue to be the most economical short term crop. Since bananas and citrus are perennial crops, no crop rotational aspects will be involved. Only demand presents a limiting factor. Fruit, therefore, should be included in the cropping pattern up to a level of production which is in line with the demand projections.

It is assumed that in the southern valley generally and the Ghor Kufrein particularly, there will be a shift from citrus towards dates and grapes. Experiments with different types of grapes by the Ministry of Agriculture at Jericho indicate that they are very suitable for the southern valley and would be a more profitable crop than citrus. The water requirements are very much lower than for citrus; moreover, the grapes salt tolerance is medium and that of citrus is low to medium. It will appear a sort of mixed citrus-dates orchards as recent experiments in limiting the spacing of the palm trees to 10 metres and planting citrus in the spaces between, indicate that the yield of citrus is increased due to shading. Date palms, however, suffer the disadvantage that they take about twelve years to become fully bearing, but they can tolerate higher groundwater salinities than any other crop.

Dairy-farming benefits on the basis of irrigated fodder crops are the smallest of all present farm types. Compared to wheat-growing, dairy-farming is much more profitable. Fodder crops have higher water requirements and fit well into any rotation scheme and may, therefore, replace wheat to a large extent. Moreover, large amounts of indispensable organic manure for an intensive cultivation of vegetables and fruits will be produced by the dairy herd. As no demand limits with respect to milk and meat production are projected, there is every reason to expand dairy-farming as rapidly as possible, mainly at the expense of wheat-growing.

Dairy-farming should be based on the cultivation of irrigated fodder crops. By using alfalfa as a perennial crop and berseem as an annual winter crop, leguminous fodder with a high protein content will be available throughout the year. Fodder yields in summer can be increased by including fodder maize in the cropping pattern. The total area under fodder crops has been calculated on the basis of the estimated fodder yields and on a certain amount of fodder consumption per animal. It has been assumed that the adult cow needs some 4 dunums of fodder crops on average per year in order to give some 3300 Kg. milk. The produced milk can be processed in a dairy plant established in the valley.

Numerous experiments have been done on the industrial crops in the Agricultural Research Stations of the valley. It has appeared that such crops as sugar-beet, cotton, safflower, sunflower, castor, linen, sesame, and peanuts can be cultivated successfully in the valley as far as climate and soil conditions are concerned. Nevertheless, owing to economic considerations, it can be suggested that only safflower, sunflower and castor should be included in the anticipated cropping patterns.

Sugar-beet cultivation should not be included in the cropping pattern due to the fact that the cost of producing one ton of sugar will be considerably higher than the import price of sugar taken as an average over the past years. According to the Austrian Mission (1967)[5] in its "feasibility study on a Sugar Industry in Jordan," the assumed prices of white sugar Jordanian made is J.D.80 per ton, while the world market price of sugar is about J.D.30 per ton. Moreover, a downward trend in the international sugar prices is expected in the future. Although the net income of sugar-beet per irrigated dunum in the valley is small (J.D.9.5 according to the Austroplan), Austroplan recommends the establishment of a beet sugar industry in Jordan since such an industry would save substantial amounts of foreign currency. However, it is better for Jordan to cultivate fruit and vegetables and to import cheap sugar from the world market than to produce sugar at home at relatively high cost.

Cotton has been omitted from the cropping pattern due to its competition with both winter and summer vegetables whose benefits are higher. Moreover, it is a difficult crop to grow and it is less suitable for crop rotation purposes, mainly because it acts as a host plant for many insects attacking vegetables. Linen should not be included in the anticipated cropping patterns since, as a winter crop, it replaces the wheat in the rotation and has fewer benefits than the wheat.

Safflower is a profitable crop which must replace wheat in the cropping pattern. As a winter crop, it is like the wheat in the dates and methods of seeding and harvesting. Its superiority derives from its higher yield, where its seeds yield is 300 Kg. per dunum on average, and the percentage of oil in seeds is approximately 40 percent of seed-weight. The cost of production is, on average, J.D.2 per dunum, whereas the price is J.D.0.05 per Kg., giving a value of J.D.15 per a dunum for the seeds only. The Ministry of Agriculture has encouraged farmers to cultivate this crop, particularly after the success of experiments done in the research stations of the valley which have shown that the consumption rate of the crop from water varies from 400 to 500 m^3. per dunum. Accordingly, the farmers have begun to cultivate the crop to such an extent that "Seed Oil Company" of Nablus imported pressing machinery preparing the plant to work from the beginning of 1967

The safflower oil industry will be successful economically since the production of oils from seeds is some 120 Kg. per dunum and the price is J.D.160 per Kg. giving a value of J.D.19.20 per dunum for the oils only. It is expected in future to introduce some of the high yield varieties such as the "Gila" variety which can raise the value of benefits.

Sunflower should be included in the anticipated cropping patterns in a very limited acreage, because it has less benefits and is more difficult to harvest than the safflower. Its advantage derives from its late cultivation potential and its medium consumption of water

(400-500 m^3. per dunum). The income of sunflower is estimated at J.D. 5.25 per dunum for seeds and J.D.11.50 per dunum for oils. The sunflower oil industry should not be encouraged owing to the small areas of sunflower crop and to the difficulty of its cultivation. The small amounts of production can be either sold as seeds in the neighbouring countries or pressed to oils with the safflower seeds in the "Seed Oil Company" plant in Nablus.

The valley is, at present, a treeless tract in spite of the paramount importance of the trees as a conservation measure. Fast growing tree species (Poplars) should be included in the anticipated cropping patterns. Veltkamp (1966),[6] has made a tentative comparison of the economics of some agricultural crops and plantations of fast growing tree species under irrigation in the Jordan Valley. From his calculations it can be concluded that the raising of fast growing wood can compare favourably with the production of agricultural crops. In fact, with an average land expectation value of J.D.80 under poplars, it seems that poplar cultivation could be a better proposition than annual agricultural crops at least on the less productive sites, which have a land expectation value of J.D.88 (cauliflower) and J.D.72 (tomatoes).

Growing tree crops could increase the possibilities of a well balanced rotation system. The flexible time schedule of operation of tree growing would provide additional employment for agricultural labour during slack seasons and reduce the work load during the busy agricultural seasons. Forest tree species can be planted to form shelterbelts and windbreaks, in linear strips suitably aligned over the cultivable areas. They can be raised along main canals, roads, and can utilise tail-end (irrigation waste) waters. These shelterbelts will use irrigation water only notionally, since no specific supplies of water need be drawn separately for them. They will be so designed and managed that they will yield regular supplies of wood also.

It is assumed that numerous industries based on trees, will be established in the valley. Under condition of adequate irrigation, intensive practices of cultivation and protection, Veltkamp has estimated the net standing value of the final crop felled per year at 50 m^3./dunum. Accordingly, it is assumed that the wood grown will be accepted mainly for box manufacture. It is believed that the present high prices paid for poles in the area, would not be maintained when the present extreme scarcity is alleviated by local production. It is known that the rapid growth of agricultural production in the valley is accompanied by an increasing demand for packaging material. The majority of the crops grown are horticultural commodities which require packaging for their transport. Other industries will also be established in the future such as a match industry, saw-milling industry, particle board industry, and pulp and paper industry.

Projected Cropping Patterns:-

Based on the considerations with respect to demand, benefits and crop rotation, as have already been discussed, the basic cropping pattern for the total area of 317,810 dunums including cereals, vegetables, fruit, forage crops, industrial crops, and fast growing species of industrial value, has been determined at a cropping intensity of 132.5 percent for the northern valley (Stage 1), and 125.5 percent for the southern valley(Stage II). The anticipated figures of the cropping patterns are shown as follows:- (Table 9.16).

The proposed cropping patterns for the valley, in comparison with the present cropping patterns, indicate the following main changes:- The cereal acreages have been decreased from 28 percent of the cropped area to 14 percent. The 50 percent decrease will be devoted to forage crops and industrial crops. Wheat will remain as the primary crop in the cereal acreage for rotation. The vegetable acreages have been decreased from 47 percent to 40 percent. The decrease will be in favour of fast growing tree species of industrial value. Although tomatoes will have the primary importance in the vegetable acreage,it is given a restricted area in the cropping pattern, a procedure which is indispensable to keep the market equilibrium undisturbed. Fruit acreages have been decreased from

TABLE 9.16. Tentative anticipated cropping patterns.

Crops	Stage I (Northern Valley)		Stage II (Southern Valley)		Total average intensities of the total valley %
	Cropped area in dunums.	Percent of cropped area %	Cropped area in dunums	Percent of cropped area %	
Wheat	12951	10	10485	9	
Barley	6475	5	4660	4	
Total Cereals	19426	15	15145	13	14
Tomatoes	6475	5	11650	10	
Other vegetables.	38853	30	40776	35	
Total Vegetables.	45328	45	52426	45	40
Bananas	12951	10	8155	7	
Citrus	16189	12.5	4660	4	
Other fruits	7123	5.5	3495	3	
Total fruits	36263	28	16310	14	21
Alfalfa	16189	12.5	9903	8.5	
Berseem	5180	4	11068	9.5	
Fodder maize	16189	12.5	17475	15	
Total forages	37558	29	38446	33	31
Safflower	12951	10	4660	4	
Sunflower	3238	2.5	5825	5	
Other Industrial crops	6475	5	2913	2.5	
Total Industrial crops	22664	17.5	13398	11.5	14.5
Fast growing trees.	10361	8	10485	9	8.5
Grand Total	171,600	132.5	146,210	125.5	129

Source:- Field work.

28 percent to 21 percent. Most of this decrease is concentrated in the citrus plantations in the southern valley. It is clear that the expansion of citrus plantations in the recent period has been invading the marginal areas of Class IV lands which have saline soils. Therefore, owing to the low tolerance of citrus to salinity and subsequently the low yields of citrus, it is recommended that the expansion of citrus should be restricted and some of the orchards must be replaced gradually by grapes and dates which have a place in the cropping pattern. Bananas will have the first place in fruit cultures due to its high benefits and adaptability with the valley conditions.

Forage crops have increased from 0.8 percent to 37 percent due to their intimate relations with the anticipated dairy farming in the valley. Fodder maize will be a leading crop since there will be a growing demand for it as cattle feed in the future. In order to stimulate the farmers to grow maize, a certain degree of subsidizing would be recommendable in view of the low benefits derived from its cultivation. Subsidies have been given at present to those farmers who allocate a part of their cultivated land in the project area for alfalfa owing to its importance for rotation and cattle feed. Berseem will have a larger place in the cropping pattern than at present.

Industrial crops will have some 14 percent of the anticipated cropping pattern with the emphasis on safflower which is most important (7 percent). Castor trees are encouraged to be cultivated at the extreme southern parts of the southern valley where they can bear the drought and heat. Fast growing tree species of industrial value will have some 8 percent of the cropping pattern where they are advantageous economically and as a means of conservation.

The following hypothetical production pattern for an assumed maximum of 317,810 irrigable dunums in the valley has been designed on the basis of the forementioned considerations, discussions with officials of the Ministry of Agriculture, and the results of experimentations of the Deir Alla Station.

TABLE 9.17. Hypothetical pattern of cropped areas, gross production value (G.P.V.) for the irrigable farming in the valley.

Crop	Cropped area in dunums	Yield in Kg. per dunum	Production in Kgs.	Price in J.D./Kg.	Value in million J.D. (G.P.V.)	Percentage of (G.P.V.)
Cereals	34,571	200	6,914,200	0.032	0.221254	2.04
Vegetables	97,754	1820	177,912,280	0.016	2.846596	26.33
Fruit	52,573	2000	105,146,000	0.042	4.416132	40.85
Forages	76,004	1000	76,004,000	0.010	0.760040	7.03
Industrial crops	36,062	300	10,818,600	0.055	0.595023	5.50
Fast growing trees	20,846	1000	20,846,000	0.012	0.250152	2.31
Total cropped area	317,810		397,641,080		9.089197	84.08
Value of Livestock products*					1.719710	15.91
Total G.P.V.					10.808907	99.99
G.P.V. in J.D. per cropped dunum	J.D. 34.01					

Source:- Information collected during field work.

* Value of animal produce:- 18,000 milk cows x 3000 Kg. = 54,000 tons of milk. Value 40 J.D./ton = 2.16 million. 10,000 calves sold as meat x 50 Kg. = 500 tons veal; 3,000 adult animals, discards x 250 Kg. = 750 tons beef. 1250 tons veal and beef x 235 J.D./ton = J.D. 0.29 million. 13,000 hides at J.D. 2 per piece = J.D. 26,000. Value of animal produce (2,479,750) - the value of forages production (J.D. 760,040) = The net value of animal production (J.D. 1,719,710).

It can be concluded that the gross productive value will rise to some J.D. 9 million as a result of the intense irrigation agriculture accompanied by high yields. G.P.V. per cropped dunum will rise from the present J.D. 15.5 to J.D. 34 per cropped dunum. It is anticipated that three main farm types will develop:- mixed farms with vegetables as main crop, and cereals and fodders as rotation crops; fruit farms, mainly specialised in citrus or banana-growing; and livestock-farms based on a dairy herd and fodder crop cultivation. The mixed farms are assumed to cover the vast majority of the cultivated area.

The average rate of the anticipated production per capita will be some 1.57 Kg. of cereals per capita per year (on the basis of the 4.4 millions population in the year 2000), whereas the average rate of consumption per capita will be some 26 Kg. of cereals per year. The average rate of the anticipated production and consumption of the vegetables will be 40.43 Kg. and 10 Kg. respectively per capita per year. Those of fruit will be 23.89 Kg. and 12 Kg. respectively per capita per year. Accordingly, the valley will continue to import wheat for the diet of its population and continue to export the cash crops of vegetables and fruit .

The trend of yields to increase in the future will be accompanied by a similar trend of costs of production. The highest increase of inputs will be observed for hired labour, fertilisers and plant protection. The total anticipated inputs per a cultivated dunum is estimated at J.D. 25 including the ordinary farm expenses and the cost of repayment and interest for the land allocated to the farmers. When subtracting those expenses from G.P.V. of a culativated dunum, which is J.D. 34, the total farm income will be J.D. 9 per cultivated dunum.

Conclusion

The cultivated lands occupy some 40 percent of the total area of the valley. Vegetables play the primary role in the cropping pattern followed by cereals and fruit. However, numerous local agricultural belts can be distinguished along the valley from north to south as follows (fig.9.13):- a citrus-banana belt occurs in the areas 1-7 of Section 1 of the project area (Stage 1) occupying some 63 percent of the cropped lands. A cereal belt includes the areas 8-9 of Section 1 occupying some 61 percent of the cropped lands. Area 10 of Section 1 represents a small citrus belt occupying 38 percent of the cropped lands in this area.

Section II of the project area comprises another three agricultural belts as follows: a cereal belt occurs in the areas 11-14 occupying 48 percent of their acreages. Areas 15-18 include the citrus-banana belt with a small vegetable belt in the area 17. They occupy 51 and 78 percent of the cropped lands respectively.

Section III of the project area represents a large vegetable belt with mainly tomatoes, cucumbers, and peppers. It occupies some 43 percent of the cropped lands in this section. There is a dissected belt of cereals (100 percent of the cropped lands) located between the area 24 of Section III and north of the Karameh in Ghor Kebid. The vegetable belt located between Karameh and Southern Shuneh occupies some 95 percent of the cropped lands. Between Southern Shuneh and Kufrein there is a banana citrus belt with a small wheat belt enclaved inside it and located in the northern part of the Kufrein area. The vegetable belt in Ghor Rameh is the southernmost agricultural belt in the valley occupying 52 percent of the cropped lands.

The agricultural yields differ from place to place inside the valley; generally, the northern valley has higher yields than the southern valley;. Soils and irrigation waters are the basic factors of the agricultural yield problems. Climate with its high temperatures, occasionally cold winds, and rain fall fluctuation affects both crop and livestock yields. Common pests, diseases and weeds play an important role by affecting yields.

The total G.P.V. of the valley has increased from J.D.872,600 in 1953 to J.D. 3,861,700 in 1965, and it is anticipated that it will reach to J.D. 10,808,907 in 2000. The G.P.V. from vegetables shows a rise from 28 in 1953 to 70 percent of the total G.P.V. in 1965, and it is anticipated that it will decrease to 26 percent. During the same period, the G.P.V. from fruit shows a rise from 12 to 15 percent and it will rise to 41 percent. The G.P.V. from cereals shows a decline from 54 to 13 percent and it will decrease to 2 percent. The G.P.V. from Livestock shows a decline from 6 to 2 percent, and it is anticipated to be 16 percent as a result of introducing forage crops in the cropping pattern. Industrial crops are anticipated to account for some 5 percent of the total G.P.V. and fast growing trees some 2 percent.

The average income of the sample farms per cultivated dunum is estimated at J.D. 11.87 per annum; whereas the total farm income of the valley in the year 1965 per cultivated dunum is estimated at J.D. 6.80. It is anticipated that the total farm income will be J.D. 9 per cultivated dunum.

It is suggested that numerous industries can be established in the valley based on the anticipated land use. Electrical industry will be erected as a result of the entire Yarmouk-Jordan Valley project. Based on this industry and on the anticipated land use, agricultural and dairy industries will appear such as processing of fruit and vegetables, a dairy and meat industry, wood industries, and fish ponds industry.

References:-

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Chapter 10.

MANAGEMENT ASPECTS OF THE PRESENT LAND USE SYSTEM.

"There can be no human geography that does not concern itself with communities as associations of skills"

C. Sauer[1] (1941).

In addition to combined physical factors, present land use is also the result of reacted human factors. Since the physical factors have been dealt with in the previous chapters, the human factors have to be explained in this chapter as aspects of land use. The economic aspects of land use such as irrigation, ownership, marketing, and population will be discussed.

Irrigation.

At the present time, water for irrigation is supplied by the gravity flow of the East Ghor Canal from the River Yarmouk, by gravity flow from perennial wadis and springs, and by pumping from wells and the River Jordan.

The East Ghor irrigation scheme utilizes some of the waters of the River Yarmouk which are shared with Syria under a 1953 agreement between the two countries. These waters are diverted by gravity through a side-channel, 9 Km. above the confluence with the Jordan and carried by a 1 Km. tunnel through to the Ghor lands on the left bank of the Jordan. A main concrete-lined canal takes water southwards under gravity, for a distance of 69 Km., along a course roughly parallel with the river and three to six kilometres east of it. Beyond this for 8 Km., the Natural Resources Authority has been authorised to take necessary measures for extending the canal. A loan from the Kuwaiti Loan Fund will be used to finance this project. The land between the canal and the river can be irrigated by a controlled gravity flow through lateral dropways. Syphons and pumps supply water to a few areas of irrigable

Plate XXIV. The East Ghor Canal.

land east of the canal.

To facilitate the process of execution, the scheme has been carried out in three main sections giving at present an irrigated area of some 123,000 dunums. It was scheduled for completion in a five-year period commencing in August 1958. Section 1, extending from Adasiyeh to the Wadi Ziglab, includes 22 Km. of main canal and is divided into ten development areas for the purposes of irrigation and drainage control, feeding a total of 30,000 dunums of land since 1961. Irrigation in Section II with eight development areas from Wadi Ziglab to Wadi Abu Kharrub (24 Km. of main canal) commenced early in 1963, feeding a total of 33,000 dunums. Section III, extending from Wadi Abu Kharrub to Arda road, includes 24 Km. of main canal and is divided into six development areas, feeding a total of 60,000 dunums of land since the end of 1965 (fig.10.1).

The total cost of the scheme is estimated at 7 million J.D. Construction funds were provided by the United States Government (5.2 million J.D.) and the monies for administrative and technical services by the Jordanian Government (1.8 million J.D.). This cost includes the construction of the main canal, the irrigation channels, and drainage nets The advantages of the present three-section scheme lie in its low construction costs and rapid completion as no dams or reservoirs have been needed and most of the water is distributed under gravity flow. Nevertheless, the flow of the canal ranges at present, between 100 and 120 mcm. per year, the amount of which is less than the potential capacity flow of the canal which is 140 mcm. per year.

Wadi diversions of the side wadis constituted the largest irrigation schemes in the valley before the construction of the East Ghor Canal. Ten wadi diversions were made under the Director of Irrigation from 1948 up to 1961 when the East Ghor Canal Authority* (E.G.C.A.) purchased most of the water shares of the side wadis in the project area.

* Hereafter E.G.C.A.

Most of the lined canals of the side wadi waters lie above the East Ghor Canal and they are now integrated with it. Those portions of the side wadi system, which lie below the East Ghor Canal consisting of inefficient, unlined supply and distribution channels, have been modified and replaced by the new system of irrigation channels of the East Ghor Irrigation Project. It is important to note that the East Ghor Canal supplies all of the irrigated area below it in the Ghor and the Zor by gravity; also it supplies some of the irrigated area above it in the Ghor by pumping.

In addition to irrigation from the East Ghor Canal and the side wadi streams, the project area is supplied also with irrigation water from springs, wells, and River Jordan itself by pumping. These supplementary sources of irrigation are very important particularly in summer, the critical period for water supply from the canal. In spite of the supplementary supply, a deficiency in water requirements occurs during summer. Therefore, as has been suggested in chapter 3, increasing the amounts of groundwater in the project area by artificial recharge is urgently needed to combat the problem of water deficit in summer. The execution of the Yarmouk-Jordan Valley project will be the only long term effective policy of tackling this hydrological problem.

The portions of the valley outside the project area to the south are dependent, in their irrigation, on the waters of side wadis such as Shueib, Kufrein, and Hisban Wadis, in addition to the waters of scattered wells and the waters of River Jordan. Suffering from deficiency and salinity of waters, these areas await the completion of the entire Yarmouk-Jordan Valley project to solve their problems.

Baker and Harza (1955)[2] have suggested a programme for the irrigation of the Jordan Valley, consisting of five stages (fig.10.2). Stage 1 refers to the area below the main canal and extending some 70 Km. south from the River Yarmouk to the present Arda road; Stage II refers to the area below a main canal to be continued south from the end of Stage 1 (Arda road) to Wadi Tarfeh north of the Dead Sea; Stage III refers to the

Plate XXV. Distribution of water from the farm-head channels.

Plate XXVI. Distribution of water-development area 2.

West Ghor; Stage IV refers to dams and irrigation facilities on the side wadis east of the River Jordan; and Stage V refers to areas above the main canals to which water must be pumped.

Early in 1964, work on the main canal had been completed throughout Stage 1 and a beginning made on the construction of the first of the side wadi dams (Stage IV). In March 1967, this dam of Wadi Ziglab was inaugurated to supply 10 mcm. of water per year. A British long term loan amounting to J.D. 1,200,000 was extended to Jordan in 1966 for the implementation of the construction of Kufrein and Shueib dams. The annual storage capacity in both dams exceeds 17 mcm. which will irrigate an area of 34,000 dunums in the southern valley (15,000 dunums at Ghor Nimrin and 19,000 dunums at Ghor Kufrein). Both dams were scheduled for completion by the first half of 1968.

In 1964, an agreement between the Government of Jordan and a Yugoslav consulting firm (ENERGO.) was signed, by which the firm had made a feasibility study of the construction of a dam on the Yarmouk. In the same year, the firm produced the final report including recommendations and setting up cost estimates and cost benefit analysis.(3) The firm suggested the construction of Khalid Ibn El Waleed Dam with an annual capacity of 200 mcm. as a part of the entire Yarmouk project; construction of Zor canals and raising the sides of the East Ghor main canal to carry 20 m^3./Sec. instead of 10 m^3./Sec.; construction of a new canal 60 Km. long parallel to the main canal with a capacity of 16 m^3./Sec. in addition to another similar canal in the West Ghor attached by a syphon; extension of the East Ghor Canal by 42 Km. to irrigate the southern valley by a system of laterals; construction of the Maqarin Dam with a capacity of 350 mcm.; and construction of six pumping stations. The objective of these suggestions is to realise full irrigation for the greatest possible area and generation of hydro-electric power from installations associated with the storage dams on the Yarmouk River with up to 62 megawatts installed capacity.

In the Arab Summit Conference held in 1964 in Alexandria, the Heads of State confirmed the construction of Khalid Ibn El Waleed dam on the Yarmouk, raising the sides of the East Ghor Canal in such a way that it can flow 20 m^3./Sec. instead of 10 m^3./Sec., and the construction of Zor canals to irrigate some 40,000 dunums which suffer from salinity induced by pumped waters from the River Jordan. In May 1965, the Jordan River and Tributaries Regional Corporation was established to undertake the responsibility of execution of the water schemes related to the River Jordan and its tributaries. In September 1965, the Regional Corporation held an agreement with the Arab Contractor Firm by which the firm agreed to construct the Khalid Ibn El Waleed Dam on the Yarmouk. In May 1966, the King of Jordan inaugurated the foundation stone of the dam body and it was expected to be completed at the end of 1968.

The Khalid Ibn El Waleed Dam Scheme is the first stage of the entire Yarmouk Scheme of the 1953 agreement between Syria and Jordan. The second stage will be the construction of Maqarin Dam on the higher Yarmouk, and the third one will be the construction of Side Wadi Dams and installation of hydro-electric power on these dams. The first stage (Khalid I. Waleed Scheme) is composed of three integrated stages: the first stage is the construction of irrigation and drainage nets and raising the sides of the East Ghor Canal; the second stage is the construction of the Dam body on the Yarmouk, adduction tunnel, and hydro-electrical power in Northern Shuneh; the third one is the extension of the East Ghor Canal to the southern valley east and west of River Jordan, and the construction of a new canal parallel to the present East Ghor Canal.

The execution works of the first stage have been done by contracts with Arab and Yugoslav firms. The work of raising the sides of the first section, a distance of some 37 Km., began in October 1964 with costs of J.D. 101,266, and was accomplished in 1966. The work in the second section (32 Km.) began in December 1965 and was accomplished in early 1967, with costs of J.D. 85,429. With regard to the Zor canals, the work of execution were divided into two stages; Stage A included the construction of three canals, Zarqa Zor Canal, East Zor South Canal, and West Zor South Canal. Works began in the Stage A in September 1965 and were expected to be accomplished in 1967 with costs of J.D. 551,320. Detailed description of Stage A, can be found in the Energoprojekt Consulting Engineers Report (1964).(4) Works began in the Stage B, including West Zor North Canal, in early 1966 and were expected to be completed in 1967 with costs of J.D. 230,232.

The execution of the second stage works (Dam body) began in August 1965 including eight parts such as colonies, adduction tunnel and accessories, dam body, grouting and grouting curtain, compensating basin, railway relocation, hydraulic steel structures and turbine generators and cranes. The total costs of the works is estimated at J.D. 13,987,982* divided between the costs of the dam body (56.5%), adduction tunnel (27.3%), Power Stations on the dam and in Shuneh(13.8%), access tunnels (0.8%) and compensating basin (1.6%). Execution works of a small part of the third stage were represented in the completion of the design, for extension of East Ghor Canal for 8 Km., in the end of 1966, and the allocation of J.D. 750,000, in the general budget of the Government, to execution works.**

Khalid Ibn El Waleed Dam is being built on the Yarmouk where the natural contours of the area provide a suitable location for a low dam of some 200 mcm. capacity and a power potential of 30,000 kilowatt hours per year.(5) The projected dam would be some 1150 m. long and 90 m. high. Its location on the Lower Yarmouk enables it to receive any waters channelled to it from the Banias and Hasbani in Syria and Lebanon. It provides enough storage for winter flood waters of the river so that the flow waters of the East Ghor Canal become regular and sufficient at any time of the year. According to the Arab Scheme of the exploitation of

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* This sum is paid by all of Arab Governments according to an agreement of Arab Summit Conference.

** It is notable that all of these execution works have been suspended since the war of June 1967 up to the present time, since they are located in or near the cease fire area.

River Jordan and its tributaries, Banias Canal (70 Km.) will discharge into this dam via Ruqad stream. The planned capacity of the canal is 12 m^3./Sec. and the annual discharge is set at 100 mcm.

Having discussed the present irrigation schemes either those implemented or those going to be accomplished, it is convenient to discuss a summary of the potential irrigation waters in the valley as is shown in the following table:-

TABLE 10.1. Water potential in the valley.

Source	Water supply in MCM.
Khalid Ibn El Waleed Dam	200
Maqarin Dam	160
Banias Canal	100
Total of the River Yarmouk	460
Wadi Arab	31.45
Wadi Ziglab	10.38
Wadi Zaqra	77.00
Wadi Shueib	08.50
Wadi Kufrein	08.25
Other side wadis	53.70
Total of side wadis	189.28
Total of the Yarmouk and Side Wadis	649.28

Source:- 1) M.MacDonald (1965), East Bank Jordan Water Resources Vol.2.
2) Energoprojekt Cons.Eng.Comp. (1964), The Yarmouk Project. Report on El-Mukheibeh Dam (Khalid).

MacDonald (1965)[6] has anticipated that some 43 mcm. of the waters of the side wadis will be used for the irrigation of areas lying above the main canal and in the immediate vicinity of the side wadis. On the other hand, Energoprojekt Cons.Eng.Comp. (1964) has anticipated that all areas lying below the main canal will be irrigated by gravity, while those extending above the canal and areas in the Zor will be irrigated by pumping. It is anticipated that some 260,250 dunums in the valley will be irrigated by gravity from main canals and some 15,200 dunums by gravity from side wadis above the main canal. On the other hand some 16,950 dunums will be irrigated by pumping from main canals and some 2,350 dunums by pumping from side wadis. Springs and wells will irrigate some 26,500 dunums. Accordingly, the total anticipated irrigated areas in the valley will be some 321,250 dunums.(7)

Irrigation Methods:- Surface methods of irrigation are common in the valley at present due to their reduced capital costs and operating expenses when compared with sprinklers. In general, surface methods appear to be most advantageous when soils are relatively uniform and can be levelled, when infiltration rates are low, when frequent gusty winds occur and when leaching is required. Thus, for most of the valley, surface methods appear to be adapted with the forementioned conditions. In the southern valley, numerous combined factors are conducive to the absence of the sprinkler method either at present or in the future, namely, expense, high values of evapotranspiration and wind erodibility index, leaching requirement from the salts, and relatively low infiltration rates of the soils.

Surface irrigation includes the general methods of flood and furrow and corrugation irrigation. Basin irrigation which is a part of flood irrigation method is widespread in the valley for close-growing crops and orchards. Border strip irrigation is used on uniform slopes up to 3 percent for some row crops. Furrow irrigation is the most common method of applying water to row crops; water is applied in the furrows between the rows of plants. It is adapted to all row crops, vegetables and orchards on gentle slopes. Corrugation irrigation is well adapted to close-growing crops on sloping and rolling lands of the valley that have low infiltration rates; it is limited due to the fact that it is relatively expensive in labour.

The valley needs a careful planning for the irrigation system. How to apply irrigation water to crops without causing soil to erode is a big problem in the valley. Furrow and corrugation layouts are handled together because they are both subject to erosive action and both are

Plate XXVII. Furrow irrigation being used in the valley.

Plate XXVIII. The irrigation of peanuts at Deir Alla.

thought of as generally carrying the water from one end of the field to the other. The allowable size of streams on sloping lands largely depends on the slope at which the furrows are laid out. The general relationship of maximum allowable furrow stream and slope is $Q = \frac{10}{S}$, in which Q is the maximum non erosive furrow stream in gallons per minute and S is the slope of furrow in percentage.[8] Thus, if the slope of the furrow is 0.2 percent, the furrow will carry 50 gallons a minute without serious erosion. With a slope of 2 percent, the furrow will safely carry only 5 gallons a minute. Maximum allowable length of run depends on several factors, including the maximum allowable stream size, the rate at which water is absorbed by the soil, and the amount of water to be stored by each irrigation.

The size of the irrigation stream depends on the soil, and depth of application. Soils of high intake rates require large streams to get the water over the land rapidly if excessive deep-percolation losses are to be avoided. Likewise, for shallow irrigation, large streams must be used. Small streams are desirable for deep applications. Wiggins (1961)[9] has suggested the maximum length of run with 10 cm. depth of application for the irrigation streams of the project area in the valley as follows:-

TABLE 10.2. Maximum length of run with 10 cm. depth of application for the irrigation streams of the project area.

Slope %	Soil Texture		
	Coarse (LL)	Medium (mm)	Fine (hh)
	Metres	Metres	Metres
0 - 0.9	100	165	220
1 - 1.9	70	110	145
2 - 2.9	55	90	120
3 - 3.9	45	80	100
4 - 4.9	40	70	90
Maximum length of run with 10 cm. depth of application	145	245	310

Source:- EGCA., Memorandum about the proposed standards for farm unit layouts. Amman (1961).

It is recommended also that for larger depths of application, runs may be lengthened up to a maximum of 390 metres.

Spacing of furrows and corrugations sometimes can be varied within certain limits. Spacing greater than 75 cm. generally is not desirable for most annual crops, because the root zone is so limited during much of the season. In general, the coarser the soil, the closer the corrugations should be spaced for efficient irrigation, but spacings of less than 35 cm. are seldom practical to construct and maintain.

Border strip layout depends on the intake rate of the soil, the slope, and the depth of application. With slopes of 0.5 percent, a flow of 0.1 cubic foot per second per foot of border strip width may be safely used; with a slope of 2 percent, the safe value falls to about 0.035. Thus a longer run is possible on the flatter slopes.

The rates of water use and the number of days of irrigation interval are very important to determine. The average requirements of various crops in the valley differ from one season to another and from month to month through the one season. For instance, the average requirements of vegetables, citrus, and bananas in the valley from November to March are estimated at 4,2, and 6 m^3./day respectively; from April to October, they are 6,3, and 9 m^3./day respectively. The number of days a crop may be expected to go without showing need for water can be estimated by the following simple calculation:[(10)]

$$\text{Irrigation interval (in days)} = \frac{SAM}{RWU}$$

In the formula, SAM stands for the supply of available moisture within the root zone (in cms.), which is divided by RWU, the rate of water use (in cms. per day). Applying this formula, Department of Irrigation has designed a schedule by which crops can be irrigated. For instance, pertaining bananas in the valley, five day intervals from approximately May to October, ten days during November, 15 days in December and down to 10 days again in the period from January to April.

Land Ownership:-

Not only has the East Ghor Irrigation Project changed the cropping pattern in the project area, but it has changed also the land ownership pattern. The following table shows the land ownership pattern prior to the execution of the project.

TABLE 10.3. Land Ownership Pattern in the Project Area* (July 1960).

Holding Size in dunums	Number of Owners	Percentage of the total of Owners %.	Area owned in dunums	Percentage of the total owned area %
1 - 9	1301	36.21	5495	3.91
10-19	708	19.70	9935	7.06
20-29	375	10.44	9006	6.40
Sub-Total	2384	66.35	24436	17.37
30-75	842	23.43	37746	26.83
76-100	108	3.01	9431	6.70
101-500	225	6.26	41831	29.74
501-1000	28	0.78	18908	13.44
+ 1001	6	0.17	8329	5.92
Grand Total	3593	100	140681	100

Source: Department of Lands and Surveys.

It can be concluded that a large part of the land in the project area was the property of a relatively small number of owners, while a large proportion of the total number of owners had title to a small part of the land. To take one extreme, 36 percent of landowners owned plots of under 10 dunums which together amounted to only 3.9 percent of the total area; at the other extreme, less than 1 percent of landowners own over 19 percent of the land in plots of over 500 dunums.

Although the figures here are not comparable to those of the UNRWA. Survey of 1956,(11) owing to the difference in area covered, evidence points to a reduction of the area of large holdings since 1956.

* The held lands in this table are privately owned (140,681 dunums), State domain area is some 37,129 dunums. Thus the total is 177,810 dunums.

The reduction was attributed to the passage of the law of the East Ghor Canal in 1959, conducing to the breaking up of many large ownerships and distributing them to members of the owners' families. On the other hand fragmentation of the lands has been a natural result of the inheritance system.

The individual parcel of irrigated land was usually of an inconvenient shape, being extremely long and narrow; only the rain cultivated land was divided into relatively square-shaped plots. This already serious situation was further aggravated by the fact that some of these long strips were split in two by other features of the landscape such as a swamp or a road.

The execution of the East Ghor Irrigation Project was accompanied by land reform (figs.10.3 and 10.4). Land has been acquired by the East Ghor Canal Authority (EGCA.) representing the Government, and redistributed to farmers under the East Ghor Canal Law of 1962.* A reasonable compensation has been paid to the landowners. The value of the land was estimated according to the land classification made in the Baker and Harza Master Plan at current prices, disregarding any appreciation in value from the construction of the project. To these was added the value of customary water rights as well as that of buildings, trees, etc., The assessment was done according to Article IX of the (EGCA.) Law by a Land Evaluation Committee presided over by a judge, and the evaluation was subject to appeal. The value is payable in 10 years and bears interest of 4%. The summary of the present land ownership in the project area is shown in the table 10.4.

It can be seen that after the execution of the East Ghor Irrigation Project accompanied by land reform, a large part of the land in the project area has become the property of a large number of owners; a large proportion of the total number of owners has title deeds of medium plots of land. At present, more than 90 percent of landowners own

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* Some paragraphs of the Article VIII of Law No.13 (1962) can be seen in the Appendix (Table 10.1 (App.10)).

Plate XXIX. A Committee engaged in redistributing farm units at work.

TABLE 10.4. Land ownership pattern in the project area*
1965.

Holding Size in Dunums	Number of Owners	Percentage of the total of owners %	Area owned in dunums	Percentage of the total owned area %
30	2332	66.99	33589	37.10
31 - 50	808	23.21	28560	31.55
51 - 62	112	3.22	6554	7.24
63 -130	202	5.80	16672	18.42
131-190	14	0.40	2090	2.31
191-200	13	0.38	3065	3.38
Total	3481	100	90530	100

Source:- Files of the East Ghor Canal Authority.

plots ranging from 30 to 50 dunums, which together amount to more than 68 percent of the total area. On the other hand, less than 1 percent of landowners own less than 6 percent of the land in plots ranging from 130 - 200 dunums. In determining the size and layout of farm units, the law has delineated the minimum size of a farm unit to be 30 dunums of irrigable land of Class I and II, and 50 dunums of Class III, and the maximum size of a farm unit to be 200 dunums. The formula which was given in Article VIII of the law, prevents any parcellation or subdivision to those farm units after their size and layout have been designed with irrigation and drainage nets.

Four points of criticism of the East Ghor Canal Plan may, however, be made. Firstly, the land is distributed only to former owners, and there is no scope for new farmers. Secondly, the land holders are merely tenants under the Canal Authority for a period of 33 years, and they do not have the satisfaction or the impetus that comes from ownership. Thirdly, the lack of follow through by the Authority when the engineering works have been completed. It has been found in the field

* The data include the land ownership in the areas 1-22 only. The data for the status of land ownership in the areas 23 and 24 have not yet been completed because the two areas were under construction during the field work.

that the (EGCA.) is not directly concerned with land improvement or its proper utilization. In 1966, a new law appeared cancelling the EGCA. and placing the Project under the Operation and Maintenance Division of the Natural Resources Authority (NRA.). Fourthly, in certain cases more than one family is now being permitted to work a single holding of minimum size; this masked subdivision, if allowed to extend, will lapse the effect of the law which protects the land from fragmentation.

The implementation of EGCA. laws with regard to farmer selection, area allotment, definition of family unit, and other matters seems to have been over-flexible and discretionary in a number of cases. Consequently, it is observable that there is a considerable number of absentee land owners who lease or rent their lands. In 1967, the number of absentee land owners in the project area is 531 owners representing 14.4 percent of the total of owners and owning some 47917 dunums (30.7 percent of the owned land). The number of resident land owners is 3139 (85.6%) owning 108087 dunums (69.3%).

The EGCA. series of laws have aimed at establishing family farms and encouraging the owner-operator type of farmer. In 1967, some 71.8 percent of the owners are owner operators and 28.2 percent of them are share-croppers (table 10.2 App.10). Two thirds of the irrigated lands (65%) are farmed by owner operators, and some 35 percent only of these lands are farmed by share-croppers. Comparing these figures with those of 1959/60 survey[12] which revealed that some 25 percent of the holdings were farmed by owner-operators and 75 percent by share-croppers, it appears that the EGCA. laws have been effective though not totally successful.

Elsewhere in the southern valley, the situation is the same as it was in the fifties, with many very small ownerships and a small number of very large ownerships. Land ownership pattern in Ghor Nimrin and Ghor Kufrein representing the southern valley is shown in the following tables:-

TABLE 10.5. Land Ownership Pattern, Ghor Nimrin 1964.

Size of Plot Dunums	Number of holdings	% of holdings	Irrigated area, dunums	% Irrigated area, dunums
1 - 30	76	39.6	1056	6.8
31-50	23	12.0	888	5.6
51-100	46	23.9	3420	22.0
101-200	27	14.1	3800	24.5
201-300	11	5.7	2648	17.0
301-500	8	4.2	3143	20.1
501-1000	1	0.5	596	4.0
Total	192	100	15551	100

Source: M. MacDonald, Shueib and Kufrein Water Use Study (1964).

TABLE 10.6. Land Ownership Pattern, Ghor Kufrein, 1964.

Size of Plot dunums	Number of holdings	% of owners	Irrigated area, dunums	% Irrigated area, dunums.
0 - 50	9	13.6	345	1.8
51-100	5	7.6	480	2.5
101-200	13	19.7	2400	12.6
201-300	22	33.3	5820	30.7
301-500	10	15.2	3750	19.7
501-1000	5	7.6	3700	19.5
Over 1001	2	3.0	2500	13.2
Total	66	100	18995	100

Source:- Ibid.

It can be seen that some 40 percent of the owners in Ghor Kufrein own plots ranging in size from 0 to 200 dunum; and 60 percent of them own more than 200 dunums which are the maximum allowable size of plots in the project area. Therefore,it is anticipated in future, after extending the East Ghor Canal to these areas of the southern valley, that some 60% of owners will hold less than 200 dunums and some 10% of holdings will decrease from more than 200 dunums in their size to less than 200 dunums. On the other hand, in Ghor Nimrin, small holdings less than 30 dunums amounting some 40 percent of the total holdings, will be enlarged to 30 dunum plots. It is anticipated that a shift will take place in the southern valley from the lands farmed at present by share-croppers (75%) to the lands farmed by owner-operators. This shift can be emphasised by the fact that a large number of farmers who work the lands of landlords by lease, rent, or share-cropping systems will have, by future law, the priority to own lands.

Marketing and Transport. The vast majority of the farm production in the valley is marketed. It is estimated that over 90 percent of agricultural production goes into the market. Not only is the valley distinctive with its central position inside Jordan between the principal markets such as Amman, Jerusalem, Irbid, and Nablus, but it is also the nearest of the vegetable and fruit sources supplying the Saudi Arabian and Kuwaiti markets. Differences of temperature between the valley and the mountainous regions on the one hand, and between the northern valley and the southern valley on the other, lead to the appearance of tomatoes and other vegetables in the markets all round the year. For instance, most of the northern valley's tomatoes are harvested and sold in the markets during the period from November to February, while those of the southern valley during the period from February to May and those of the mountainous regions from May to October.

Amman is by far the most important internal market for the output of the valley, taking over one-third of the total amount sold by value, whereas Damascus is the most important external market and takes almost one-quarter of all sales. No recent data are available on the real quantities of output exported from the valley. However, since bananas are almost the only crop in Jordan predominating the valley, then it can be possible to take the Jordanian exports of bananas as representative to the valley. The total exports of Jordanian bananas in 1965 amounted to some 4438 tons. Syria has the primary importance as a market for bananas (2037 tons), followed by Iraq (1118 tons), Saudi Arabia (138 tons), Kuwait (100 tons) and others such as Qatar, Bahrein, Iran, Lebanon etc., (1045 tons). Syria has the primary importance in marketing of Jordanian vegetables also; this is due to

Plate XXX. Tomato packing near Northern Shuneh.

the fact that the time of the high Syrian demand to the vegetables coincides with the time of the early harvesting for the crops of the valley particularly during winter and spring. This case can be applied also on the other markets in Iraq, Kuwait and Saudi Arabia; but Syria is distinctive with its relative nearness and subsequently the prices are lower than other countries.

The largest part of the sold produce was marketed through commission agents who usually receive a fixed part of the sold produce (5-10%). The remaining part was almost completely sold to wholesale merchants at fixed prices. Less than 1% was sold directly to consumers or retail merchants.

At present, the produce, either taken by the farmers to a hisbi (fruit and vegetable market) operated privately, or to a municipal market, is collected there by merchants for exportation. Two main marketing centres in the valley are Northern Shuneh (northern valley) and Karameh (southern valley) in which most of the sold produce is collected to be exported by trucks to Amman, Irbid and Salt inside Jordan and to the neighbouring countries. Direct sale to consumers, retail merchants and consumers' co-operatives, constitute a very small percentage of the total sales.

In 1966, corrective legislation was enacted, entrusting the supervision of the auctioning to municipal councils, and barring the commission agents from any other activity. The law also provides for the establishment of stalls for marketing co-operatives; these are, however, scantily used.

A United Nation Marketing Centre was established in Jordan for a period of four years (October 1964 - October 1968), to provide research, demonstration and training in agricultural marketing. In its demonstration programme, the Centre with the co-operation of the Government has established two commercial-sized fresh fruit and vegetable grading and packing plants at Northern Shuneh for citrus and at Wadi Yabis for tomatoes. In 1966, each of the plants has operated on a commercial basis by marketing cooperatives under the technical supervision of the Marketing Centre. After termination of the project, it is planned that the cooperatives will have the opportunity to purchase the plants. Suspicion of the farmers in the new practices which are not familiar to them is a serious problem. This point is emphasised by the fact that present grading and packing is generally, on satisfactory. The cooperatives are in need of more working capital and properly-trained management in order to build up the loyalty of their members and make proper use of the grading and packing centres in the valley. It is necessary to encourage the farmers to use the two grading and packing plants. To improve packing, farmers can be taught proper handling through films, pamphlets and demonstration.

Recent expansion in the vegetable cultivation has created a problem of marketing the increasing output, particularly with tomatoes. There must be a parallel development of a modern, efficient system for the marketing of these products, both within Jordan and in new and expanded export markets. The capacity of the internal and external markets of the neighbouring countries is limited. In some years when tomatoes are not exposed to pests and diseases, the output increases the capacity of markets to such an extent that low prices lead to losses for the farmers. In the years when the output decreases less than average, due to diseases and pests, it cannot satisfy the great demand of the markets, and the prices rise quickly in the interest of farmers. This remarkable fluctuation in the prices of vegetables leads to the loss of external markets which need stable amounts of output with stable prices. Likewise, the fluctuation of prices affects also the internal consumers and the farmers themselves.

Therefore, to tackle this problem, it is suggested first of all to decrease the acreage of vegetables to such an extent that a harmony must be found between the output and the markets. Secondly, protection against disease must be stronger and more effective in order to prevent fluctuations of crop supply. Thirdly, expansion of storage facilities to such an extent that they can absorb surplus output. The recent rooms of cold storage which are attached to the two packing plants are not sufficient. The southern valley needs storage facilities in Karameh to solve the storage problem of crops there. Fourthly, preparing all the required data and statistics on which the marketing policy can be based. As far as the markets are concerned, data should be collected and analysed on potential export markets for Jordanian fruit and vegetables. According to the results, the feasibility of developing new markets for various products can be assessed. There is a possibility in gaining admission into European tomato markets; tomato prices and quality of the valley can compete with those of North Africa, Canary Islands and Spain. By studying the requisites of markets, it is easy then to cultivate the most demandable quality. For instance, the European markets require the circular fine tomatoes, whereas the Arabic markets require other qualities. On the other hand, the quality of tomatoes needed for canning differs from that needed for food.

The truck is at present the principle means of transport in the valley. The condition of the main roads is generally acceptable. There is an elongated asphalted road crossing the valley from north to the south parallel with the escarpment.

Across the southern valley, there runs three main transversal asphalted roads, the first main one is the highway Amman-Jerusalem passing through Sweimeh Bridge; about 10 Km. distance, the Salt-Jericho road passes through Southern Shuneh and King Husein Bridge, and at about 34Km. distance the Salt-Nablus road passes through Damia Bridge. In the northern valley, two other transversal roads run from Irbid to Jisr Majami Bridge via Northern Shuneh, and from Irbid to Sheikh Husein Bridge via Zamaliyeh.

The agricultural development in the valley led the Government to reconsider the status of this net of roads. It has been decided to broaden the width of the main longitudinal North Shuneh-Damia road from 3 to 6 metres. It was expected to complete this improvement by the end of 1967. In the budget of 1968, a sum of J.D. 355,000 was allocated for the expansion of this vital road from Damia to the south.* The projected growth of agricultural activities and exports will require further improvements of the road system.

The new secondary roads constructed by the EGCA. between the farm units of the project area are still of earth without asphalt. Since the transport flow is concentrated upon those country roads attaching the farms with the villages and the markets, it is necessary to construct them of gravel to avoid delays in transport during the rainy seasons.

Not only are internal roads of the valley important for transportation of exports, but external roads have also vital importance for transporting the exports and should be integrated with the internal roads. Mafraq city has a nodal situation of communication between the valley and the markets of neighbouring countries. Via Mafraq the exports are orientated to Syria-Lebanon, Iraq-Iran, and Kuwait-Bahrein-Qatar-Saudi Arabia. Therefore, care should be taken to increase the connection of Mafraq with all parts of the valley and improve the present roads between them. In the Seven-Year Programme for Economic Development of Jordan (1964-1970),[13] the road projects involved are:- Mafraq-Jerash-Kufrinja-Kureiyima; and Mafraq-Northern Shuneh-Damia-Southern Shuneh. From these projects, the Northern Shuneh-Damia road has almost been accomplished and the costs of its expansion towards the south were allocated in the budget of 1968. The Mafraq-Northern Shuneh road needs improvement in the mountainous part between Irbid and Northern Shuneh. In the 1967 budget, a sum of J.D. 140,000 was allocated to Kufrinja-Kureiyima road as a part of the Mafraq-Kureiyima road. In the same budget, a sum of J.D. 50,000 was allocated to finance farm to market roads in the project area.

In 1967, the Government began to construct an asphalted highway connecting Ghor Safi at the southern end of the Dead Sea and

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* Implementation of this project has been suspended as a result of continuous events of shelling in the area.

Aqaba. It was expected to complete this road in 1968. It is anticipated that this road will be connected with the valley in future. Then, the exports of the valley to Saudi Arabia will be transported via this road.

Jordan competes with Syria and Lebanon as a source of supplying Kuwait with fruit and vegetables. According to Scherer (1964)[14] transportation costs per truck along the road from Amman to Kuwait, via Iraq, are estimated at about 10 fils/Kg. The following data on duration and costs of truck transportation to Kuwait are mentioned in table 10.7 :-

TABLE 10.7.

Country	Duration and distance one way		Costs per truck in K.D.(loading capacity 10-12 tons).	Number of controls.
	Duration in day	Distance in Km.		
Jordan-Amman	3 days	1500 Km.	140 - 150 K.D.	4
Syria - Damascus	4-5 days	1700 "	170 - 180 K.D.	5
Lebanon-Beirut	5-6 days	1800 "	180 - 190 K.D.	7

Source:- FAO. "Marketing of fresh fruit and vegetables" (1964).

It is anticipated that fruit and vegetables can be transported in open trucks to Kuwait without major losses during the period October-April.

Population and Settlement.

Population growth and distribution:-

In 1947, the population of the valley was estimated at 12,000 persons. As a result of the 1948 war, the population has increased catastrophically by the influx of Palestinian refugees to the Jordan Valley. By 1952, an UNRWA. report[15] estimates that some

29,833 Palestinian refugees were living in the Eastern Jordan Valley. By 1953, another UNRWA. report[16] estimates them at 33,767. Thus, the total number of population in the valley were 41,833 persons in 1952 and 45,767 persons in 1953. By 1961, according to the official census of the Government,[17] the total number of population in the valley was 62,477 persons. By 1966, it was estimated at 70,227 persons according to a natural annual increase of 2.5%.

The area, covered by the distribution of population, comprises twenty-six cadastral villages lying in the valley from the Yarmouk River to the Dead Sea (fig.10.5). Choosing the cadastral village as the unit of the population distribution has the advantage of allowing the total area of the valley to be divided into a number of districts the boundaries of which are exactly known. Geographic density of population averages is shown in the following table:-

TABLE 10.8. Area and Population Density of Villages.

Village	Area in Square kilometres	Census of 1961		Estimation of 1966	
		Number of population	Average number of persons per Km².	Number of population.	Average number of persons per Km².
Adasiyeh	9.464	526	55.58	592	62.55
Baqoura	7.707	2280	295.82	2565	332.81
Mashrou'	12.384	559	45.14	629	50.79
Sukhour el Ghor	18.067	6191	342.67	6965	385.51
Taybeh	8.822	2657	301.18	2989	338.81
Qla'at	5.420	665	122.69	748	138.01
Hamra	8.144	1234	151.52	1388	170.43
Azziyeh	1.941	148	76.25	167	86.04
Buseileh	3.053	187	61.25	210	68.78
Hurrawiya	1.860	1492	802.15	1679	902.69
Abou Ziad	5.729	753	131.44	847	147.84
Hammeh	2.661	127	47.73	143	53.74
Jirm	9.292	1738	187.04	1955	210.40
Auja Shamaliyeh	2.023	168	83.04	189	93.42
" Janoubiyeh	8.407	1018	121.09	1145	136.20
Rasiyeh	1.917	1269	661.97	1428	744.91
Ghor Farah	34.347	2010	58.52	2261	65.83
" Wahadineh	47.125	4608	97.78	5184	110.01

TABLE 10.8. Continued:-

Village	Area in square kilometres	Census of 1961		Estimation of 1966	
		Number of population	Average number of persons per Km.^{2}	Number of population	Average number of persons per Km.^{2}
Ghor Balawineh	10.694	816	76.30	918	85.84
Deir Alla	23.847	2716	113.89	3056	128.15
Tawal	41.697	4261	102.19	4794	114.97
Ghor Damia-Shaqaq	33.281	1454	43.69	1636	49.16
Ghor Kebid	51.130	20000	391.16	22500	440.05
Ghor Nimrin	78.841	2198	27.87	2473	31.37
Ghor Kufrein	83.205	1770	21.27	1991	23.93
Ghor Rameh	79.089	1632	20.63	1836	23.21
Total - All Villages	590.147	62,477	105.86	70,288	119.10

Source:- Department of Statistics (1961) and various.

It can be concluded that the average density of population has increased from 106 in the census of 1961 to 119 persons per square kilometre in the estimates of 1966. This increase in density is due to the fact that natural growth is at a rate of about 2.5 percent annually. The figures of the valley can be compared with the figures of average density of the country as a whole which were according to the census of 1961 some 16 persons/Km.^{2}, and according to the estimates of 1965 some 22 persons/Km^2. It may also be compared with figures for other countries at 1965 population estimates(18):- 224 for the United Kingdom, 21 for U.S.A., 10 for USSR., 11 for Chile, 171 for Italy, 109 for Hungary, 65 for Greece, 1 for Australia, 29 for Syria and Kuwait, 18 for Iraq, 231 for Lebanon, 30 for UAR., 27 for Tunisia, 5 for Algeria and 1 for Libya.

Density of population differs from one part to another according to physical and human factors. It is observed that 18 cadastral villages, representing 82 percent of the total area of villages, have densities of population ranging from 20 to 150 persons/

Km^2. Densities between 150-300 persons/Km^2. occupy some 3 percent of the area, whereas those between 300-450 persons/Km^2. occupy some 14 percent. Only 0.6 percent of the area is occupied by densities of more than 450 persons/Km^2.

Water and land have played a paramount role in the distributi ng of population. The northern valley has higher densities than the southern valley since the former has higher amounts of annual rainfall, has more perennial side streams, and has most of its lands of Class I, II and III lands which are cultivable. Nevertheless, differentiation of densities can be observed within the one part of the valley. For instance, Harrawiya area has the highest density of all in the valley (903 persons/Km^2.) followed by Rasiyeh area (745), Ghor Kebid (440), Sukhour el Ghor (385), Taybeh (339) and Baqoura (333). Most of these cadastral villages comprise numerous settlements found usually wherever side streams permit irrigation. Baqoura area is irrigated by Yarmouk river, Sukhour el Ghor by Wadi Arab, Taybeh and Harrawiya by Wadi Ziglab and River Jordan, and Rasiyeh by Wadi Jurum. In addition to their irrigation also at present by the East Ghor Canal, those cadastral villages include Class I,II lands of good agricultural potential.

On the other hand, most of the cadastral villages of low densities such as Adasiyeh, Mashrou', Buseileh, Hammeh, Ghor Farah, Ghor Damia-Shaqaq, Ghor Nimrin, Ghor Kufrein, and Ghor Rameh, have either non-arable lands of Class VI lands or arable lands of Class IV which need levelling, leaching, and good management. Such villages remained up to recent times with small patches of cultivation and the majority of their lands either left fallow, waste, or used for grazing. Since some of these villages are located at present in the project area of the East Ghor Canal and some others wait for the expansion of the project area to absorb them, it is anticipated that an increase in the densities of their population will occur.

The geographic density of population belies the real distribution of population and the figures give an exaggerated impression of variation owing to the way in which the cadastral boundaries ignore the location of settlements. Some cadastral villages contain almost exclusively habitations while others are largely farmland and waste. The picture of population density would have been altered, had the agricultural density been calculated. It is difficult to know the agricultural lands of each village in the project area. Nevertheless, the irrigated lands of the areas of sections are helpful. Since each area of irrigation agriculture is located within the frontier of each village, it is possible to calculate the irrigated agricultural density in the project area below the main canal only and not above the canal. Elsewhere outside the project area in the southern valley, the agricultural density was calculated for the irrigated agricultural area only.

The agricultural density of population is shown in the table 10.9.

It can be seen that Ghor Kebid has the highest agricultural density in the valley since Karameh which is the biggest refugee settlement in the valley is located in the centre of a small cultivated area of the Ghor Kebid. Dividing the densities into groups reveals that the areas of Adasiyeh, Qla'at, Buseileh, Auja Shamaliyeh, Ghors Balawineh, Nimrin, Kufrein and Rameh, have densities less than 200 persons/Km^2. (fig.10.6). Those relatively low population densities are due to the fact that most lands of these areas are of Class IV and VI lands with saline soils or poor drainage. The medium population densities 200-400 persons/Km^2., are found in the areas of Hamra, Jirm, Ghor Farah, Deir Alla, and Tawal, with saline soils or rough topography. The high population densities of 400-600 persons/Km^2. occur in the areas of Sukhour el Ghor, Harrawiya, Auja Janoubiyeh and Damia-Shaqaq; In addition to their good irrigated lands, these areas comprise some important settlements such as Northern Shuneh in Sukhour el Ghor area and Muaddi in Damia-Shiqaq area. The location of these settlements on the roads connecting the valley with the Eastern Plateau of Jordan

TABLE 10.9. The Agricultural density of population in the valley, 1966.

Village	Irrigated Agricultural Area in square kilometres.	Number of population	Agricultural Density in persons per Km.^{2}
Adasiyeh	4.035	592	146.70
Baqoura	3.059	2565	838.51
Sukhour el Ghor	12.722	6965	547.47
Taybeh	4.343	2989	688.23
Qla'at	4.029	748	185.65
Hamra	4.030	1388	344.41
Buseileh	3.553	210	59.10
Harrawiya	3.553	1679	472.55
Jirm	6.142	1955	318.30
Auja Shamaliyeh	3.200	189	59.06
" Janoubiyeh	2.116	1145	541.11
Rasiyeh	2.116	1428	674.85
Ghor Farah	9.299	2261	243.14
" Wahadineh	7.960	5184	651.25
" Balawineh	9.419	918	97.46
Deir Alla	10.926	3056	279.69
Tawal	23.288	4794	205.85
Ghor Damia-Shaqaq	2.835	1636	577.07
Ghor Kebid	9.450	22500	2380.95
" Nimrin	12.500	2473	197.84
" Kufrein	22.300	1991	89.28
" Rameh	17.200	1836	106.74
Agricultural density of the valley in 1953 = 213.86			
" " " " " " 1966 = 283.42			

Source:- Various.

attracts the population to settle in the area. The very high population densities of more than 600 persons/Km.^{2} occur in the areas of Ghor Kebid, Baqoura, Taybeh, Rasiyeh, and Wahadineh. The very high densities are due to the fact that the agricultural areas are small, because of saline soils or rough topography, when compared with the high numbers of population in these areas. With the exception of the odd case of Ghor Kebid in which Karameh refugee settlement is found, the good limited agricultural lands in these areas attract population.

Comparing these groups of densities with the type of cropping it appears that there is a correlation between the high densities and the cash crops of high incomes such as citrus, bananas, tomatoes, and eggplants. For instance, there is a correlation between the high densities of Baqoura, Sukhour el Ghor and Taybeh areas and the banana-citrus growing belt in areas 4-8 of section 1 of the project area. On the other hand, the correlation is clear between the high densities of Rasiyeh-Auja Janoubiyeh area and the cauliflower-citrus growing in area 14 of Section II. Moreover, there is a correlation between the high densities in Ghors Wahadineh and Kebid and the tomato growing in areas 18-21 of Section III and Karameh area in the southern valley.

Comparing the agricultural density of the valley with that of the whole country, it appears that the density in the valley has increased from 214 persons/Km.^{2} in 1953 to 283 persons/Km.^{2} in 1966, whereas that of the country has decreased from 190 persons/Km.^{2} in 1952 to 127 persons/Km.^{2} in 1966. The contradiction between these figures is due to the fact that there is a greater population pressure on the agricultural lands of the valley than on those of the country. The irrigation agriculture in the valley cannot keep pace with the population growth, whereas in the country as a whole dryland farming has greatly increased at the expense of grazing land.

Driving through the area along the main highway road from north to south, one observes a continuous line of settlements along this road. Similar to the fall line cities of the eastern coast of U.S.A. which represent a break between Piedmont plateau and the coast, these small settlements of the valley represent a break between the eastern highlands and the valley. From north to south, these settlements are Baqoura, Northern Shuneh, Zamaliyeh, Deir Alla, Southern Shuneh, Kufrein, and Rameh. These settlements on the openings of side wadis have been used as gateways of the valley by which transport between the valley and the eastern plateau is channelled. It is predicted that new settlement will be established, after the expansion of the East Ghor

Canal to the south, on the confluence of this main road of the valley with the new highway Amman-Jerusalem passing through the southern valley; on this cross roads, there is, at present, a core of this anticipated settlement represented by some facilities for the comfort of passengers such as a fuel station and Cofé place ..etc.

It is worthwhile mentioning that the first old stations on the openings of side wadis led the Romans to construct, between them, an elongated road which is the core of the present one. The road attracted new settlements to the area between the old settlements in order to benefit from waters of side wadis or springs in irrigation. Their sites were selected as far as possible on the non-cultivable lands of the foot-hills along which the road runs. Moving southwards of Northern Shuneh which is surrounded by other, smaller settlements, one passes through long stretches of sparsely settled farmland, interrupted only occasionally by more important clusters of houses such as Waqqas and Yabis, until one reaches Kureiyima and the more densely settled region of Wadi Zarqa between Deir Alla and Muaddi. From the latter to Karameh in the southern valley no settlement is found except Muthallath Masri which is used as a comfort place for passengers at the present. It is anticipated that this station on the cross road of Damia-Nablus will be a new settlement after the completion of the East Ghor Canal expansion towards south; the anticipation is based on the fact that there are some scattered patches of wheat and barley cultivation at present in this area which will be converted to the irrigation agriculture in future and will need a new settlement for farmers. From Karameh to Rameh, one can observe three new settlements of Palestinian refugees; Karameh and Sakneh are located north of Southern Shuneh along the main road, and Joufeh is located between Southern Shuneh and Kufrein, these new settlements have been established since 1950 and are part of the second stage of settlement. Between Rameh and Kufrein, there is a small stretch of settled farmland. No settlements are found south of the highway Amman-Jerusalem except Sweimeh village north east of the Dead Sea.

The settlement along the main north-south road of the valley can be considered as the main first stage of settled life. It was followed by a second stage of parallel settlements established on the badlands since 1950. Their location on or near the escarpment between the Ghor and the Zor was a successful selection of settlement sites for the following reasons: firstly, they are located on non-cultivable lands to benefit from the cultivable lands for cultivation. Secondly, they are located on highlands far from the floods of the River Jordan. Thirdly, their sites overlook the farms of the Zor and enable the farmers to practice their work near their settlements. The rehabilitation of the Zor since the beginning of the fifties is the main factor of creating such new settlements on the badlands. Rehabilitation of the Zor has tempted some of the families who have farms in the Zor to live in their farms. Likewise, there are scattered settled farmlands in the Ghor between the settlements of the two stages. Such settled farmlands are called after the names of their establishers e.g. Zor el Basha, Zor el Shishan, Halabi farm, Khirbet Al Yousif, Sharif farm, Zor Tureikhim, Zor Quweisim, Zor Nabeilah, Zor Saidiyeh, Khirbet Khalaf, Zor Marayheh, Zor Sharari, Zor Suheiban, Zor Basharat and Dawoudi farm. These scattered farms are not real settlements since each farm has no more than one family. The settled farmlands of the Ghor differ from those of the Zor regarding their size; they include more than one family and usually the name of the settled farmland is called after the name of the tribe chief who lives with some members of his tribe in cluster of houses near their farms. e.g. Salahat, Alaqmeh, Shahadat, and Abou Na'im. The biggest settlements of the Second Stage settlement are Manshiyeh village in Sukhour el Ghor area and the twin villages of Jasoureh and Tal Arba'in in Ghor el Arba'in area.

<u>Religion</u>:- The population is almost entirely Muslim, though small groups of Bahais* and Christians are found. According to the census of

* Bahais are Persian people originally; In 1879, Sir Abdul Baha Abbas, head of the Bahai faith bought lands with his group and founded Adasiyeh village on the Yarmouk.

1961, Muslims were 99.56 percent of population in the valley, divided between the project area (99.34%) and the southern valley (99.89%). Christians were 0.30 percent of population of the valley, divided between the project area (0.42%) and the southern valley (0.11%) and scattered throughout the entire area with only a small concentration in Northern Shuneh and Southern Shuneh. Bahais were 0.13 percent of the population of thevalley and 0.22 percent of the population of the project area where they have their community at Adasiyeh village.

Age:- According to the census of 1961, the age structure of population revealed the youthfulness of the people of the valley (fig. 10.7). Over 43 percent of the population is under 15 years of age. Over 18 percent is under 5 years old. This large measure of youth reflects the fact that people almost all marry, they marry young, and they have many children. Some 6 percent is over 60 years old. The result of all these tendencies is that the young under 15, together with the aged over 60, constitute almost exactly one-half of the total population, a half which cannot be expected to work and which only a small proportion does in fact work. They can be supported by a potential labour force of the other half of the population, aged 15-59, and are actually supported by a smaller active labour force. Population by age group is shown in the table 10.10 and fig.10.8.

TABLE 10.10. Population - By Age Group, Census 1961.

Age Group	0 - 4	0 - 14	15 - 19	20 - 59	+ 60	Total
Project Area	6748	15977	4189	14479	2232	36877
Southern Valley*	1011	2482	576	2204	348	5600
Total of the valley	7759	18459	4765	16683	2580	42477
Percentage of total population of the valley.	18.26	43.45	11.21	39.27	6.07	100

Source:- 1) Dept.of Statistics, Census of Population and Housing Ajloun and Belqa Districts (1961).
2) Dept.of Statistics, the East Jordan Valley (1961).

* Karameh refugee settlement was excluded from the population census; However it appeared from field work information that some 209 persons were less than one year and some 7608 from 1-15 years; i.e. some 35.5 percent are less than 15 years.

It can be concluded that the population over 60 has the least percentage of all age percentages in the valley reflecting a short life expectancy. Moreover, the percentages of infants and children are more than those of labour force age. Accordingly there is a high demand on the labour force. Unless labourers take high wages, they will not be able to support the high numbers of their families.

Socio-Economic Conditions:- Field observations show that 75 percent of the inhabitants originally came from amongst the Palestinians. The result of 300 student three samples, taken from Northern Shuneh, Deir Alla, and Karameh, shows that Palestinians comprise 70 percent of the population in Northern Shuneh, 66 percent in Deir Alla, and 88 percent in Karameh. Fusion between the two groups is progressing.

The dwellings are mostly built of mud bricks at present, and some of them are built of cement. Mud brick dwellings are preferred in such a hot climate of the valley since they give more protection against the scorching sun, they are easy to build and cost little money. The earth which is used can often be obtained free and usually available near the building site. The final product, with a roof of rushes and reeds supported by poles, is a house which is well insulated from the sun in summer time. Most of cement or stone are concentrated in the northern part of the valley particularly at Northern Shuneh, Mashrou and Yabis settlements, since the temperatures are lower than those of the south, in addition to the fact that stone and cement houses are evidence of the high standard of living which has accompanied execution of the East Ghor Irrigation Project in the north.

Tent dwellings are more common towards the south. In fact this type of dwelling was widespread as permanent houses for wandering tribes before the fifties, but it is used at present temporarily during planting and harvesting when some families move from their permanent dwellings in their settlement to their far farms. This phenomenon emphasises an important fact that means of communication in the valley still need to be taken care of. Recently, tents have been replaced by temporary shelters, particularly, in the southern part of the project area where these temporary settlements tend to be less concentrated in nucleated villages and more dispersed over the entire countryside.

At present, most of the dwellings in the valley have bedrooms and kitchen beside the living room; few houses have gas cookers and refrigerators; electricity is available to only a handful of villagers. The dwellings are provided with water in four different ways; by the river or side wadis, which is the most common source, by irrigation canals, by springs or wells, and by pipes (fig.10.9). Clean drinking water is scarce although quantities of water are sufficient for domestic use. Kerosene is the most common type of fuel used, followed by firewood, electricity and gas. The most common family size contains 7 dependents. For example, in Karameh, there are 3,379 families including more than 22,000 persons. In some cases, families with 10 or more dependents are found.

As a result of agricultural development, a high demand on the labour force has occurred; this has been accompanied by a rise of wages from five shillings for a worker per day to twelve shillings. Although the number of tractors has increased from 40 tractors in 1953 to some 200 tractors in 1966, the high demand on the workers is expected to continue in future especially for harvesting of vegetables and fruit. The result of a sample taken for 150 persons of ages between 20 and 59 years, shows that unemployment is not found between them; some 95 percent of them are engaged in farming, 2 percent are engaged in trades, 2 percent are engaged in occupations which service the agricultural community by supplying food and household goods, education, protection, mechanical skills, medical services, and other requirements, and one percent are unemployed (fig.10.10).

In fact there is seasonal unemployment and a peak period of work in the valley. This is natural in an agricultural community which depends on a single crop; However, the seasonal unemployment has decreased since the fifties. At present, the vast majority of the labour force works more than 300 days on average per year. It is anticipated , according to the labour force present status, that the

Plate XXXI. Tractors are clear evidence of the recent development in the valley.

Plate XXXII.

Temporary houses dispersed over the project area on the farms.

full development of the valley will be accompanied by the need of importing labourers from outside the valley.

Since the vast majority of the inhabitants of the valley, either landlords or sharecroppers or farm labourers or others, benefit from the development taking place in the valley, it is expected that the family budget will be affected by this development. Postulating that each farm, of those already dealt with in farm budget in the last chapter, is held by one family, and dividing the total net incomes of these farms by the total number of the farms, the result can be taken as a family budget which ranges between J.D.300 and J.D.400 per year. It is notable that the bulk of foodstuffs consumed is bought for cash, indicating that the valley's economy is an exchange economy, not a subsistence economy. Expenditure on coffee, tea, and sugar, and on presents, entertainment and hospitality constitutes a high proportion of the total budget.

Medical expenses are high for the average farmer with a small farm. The largest portion of expenditure goes to private doctors since clinics and hospitals are not adequate; there are no resident doctors in the villages. Field investigations in the Karameh settlement (22,500) show that there are two doctors only working in one clinic; there are no hospitals, patients are sent to hospitals in the neighbouring cities such as Salt, Jericho, and Jerusalem, Moreover, there are some 36 sanitation workers and a hygiene office. The most noteworthy achievement has been the eradication of malaria. Eye diseases are the most widespread diseases in the valley due to their correlation with hot climate and dusty winds of the valley.

Education costs nothing for the majority of families; for the rest most expenditure is not more than J.D.2 monthly. There are some 50 schools in the valley, 30 for boys and 20 for girls. Most of these schools are elementary and preparatory, they are spread in some big villages. Three secondary boy schools are found in Northern Shuneh, Muaddi, and Southern Shuneh; girls have not yet secondary schools and some of them are sent to neighbouring towns to continue their secondary education. The education received by the population has been almost entirely academic and not technical or vocational training. Most of the people reported as unemployed had received some secondary education and were loathe to work in agriculture or its services. This point emphasises the fact that the valley needs agricultural and technical schools. There is a great pressure by the pupils for schools where the only school available is outside the village, or for secondary schools or girls' schools where none are available. This pressure is a clear evidence of general progressive trend of people towards education.

In planning the construction of new schools and the expansion of existing ones, account must be taken not only of need but also of demand. In the valley, either at the present time or in the future, there is a high demand on educated farmers having worthwhile experience of irrigation agriculture matters. Just to educate academic subjects, and then to have hundreds of unemployed students who dislike to work in agriculture, is not particularly beneficial. Field observations show that, on average, there are 48 students per teacher, a number which cannot help to give the best results in examinations.

Since 1966, the Eastern Jordan valley has been divided into two sub-districts: Northern Shuneh subdistrict, one of subdistricts of Ajloun District and including most of the northern valley from the Yarmouk River to south of Kureiyima village. Southern Shuneh subdistrict, one of subdistricts of Belqa District, and including the southern valley beside the Deir Alla area of the northern valley. Accordingly, public facilities and utilities have spread out adequately particularly after establishing the village councils through the valley. With the exception of Northern and Southern Shunas which are the administrative centres of the valley, each big village has a village council. Often a couple of neighbouring villages share the same facility. For instance the small village of Sawalhi shares with DeirAlla the same village council since they are adjacent to each other, whereas each of Muaddi and Damia has its own village council.

Settlement Planning:- As already mentioned, it is anticipated after the completion of the entire Yarmouk Project, that new centres of activity will emerge. There can be a shift of population inside the valley from the north towards the south; in other words, the shift will be to that area in the valley where population is not dense at present. Most of settlement will be concentrated along the main highway crossing the valley from north to south.

It is suggested that four central towns should be the administrative centres of the valley (fig.10.11). The elongated strip of the valley is the first factor taken into consideration on selecting these four centres. To facilitate the contact of village groups with their centres, it is relevant to select Northern Shuneh and Yabis as centres for the Northern Ghors; Muaddi as a centre for the Middle Ghors; and Southern Shuneh for the Southern Ghors; those four centres are located along the main road N.Shuneh-S.Shuneh. The gateways of the valley to the neighbouring regions are the second factor taken into account on choosing these four centres; Northern Shuneh located on the entrance of Wadi Arab to the valley is connected with Irbid city by a road (35 Km.) and with western valley by Majami Bridge (Confluence Bridge); Yabis located on the entrance of Wadi Yabis has the same connection; Muaddi ("crossed by") located near the entrance of Wadi Zarqa and near Arda triangle ("cross road") leading to Salt towards east and Damia Bridge-Nablus towards west; Southern Shuneh located on the entrance of Wadi Shueib to the valley, is connected with Salt towards east, with King Husein Bridge-Jericho towards west, and with the Kufrein Rameh-Amman-Jerusalem highway towards south.

Location of these four centres near the openings of four main side wadis, Wadi Arab, Wadi Yabis, Wadi Zarqa, and Wadi Shueib, on which four dams will be constructed, may make these centres industrial ones beside their importance as agricultural centres. Northern Shuneh power station which is part of Khalid Ibn el Waleed Dam Project on the Yarmouk, will cost some J.D.1,343,673 or some 9.6 percent of the total costs of this project, and will work by the water power of the Yarmouk passing through a 14 Km. tunnel towards Wadi Arab. This power station which converts Northern Shuneh to the largest industrial centre in the valley, will supply the other three centres and villages of the valley with electricity. The dams on those four side wadis will create artificial lakes behind them. Combined with forests cultivcated in their area,those lakes may add a new function for the centres by making them recreational areas attracting the people of surrounding villages.

The four centres will be the main marketing places in the valley from which exports are transported outside the valley, and the villagers buy their needs, either those connected with their consumed foodstuffs or with their farm requirements. Packing plants are expected to be established in them beside storage rooms. At present, they are the only towns in the valley having secondary boy schools. It is anticipated that secondary girl schools beside agricultural schools will be erected in such sufficient numbers that these centres can become the educational centres in the valley.

Generally speaking, it is suggested that these four town centres will provide administrative centres by having each governmental collective building including Kayem Makam Office, (Governor of the area) Police Office, Education Office, Hygiene Office, Agriculture Office, Social Affairs Office, Justice Court Office and the East Ghor Authority Office. The latter office is the principal authority which, with the cooperation of other offices manages all the matters of the area of the town centre physically and socio-economically. Town centres will provid business centres by having banks, commercial offices, cooperative societies and industrial offices. They will provide also higher education and social centres by having academic and technical schools, transport stations, hotels and cinemas, etc.

Mayors of municipalities of these town centres and those of their attached villages have, with the cooperation of the local East Ghor Canal Authority, to plan for their towns and villages. No planning has yet been done for the settlements of the valley. However, when planning for the valley settlements, three basic points should be taken into consideration: Firstly, building material should be made of mud bricks with internal and external mud plaster; the roof is composed of boards with rolled earth on top; the flooring is of cement. Secondly, climate of the valley determines that rooms must be of big size and have high roofs, and small openings in order to lighten excessive heat transmission. Houses should have, generally, sufficient outdoor court areas with high boundary walls to protect them from harmful winds. Thirdly, Land Class should be considered; villages must be established on Class VI land which is non-arable and planning of their growth must be designed, as far as possible, in such a way that the growth trend moves toward non-arable lands. For instance, Northern Shuneh growth should be designed in such a way that it moves towards north and south along the foot hill on the non-arable lands, its growth towards west must be stopped since it is on the expense of cultivated lands; likewise, its growth towards east must be stopped since this growth induces problems of transportation inside the town.

Conclusion:-

The Eastern Jordan Valley is passing through a stage of development represented by irrigation projects, land reform, marketing regulation, and population social change. The project area of the East Ghor has the primary importance of all irrigated areas in the country regarding intense irrigation agriculture. It is the pioneer area in which the most recent techniques are applied; therefore it will be the model for any other area going to be developed, and it is the experimental field for the use of land and water.

In the field of irrigation, the valley irrigated area will be some 321,250 dunums as a result of completion of the suggested irrigation projects. It will be more than 2 percent of the total present cultivated area in the country. In spite of its small size when compared with the big size of cultivated lands, the irrigated area will create such an intense agriculture, high yields and outputs that it will supply the local consumption with its needs of vegetables, fruit and dairy-meat products and there will be a surplus to be exported outside Jordan.

In the field of land reform, the project area has seen, for the first time of the history of Jordan, a process of re-distribution of the land according to a scientific Land Class basis. The lands have been divided into farm units approximately square-shaped with roads going around them, and not through them. Their numbers are some 3435 farm units with an area of the unit averaging 32 dunums. The total length of the laterals taking from the East Ghor Canal and feeding the farms is estimated at 398 Km. The total length of the drains is estimated at 250 Km. The re-distribution of the lands into new farm units is aimed at obliteration of the old system of ownership with its problems and the construction of a new system based on farm unit layout in such a way that its size can satisfy the living of a farmer family and its shape can be adapted with topography and the new irrigation drainage nets. The second aim is to convert the highest numbers of labourers into owners of the lands by selling them the surplus lands, owned by feudalists, increasing the maximum holding (200 dunums). Those new owners pay the value of their lands to the EGCA. by instalments. The land reform is conducive to the increasing of yields and outputs, the increasing of incomes and the raising of the standard of living. The increase in the value of output as a result of the East Ghor Irrigation Project has been already elucidated; the project has increased also the Government budget some J.D.500,000 from taxes and irrigation water fees. There is a considerable increase in the efficiency of labour also, this can be observed by the move of farmers from their nucleated villages to live on their holdings.

In the field of marketing, the valley has been saved from commission agents, who used to monopolise the marketing, since the enaction of a law in 1966 barring them from practicing their auctioning. At present, there is an agricultural marketing office in Northern Shuneh for the service of farmers. Two grading and packing plants have been established in Northern Shuneh and Yabis attached with storage rooms.

In the field of services, the main road Northern Shuneh-Southern Shuneh has been enlarged, between Northern Shuneh and Damia, from 3 to 6 metres to be able to bear the pressure of transport on it. Numerous country roads have been opened between the farms and villages to connect the farms with markets. New settled farmlands have been erected to make the farmer in connection with his work. Municipal village councils have been established to take care of the villages by tackling the problems and supplying the requisite facilities. For instance, the Northern Shuneh Municipality which takes a subsidy of J.D. 600,000 annually from the Government, is going to execute some schemes such as drinking water, electricity, opening roads, construction of schools. The population of the project area are more than those outside it, it is anticipated that an increase of population will occur, and there will be a shift of population from the north to the south.

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CONCLUSION.

"Water, land, and people are inseparable components of one thing, our welfare" E.T.Benson[1].

"The social lesson of soil waste is that no man has the right to destroy soil even if he does own it in fee simple. The soil requires a duty of man which we have been slow to recognize".

A.Stefferud[2].

It is clear from these two quotations that water and soil are very important in the life of man. These two problems affect not only the Jordan Valley but also the whole of the country and, with their wide ramifications, are particularly amenable to geographical study. According to Professor W.B. Fisher, it can be cited that "Geography, because of its wide approach and willingness to accept the need to consider both human and environmental topics as interlinked, offers specially useful and relevant concepts and methods".[3] The nature of problems of soil and water in the valley might not differ greatly from other soil and water problems in semi-arid zones in different parts of the world, but the result of these two problems upon the agricultural economy of Jordan is more important than is generally appreciated.

Climate plays an important role in the problems of soil and water utilization. It has been shown that the wind erodibility index is high in the southern valley; accordingly, it is expected that both soil erosion and evaporation are high. Added to the fact that temperatures are high in the valley generally and in its southern part particularly, it appears that the water balance is severely deficient. evaporation and transpiration are everywhere high and seem to be extremely high in the southern valley. Optimal irrigation techniques are difficult to establish with any great accuracy under these climatic conditions.

In Appendix 1, Consumptive Use Coefficients for different crops, and irrigation and diversion requirements throughout the year, have been estimated according to the Blaney-Criddle method. At a field irrigation efficiency of 65%, a figure adopted for the gravity irrigation method by Baker-Harza, irrigation and diversion requirements are estimated at 900 and 1390 cu.m./dunum respectively. The average annual water requirements for various types of irrigated crops are shown in the following table 11.1 :-

Type of crop	Total water requirements cu.m./dunum per year	Phasing
Winter cereals	500	4 cu.m. daily
Citrus	1000	7 months - 3 cu.m. daily; 5 months - 2 cu. m. daily.
Vegetables	2000	7 months - 6 cu.m. daily; 5 months - 4 cu. m. daily.
Bananas	3000	7 months - 9 cu.m. daily; 5 months - 6 cu. m. daily.

Source:- MacDonald (1951).[4]

Figures for the Trucial States (W.Halcrow)[5] and Wadi Dhuleil in the desert of Jordan (M.MacDonald)[6] resemble those of the Jordan Valley. The water requirements are generally high for more than half of the year, emphasising the fact that water is indispensable to the agriculture in a semi-arid valley. Moreover, the effective use and conservation of water on farms will become increasingly important, and conflicts over water-use will have to be resolved.

The monthly wind erodibility index can be taken as further evidence of the role played by climate in exacerbating soil and water problems. It is evident from the results of applying the monthly wind erodibility equation on the valley, that the wind erodibility index is highest in summers in the southern valley and in winters in the northern valley. Considering the fact that ample areas of the southern valley are bare of vegetation and crops in summer, and most of the winters of the northern valley are exposed also to water erosion, the hazard will be doubly increased on soil and water of the valley. This phenomenon explains why citrus and winter vegetables, such as tomatoes and beans, are not successful in the Ghor of Deir Alla and are concentrated in the Zor of the same area for protection from the strong winds of winter; it explains also why most of the cultivable lands of the southern valley are either left fallow in summer or cultivated with melons or water melons only and not with vegetables of blossom and small fruit, lest they should fail by strong summer winds and high evapotranspiration. Consequently, measures for controlling strong winds should have the utmost importance.

However, the climate of the northern valley is less severe than that of the southern valley. The first has a lower wind erodibility index, and lower values of temperature and evapo-transpiration than the latter. This fact is emphasised by the results of the two experiments carried out on bananas in two sites at the same elevation in Northern Shuneh and Southern Shuneh. The slight difference in temperature (1 - 1.5°C) is reflected in the rate of water consumption; the consumptive use figures obtained at Southern Shuneh are significantly higher than the figures for Northern Shuneh. This experiment showed that the direct water loss due to evaporation from the surface of the soil was about 29 percent of the total evapo-transpiration. As the second widespread fruit in the valley after citrus, and as the most profitable crop in the valley, bananas require more frequent applications of water and shorter watering intervals than any other plant. Soil moisture tests made by Irrigation Department of the Natural Resources Authority in banana orchards have indicated that most of the roots exist in the upper 50 cm. of the soil profile, the moisture of which decreases rapidly.

The water balance of a plant is bound to be upset if it cannot receive as much water from the soil as it loses through transpiration. This is true during the successive dry years.

TABLE 11.2. Area failed during the dry year 1959/60 due to lack of rainfall or water.

Crop	Irrigated crops			Un-irrigated crops		
	Total area failed in dunums	Area failed due to lack of rainfall or water, in dunums.	Percentage of the total area failed.	Total area failed in dunums	Area failed due to lack of rainfall or water, in dunums.	Percentage of the total area failed.
Wheat	8092	7428	92	23157	22623	98
Barley	1005	864	86	3472	3439	99
Marrow	1003	436	43	106	52	49
Tomatoes	1293	224	17	-	-	-
Beans	362	68	19	50	50	100
Onions	9	3	33	-	-	-
Cucumbers	261	73	28	20	20	100
Watermelons	244	100	41	-	-	-
Eggplants	219	48	22	-	-	-
Cabbage	57	11	19	-	-	-
Cauliflower	51	3	6	-	-	-

Source:- Department of Statistics (1961)[7]

It can be seen that lack of water is the primary factor of crop failure in the valley. Moreover, un-irrigated areas have higher percentages than irrigated areas since the first areas are dependent directly on the rainfall, whereas the latter areas are dependent indirectly on the rainfall which affects the flow of springs and streams. Even at the present time, as long as the waters of the Yarmouk and other side streams have not yet been regulated by dam construction, the problem of irrigation water deficiency still occurs in the valley.

Plants wilt if the gap between transpiration and absorption remains wide for long. The disturbance in the water balance produces important changes in the cells; the concentration of the cell sap increases and the hydrature drops. Therefore, the osmotic value is not stable, it fluctuates between minimum and maximum points according to the plant species. The osmotic value increases when the plants of the valley face difficulties in obtaining water from the soil. With the exception of the successive dry years in which crops are exposed to failure or low yields, the crops at the present time face a critical period of three summer months in which there is a deficiency in irrigation water; this deficiency limits the area of cropped land in summer in such a way that it becomes either small or is left to fallow. As far as permanent crops are concerned, they are left suffering from high osmotic water pressures. Field observations show that there are some banana plantations at Wadi Yabis in the project area suffering from wilting due to the deficiency of water supply in summer. It seems that some of these plantations have been cultivated with bananas without licence from the Ministry of Agriculture in disregard of the new article (1966) attached to the East Ghor Canal Authority Law.

In addition to its unreliability as a source of water, precipitation, due to heavy intensities during short periods, is conducive to soil erosion and water losses. Raindrops strike the soil from a vertical direction whereas flowing water moves horizontally over it. Runoff takes the forms of sheet flow and channelized flow. The former, coupled with raindrop action, produces sheet erosion. The concentrated scouring action of the channelized flow causes rill and gully erosion. It has been shown in Chapter 7 that the mean erosion value of the valley is 415 tons per square kilometre per year. The mean erosion value of the northern valley is 443 tons/sq.km./year, and of the southern valley is 358 tons/sq.km./year. The values of the valley range from 300 tons to more than 500 tons/sq.km./year. The tendency of rainfall to be concentrated in relatively short periods during the year, and the long gradual slopes of the valley floor, all these factors contribute to high values of erosion. It is observed that the highest erosion rates are in the central part of the valley, particularly the zone located between Ghor Damia in the south and Ghor Farah in the north. It can be assumed that where erosion values are low, the cost of conservation measures will also be low and restrictions upon land use will be less limiting. Thousands of dunums are susceptible to the floods of the River Jordan in the Zor and of the side streams in the Ghor.

Rainfall patterns at the various locations of the valley differ with respect to the distribution of erosive rains during the year. About 60 percent of the year's erosive rainfall occurs during November, December and January which are the first three months after the seedbed preparations have been made for winter crops. Moreover, the ground during this period is still bare or with limited cover. Therefore, conservation measures which afford the greatest possible protection during the seedbed period are very important in the valley. Likewise, the building of valley plugs, gradoni terraces, and contour stone walls is needed to protect the new irrigation projects from the transportation of silt down stream from the Eastern Highlands.

The increasing pressure of population on the cultivated lands, the deficiency of irrigation water in amounts to keep pace with the expansion of the cultivated land, and the fluctuations of rainfall are factors which have led to the search for additional sources of irrigation, namely, groundwater. From the beginning of the sixties, hundreds of wells have been dug and pumped, and the groundwater level has declined more than 10 metres in the past 15 years due to excessive rates of withdrawal. In addition there has been a serious increase in the salinity in the alluvial aquifers which is believed to be caused by the lateral movement of highly saline water from the margins of the alluvial fans toward the depression cone; there is also upward leakage from poorer quality water in sand and gravel artesian aquifers. According to Baker-Harza, the annual recharge from the two groundwater zones of the Eastern Jordan Valley (Ajlun and Belqa) is less than 105 mcm. This estimate of annual recharge is a maximum estimate; the annual recharge may be much less particularly during successive years of drought. During the dry years 1962/63, 1965/66, which had rainfall amounts well below the average, groundwater recharges into the aquifers of the southern valley were estimated to be 22 and 20 mcm. respectively, while totals of 36 and 40 mcm. respectively of groundwaters were extracted.

Groundwater salinity has created two additional problems. The first direct problem is the successive abandonment of wells which were formerly used. In 1962/63 the total of the capped and abandoned wells was estimated at 320; in 1965/66, it was estimated at 438, showing an increase of 37 percent. The total loss was estimated at J.D. 438,000 based on the fact that the cost of each well is approximately J.D.1000. The second indirect problem is the contamination of the soils by using saline waters from these wells. An investigation has been undertaken by the Groundwater Division, in the southern valley, to estimate the salt accumulation in soil irrigated by well groundwater, as is shown in Chapter 3. Taking well No.54 as an example, it appears that this well added some 7 tons of salts to 4 dunums annually during the period from the spring of 1962 to the spring of 1965, a figure accounted for by the increase in water salinity from 950 ppm. to 1080 ppm. during this period. Ester Boserup's remarks are apposite here:-

"When the analysis is based upon the concept of frequency of cropping, there can be no temptation to regard soil fertility exclusively as a gift of nature, bestowed upon certain lands once and for all. Thus soil fertility, instead of being treated as an exogenous or even unchangeable 'initial condition' of the analysis, takes its place as a variable, closely associated with changes in population density and related changes in agricultural methods".(8)

Saline soils, either those formed on marls or those formed on alluvium and irrigated by saline groundwater, are one of the main limitations in the valley. At present, there are some 70,000 dunums in the valley which require salt leaching before a satisfactory level of crop production can be expected. This area is almost entirely located in the southern valley. The soluble salt percentage of these soils ranges upward from 0.2%, with the average percentage somewhat greater than 3 percent. Soil limitations are reflected in the distribution of the cropping pattern of the valley. Citrus and banana plantations are concentrated in the northern valley where the soils have no such limitation. In the southern valley, they are generally scattered along the Southern Shuneh-Rameh road in the eastern part of the Shueib-Kufrein alluvial fan where the soil is less saline. Most plantations depend, for their irrigation waters, on the good waters of Shueib and Kufrein streams. There are several citrus plantations located on Class IV land between the Southern Shuneh-Kufrein road and the badlands (Katar) which depend on well groundwater. As a result of the abandoned wells, some of these plantations have been replaced by other crops; some others have been left fallow and still continue with low yields and high costs.

Most of citrus and banana plantations tend to be concentrated in the Zor for the following reasons. Firstly, the Zor has a renewable alluvial soil which is fertile and loamy. Secondly, most of the alluvial Zor soils are non-saline since they are recent soils. Thirdly, these plantations depend on pumping from the River Jordan or from wells, the waters of which are necessary for these permanent crops. Finally, the Zor gives more protection than the Ghor to strong winds. Nevertheless, farmers in the Zor complain about the winds which carry the airborne salts from the Katar and deposit them on their farms; furthermore, farms located along both the bank of the River Jordan and the Zor escarpment are exposed to floods from the river and from its tributary streams, damaging crops by water velocity and land slides.

Not only are citrus and banana plantations in the southern valley limited in scattered patches when compared with those of the northern valley plantations, but they also give lower yields and incomes. To be suitable for cultivation, soils of the southern valley and particularly saline soils need continuous management for levelling, leaching, fertilising, irrigating and protection from pests and diseases. In addition to their high value as cash crops, vegetables account for an important area in the cropping patterns, particularly in the southern valley, due to their greater flexibility in soil and water requirements. For instance, tomatoes and eggplants, which are the main vegetable crops in the valley, are widespread in the southern valley since they can tolerate saline soils. However, vegetable yields in the northern valley are higher than those in the southern valley due to the fact that the northern valley has more water and better soils.

Soils of the valley are generally immature, relatively low in organic matter, and of a calcareous and gypsiferous nature. The basic fertility of the soils is relatively high with the exception of nitrogen and phosphorus. Textures range from light to heavy, with clay loams and clays predominant. The water holding capacity of the soils is good and infiltration rates are satisfactory with the exception of a few scattered areas in the northern valley.

The total land area of the Eastern Jordan Valley is approximately 605,840 dunums. Of this, about 279,610 dunums are currently suitable for crop production, and about 84,474 dunums are capable of varying degrees of crop productivity after reclamation. Lands of Class I and II are suitable for all crops, except soils of fine textures in Adasiyeh area and some parts of Zor which belong to Class III. They have above normal and normal yield potential respectively. Most of them have no limitations due to the fact that they do not suffer from stoniness, unfavourable topography or hazard of flooding. The minority have slight limitations owing to the presence of stones and this results in a reduction in farm benefits of the order of 0.5 J.D./dunum per annum. Lands of Class III have a normal yield potential, but are less suitable for fruit trees and salt-sensitive vegetables. They have moderate limitations particularly the land on the Ghor with steeper than normal slopes or with rolling relief, and the land in the Zor exposed to the hazard of flooding.

Lands of Class IV have a normal yield potential but are less suitable for deep-rooted and moderate salt-sensitive crops, because of the presence of salinity at depths less than 90 cm. They have severe limitations since they have dissected micro topography. These soils cannot feasibly be irrigated by surface methods. All lands of Class VI have very severe limitations on use imposed by excessive stoniness, steep slopes, severe erosion or poor drainage. Upgrading of these lands is judged to be economically unfeasible.

Farm samples have been selected to discover the effect of water on the farm economy. It has appeared, as shown in Chapter 9, that the income of the farms of Class I and II lands is higher than that of the farms of Class III, and the latter is higher than that of Class IV land. Moreover, the incomes of irrigated farms are higher than those of non-irrigated farms, even if they are on the same land class. These results confirm and coincide with the results reached by Baker-Harza (1955) which revealed that the income of one dunum of Class I and II land is 1.7 that of Class III land. These results have been taken into account when the Government enacted the East Ghor Canal

Law; with regard to the article concerning the size of land ownership unit in the project area, the minimum size has been determined to be 30 dunums of Class I and II lands and 50 dunums of Class III lands.

As a result of the economic and political history of Jordan since 1950, a highly unbalanced and distorted economic system has developed. The major symptoms of this are the chronic balance of payments deficit and a situation in which current budgetary aid accounts for about half of the current revenue of the Government. Therefore, agriculture must carry the main burden of the production increases which are required. An effective agricultural programme must clearly depend first of all on the development of water resources in a way which gives the maximum return for the minimum capital outlay. As the population increases, this means that production must grow at a very rapid rate - probably 7% a year if the objective is to be achieved.

The East Ghor Irrigation Project is one of the major planned agricultural developments in Jordan. The main objectives of the project are:- Firstly, diversion, control, and maximum use of the water of the Yarmouk River, and of the side perennial streams for the benefit of the lands of the project area; secondly, farm unit layout, or in other words, reparcellation of the lands that lie within the project area; thirdly, land reform, or rather, land redistribution based upon a new ownership pattern; finally, farm development which is of two phases: land development and the productivity of the farms themselves.

To carry out these objectives, the East Ghor Canal Authority was established by law. All of the first three objectives were fully carried out, but the fourth objective of farm development was carried only partially by the EGCA. The Authority carried out land levelling in farm units that contained land above the water surface in the delivery box for the unit. Other land development work like levelling to grade, benching, head ditching or similar work was left as being the responsibility of the farmers under the guidance and technical assistance of the Development Division of the Ministry of Agriculture. Increasing the productivity of the land is also the responsibility of the Ministry of Agriculture and the farmers.

Field observations show that numerous farm units in the project area still require reclamation by either upgrading or leaching. Some of these farms cannot use water from the East Ghor Canal as they have not yet levelled their land. The one hundred pounds given to the farmer as a loan by the Ministry of Agriculture is not sufficient to reclaim the allocated farm unit. Other farms are supplied with the East Ghor Canal waters in spite of their failure to carry out the requisite levelling. Henry George's remarks are apposite here:-

"What is necessary for the improvement of land is not its private ownership, but the security of improvements. It is not necessary to say to a man 'this land is yours', in order to induce him to cultivate or improve it. It is only necessary to say 'whatever your labour or capital produces on this land shall be yours'".(9)

It is true that the East Ghor Irrigation Project has been successful, to some extent, in converting the tenants to landowners. Arthur Young, writing in the eighteenth century, remains the most immortal in this context: to cite two of his texts, "the magic of property turns sand into gold", and "give a man the secure possession of a bleak rock and he will turn it into a garden; give him a nine years' lease of a garden and he will convert it into a desert".(10) It is true that when a man is free to reap all the profit from his own investments of capital and labour, he has the greatest possible incentive to invest, to work and to keep the land in good heart. It is, unfortunately, also true that a system of owner occupation in the valley lacks any guarantee that the farmer will be able to raise the capital that he needs and whose investment in the farm would benefit the community as a whole.

Preparing the farm units to be suitable for irrigation agriculture is not the final work of development. To increase the productivity of the land, farmers should use efficient methods of new irrigation techniques, selected seeds, fertilizers, shelters and windbreaks, contour ploughing, contour terracing, strip cropping, crop rotation, and in short, proper management. To create proper management in the valley, the co-operated experienced farmer must be found first. It is easy to find the hard working farmer who, particularly in the southern valley, exerts his utmost to convert the Class IV land into productive farms, but it is difficult to find the farmer who has efficient experience in the new techniques of irrigation, selection of suitable crops and conservation of the soils, waters and crops of the farms. It is difficult also to create a co-operative spirit between groups of farmers since the limited number of co-operative societies at present is evidence of the farmers' reluctance to be enrolled as members in these societies. It is the responsibility of the Ministry of Agriculture to create that farmer who must be an example for other farmers in the country, and create the farm which could be an example for other farms in the country. In addition to enlightening the farmers with the benefits of co-operative societies by holding numerous meetings and issuing pamphlets, the success of these societies in realizing their goals is the best stimulus to their further growth.

The Japanese agricultural co-operatives are a good example of the successful provision of credit to peasant farmers. The land reform of 1946 has created a very difficult agrarian situation by forbidding the owner-occupiers to hold more than 30 dunums. It has been alleviated by an extensive co-operative movement. Every farmer belongs to at least one of the co-operative societies which handle the sale of crops and the purchase of farmers' requisites as well as the provision of short term credit. Long term credit is, in turn, supplied to the societies by the Government.(11) The Egyptian Government has also attempted to deal with the problems which follow the distribution of land to a poor peasantry by co-operative organization. Miss.Warriner aptly comments "it used to be said that Egypt is a country of large properties and small farms. So far as the requestioned land goes, the reverse is now true, for it is held by small proprietors and farmed in large units".(12) This part of the Egyptian Land Reform is, then, a most interesting attempt to solve both the social problems of income distribution and the economic problems of the supply of capital to agriculture and of the efficient use of the land. Boserup remarks are apposite here:- "When a given area of land comes to be cropped more frequently than before, the purpose for which it was hitherto used must be taken care of in a new way, and this may create additional activities for which new tools and other investment are required". "The degree of security of tenure for the cultivator is one of the important determinants of investment".(13)

RECOMMENDATIONS.

The Jordan Valley has a long history of occupance and economic activity, but recently has been going through a phase of unprecedented economic and social development. It is perhaps only natural that many problems and difficulties of environmental use have arisen during this recent period; this is particularly the case today as development projects have not been finally accomplished and therefore have not been able to show the total results.

The East Ghor Irrigation Project is merely a small part of the entire Yarmouk-Jordan Valley Project discussed in Chapter 10. It is therefore strongly recommended that work continues on the entire project so that the Kingdom of Jordan and the Jordan Valley in particular can benefit from the improvements. In addition to the construction of dams on the Yarmouk and on the side wadis and to the expansion of the East Ghor Canal into the southern valley and also into the western Jordan Valley, a prime need in the area is the rational development of groundwater resources. The Ground Water Division of the Natural Resources Authority (N.R.A.) thus has the urgent task of designing a groundwater policy for the area based on control of well digging and water extraction and on implementing artificial recharge as suggested in Chapters 2 and 3.

The present cropping pattern is satisfactory although there are hidden dangers in the trend towards cash cropping where this is carried out without due regard to questions of soil fertility, crop rotation and the marketing projects. The development of the cropping patterns suggested in Chapter 9 has been based on considerations of projected demand for agricultural commodities, benefits to farm and national economy and on agronomic considerations. The ultimate cropping intensity is anticipated to be about 135 percent for the northern valley and 125 percent for the southern valley. These are slightly conservative levels but are practical in view of the experience of farmers in the valley in maintaining the benefits of the summer fallow. By reducing the acreages of vegetables, fruit, and cereals, it should be possible to introduce new cropping patterns, particularly with respect to fodder crops, industrial crops and forest trees.

It is recommended that varied industries be established in or near the valley; this will be particularly important if the increasing demand for milk, meat and dairy products continues. It is recommended that a wood industry for fruit and vegetable boxes is established based on locally grown trees. These trees can prevent soil erosion and the silting up of irrigation canals and they can also improve agricultural production by providing protecting wind breaks for field crops. Juice and oil industries are recommended for the valley based for citrus and safflower crops respectively.

Marketing facilities and their organisations need improving. The Agricultural Extension Education and Training Services should be strengthened and their efforts more completely integrated than at present. The Agricultural Research Service also needs re-organising and strengthening in order to give competent technical advice to farmers.

Present control for the Jordan Valley is vested in the Natural Resources Authority, a large organisation which has surveillance over resource development in the whole of the Kingdom. However, it is thought that it would be far better if there were a separate Jordan Valley Authority which would be financially autonomous and legally independent. This Authority could plan the siting and layout of the new villages which need to be developed and would plan in advance for the detailed administrative, technical and social aspects of the scheme. Subsequently, it could be charged with the following tasks:-

1 - Operating and maintaining the irrigation system, distributing irrigation water, and fixing and collecting rents and water rents.

2 - Providing agricultural advice and services to farmers, including facilities for the purchase of seeds, fertilizers and implements.

3 - Providing facilities for hiring machinery for threshing, spraying etc.

4 - Facilitating the disposal of produce by market research, the provision of transport facilities and sponsoring of processing plants.

5 - Assisting in the supply of agricultural credit, preferably through local branches of Agricultural Bank.

6 - Fostering the development of co-operative societies and aiding agricultural and social research.

7 - Assisting village welfare in the development of water supplies, and improved housing, recreational facilities, communal activities, and education in the valley.

8 - Fostering the development of self governing bodies of cultivators and villagers and supporting the development of progressive local authorities.

Obviously, the administrative status of the Jordan Valley must be considered in this context and it is recommended that a separate District be created with its offices within the valley. As seen in Chapter 10, it is recommended that this District be sub-divided into Sub-Districts (Qatda), four of which must be in the Eastern Jordan Valley; Northern Shuneh, Yabis, Muaddi, and Southern Shuneh would provide suitable centres for the administrative Sub-Districts. In turn, the Sub-Districts can be sub-divided into Nahiyas to facilitate local services. It is tentatively suggested that each Nahiya can serve an area with 6,000 inhabitants. In addition to administrative offices each of the four Sub-Districts should have markets, secondary agricultural schools, hospitals, and recreational facilities. Each Nahiya should have an elementary school, clinic, small market, and Police Post.

The Jordan Valley Authority, with the co-operation of the Ministry of Agriculture, the Co-operative Central Union, the Department of Co-operatives, the Ministry of Health, and the Ministry of Public Works, would be in a good position to shape rural development projects in the valley. Rural Development which will be required comprises the following:-

1 - Multi-purpose community centres in the Sub-Districts which will serve as centres for training extension personnel and for educational and community activities of the farmers.
2 - Co-operative Societies in the Sub-Districts to include marketing centres, service centres and machine rental and repair services.
3 - Separate Co-operatives for livestock and marketing in each Sub-District.
4 - Health Centres in each Sub-Districts to be managed by the Ministry of Health.
5 - The designing and construction of 300 Km. of gravel roads to link farms and market centres.
6 - The opening of centres for training co-operative and employees.
7 - The establishment of veterinary services in each Sub-District.

The Jordan Valley must play an even more important role in the national economy. In the future, it must contribute towards a reduction of imports of agricultural produce and must provide an even greater contribution to export earnings of high quality produce. Within the valley, development must aim at increasing the value and reliability of irrigated produce and at lessening the environmental hazards which beset irrigated agriculture. It is estimated that a more prosperous community in the valley will not only have a much better social organisation based on family-owned farms and will not only create more employment possibilities, but will also contribute a sum of not less than J.D. 20 million to the national income every year.

It seems apt to end this discussion with the following words from Schultz (1964)[(14)] :-

"When I see how little success most countries are having in increasing agricultural production, I can see why one might well believe that it is a rare and difficult art to master".

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A P P E N D I C E S

APPENDIX I

TABLE 1.1.

Atmospheric Pressure at Jericho (mb.)

Year	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1964	1062	1056.4	1054.7	1055.2	1055.8	1051.9	1037.8	1038.9	1043.1	1047.9
1965	1048.8	1049.6	1048.7	1046.2	1045.4	1040.7	1038.3	1038.2	1042.4	1045.9
Average	1055.4	1053	1051.7	1050.7	1050.6	1046.3	1038	1038.5	1042.7	1046.9

Year	Nov.	Dec.	Autumn.	Winter.	Spring.	Summer.
1964	1049.7	1052.2	1046.9	1056.9	1055.2	1042.8
1965	1050.7	1051.4	1046.3	1049.9	1046.8	1039
Average	1050.2	1051.8	1046.6	1053.4	1051	1040.9

Source: Met.Dept. and various.

TABLE 1.2. Frequency of wind direction. Percentages of total observations.

(Tiberias).

Wind.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
N.	6	0	6	0	0	0	0	0	0	0	0	0	
NE.	0	0	0	0	0	0	0	0	0	0	0	0	
E.	3	11	0	0	0	0	0	0	0	0	10	29	
SE.	0	0	0	0	0	0	0	0	0	0	0	0	
S.	0	0	10	0	0	0	0	0	0	3	0	3	
SW.	0	0	0	0	0	0	0	0	0	0	0	0	
W.	10	7	6	33	71	93	100	58	23	42	13	0	
NW.	0	0	0	0	0	0	0	0	0	0	0	0	
Calm	81	82	78	67	29	7	0	42	77	55	77	68	

Jericho (1921-34) (observations 0800, 1400, and 2000 hours).

Wind.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
N.	19	14	18	17	20	18	13	13	19	22	20	18	18
NE.	15	13	22	23	27	24	19	24	23	25	20	14	21
E.	3	4	6	7	5	6	6	7	8	7	5	2	6
SE.	4	5	6	10	12	15	19	16	14	10	7	7	10
S.	9	9	5	7	9	8	12	11	8	7	6	7	8
SW.	11	15	7	5	4	5	7	8	5	4	7	10	7
W.	12	14	10	8	6	6	6	4	3	5	8	13	8
NW.	23	21	22	20	13	14	14	13	12	14	21	25	18
Calm	4	5	4	3	4	4	4	4	8	6	6	4	5

Source:- Naval Intelligence, Palestine and Transjordan. Oxford (1943).

TABLE 1.3. Wind Velocity: Analysis of two representative stations

(in Kms.)

Station	Period of record.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Total
Deir Alla	1964-1966	9.6	10.3	8.9	8.2	9.4	5.8	5.8	9.4	10.3	9.1	12.5	16.8	9.7
Jericho	1964-1966	7.2	7.7	9.8	11.2	11.2	12.2	11.8	13	10.3	9.1	10	8.2	10.1

Source: Met.Dept. and various.

TABLE 1.4 Cloud amounts (Oktas): Analysis of eight stations over a period of two years (1964-1965).

Northern Valley.

Station	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Northern Shuneh	4.8	4.3	3.6	3.8	1.8	1.2	1.4	1.7	1.4	1.7	2.9	4.1	2.7
Wadi Jurum	2.8	2.3	2.3	2.8	0.8	0.5	0.2	0.4	0.7	1.0	2.3	2.9	1.7
Wadi Yabis	2.7	3.3	2.6	2.6	1.5	0.9	0.6	0.9	1.1	1.2	2.4	2.8	1.9
Deir Alla	3.8	4.3	3.3	3.5	1.5	1.0	0.5	0.7	0.7	1.5	2.9	3.6	2.3
Average	3.5	3.6	3.0	3.2	1.4	0.9	0.7	0.9	1.0	1.4	2.6	3.4	2.2

Southern Valley.

Southern Shuneh	3.6	4.1	3.4	2.7	0.9	0.5	0.3	0.6	0.6	1.4	2.5	2.6	1.9
Wadi Hisban	4.5	3.5	3.3	3.1	0.8	0.3	0.1	0.4	0.5	1.2	2.6	3.2	2
Jericho	4.1	3.6	2.9	2.9	1.0	0.6	0.2	0.3	0.4	1.2	2.5	3.2	1.9
Dead Sea North	4.2	3.2	3.6	3.0	1.5	0.4	0.1	0.3	0.4	1.6	2.9	3.0	2
Average	4.1	3.6	3.3	2.9	1.0	0.5	0.2	0.4	0.5	1.4	2.6	3.0	2.0

Source:- Met. Dept. and various.

TABLE 1.5. Number of cloud-days per annum: Analysis of seven stations over two years.

Northern Valley

Station	Period of record	Jan.		Feb.		Mar.		Apr.		May.		June.		July.	
		C*	O	C	O	C	O	C	O	C	O	C	O	C	O
Northern Shuneh	1964-1965	5	16	5	13	6	8	12	13	22	1	28	0	24	0
W.Jurum	"	22	9	28	6	29	1	35	1	34	0	46	0	55	0
W.Yabis	"	4	5	2	4	5	0	6	1	24	1	32	0	36	0
Deir Alla	"	1	7	2	10	4	4	5	3	13	1	19	0	35	0
Total	"	32	37	37	33	44	13	58	18	93	3	125	0	150	0
Percentage		46.4	53.6	52.9	47.1	77.2	22.8	76.3	23.7	96.9	3.1	100	0	100	0

		Aug.		Sept.		Oct.		Nov.		Dec.		Total of clear sky days	Total of overcast days
		C	O	C	O	C	O	C	O	C	O		
		5	0	15	0	32	1	19	5	6	10		
		41	0	41	1	47	3	29	7	19	1		
		42	0	31	0	39	0	20	3	10	4		
		17	0	21	0	32	0	16	3	6	5		
Total		105	0	108	1	150	4	84	18	41	20	1027	147
Percentage		100	0	99.1	0.9	97.4	2.6	82.4	17.6	67.2	32.8	87.5	12.5

TABLE 1.5. - Continued:

Southern Valley.

Station	Period of record	Jan.		Feb.		Mar.		Apr.		May.		June.		July.	
		C*	O	C	O	C	O	C	O	C	O	C	O	C	O
Southern Shuneh.	1964-65	8	10	5	8	11	6	14	2	41	0	47	0	54	0
W.Hisban	"	4	22	3	7	15	8	5	3	30	1	44	0	54	0
Dead Sea North.	"	14	16	9	5	12	4	8	4	28	0	38	0	54	0
Total	"	26	48	17	20	38	18	27	9	99	1	129	0	162	0
Percentage		35.1	64.9	46	54	67.9	32.1	75	25	99	1	100	0	100	0
		Aug.		Sept.		Oct.		Nov.		Dec.		Total of clear sky days		Total of overcast days	
		C	O	C	O	C	O	C	O	C	O				
		50	0	45	0	39	1	26	11	19	5				
		56	0	51	0	43	0	25	7	22	9				
		44	0	43	0	37	3	24	14	17	6				
Total		150	0	139	0	119	4	75	32	58	20	1039		152	
Percentage		100		100	0	96.7	3.3	70.1	29.9	74.4	25.6	87.3		12.7	

* Note C = Clear sky $0 - \frac{1}{8}$

O = Overcast $\frac{7}{8} - 8/8$.

Source:- Met.Dept. and various.

TABLE 1.6a. Monthly percent of Day time hours for Latitude 32° North.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Percent	7.20	6.97	8.37	8.75	9.63	9.60	9.77	9.28	8.34	7.93	7.11	7.05

TABLE 1.6b. Mean duration of sunshine (hours) : Analysis of two stations over six years (1961-1966).

Station	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual
Deir Alla	5.8	6.7	7.2	8.9	11	12.3	12.9	12	9.9	9	7.6	5.8	9
Jericho	6.2	6.7	7.3	9.2	11	12.5	12.9	12.2	10.3	9.2	8.3	6.6	9.4
Average	6	6.7	7.3	9.1	11	12.4	12.9	12.1	10.1	9.1	8	6.2	9.2

Source:- Met.Dept. and various.

TABLE 1.7. Mean Monthly temperatures (Degree Centigrade).

Northern Valley.

Station	Period of records	Years of record	Elevation metres	Jan.	Feb.	Mar.	Apr.
Northern Shuneh (Wadi Arab)	1950 - 1965	16	-205	13.5	14.8	17.4	20.1
Wadi Ziglab	1950 - 1964	15	-200	13.9	15.4	18.5	21.4
Wadi Jurum	1950 - 1965	16	-180	13.3	14.6	16.9	20.5
Deir Alla	1951 - 1965	15	-224	14.9	16	18.5	21.5
Average				13.9	15.2	17.8	20.9

May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual
24.6	29.3	30.6	31.0	29.3	25	20.8	16.2	23
25.9	29	30.7	31.7	30.3	26.8	21.4	15.6	23.4
24.6	29.1	29.8	31.2	29.1	24.6	19.9	16.2	22.5
26.3	30.2	31.3	32	30.2	26.3	21.6	17.3	23.8
Average 25.3	29.4	30.6	31.5	29.7	25.7	20.9	16.3	23.1

TABLE 1.7. - Continued:

Southern Valley.

Station	Period of records	Years of records	Elevation metres	Jan.	Feb.	Mar.	Apr.	May.	June.
Wadi Fari'a	1955-1965	11	-250	14.1	15.1	18.2	21.4	25.7	30
Jericho	1941-1965	25	-276	13.9	15.3	18.2	21.4	26.2	30.4
Wadi Hisban	1958-1965	8	-185	14.4	14.9	17.9	21.7	25.3	29.5
Dead Sea North	1928-1943	16	-387	14.6	15.9	18.7	21.4	26.7	29.4
Average	-	-	-	13.3	15.3	18.3	21.5	26	29.8

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual
	30.9	32	29.8	26	21.4	16.8	23.5
	31	31.7	29.6	25.5	21	16.2	23.4
	30.1	31.1	29.2	25.5	21.7	17.6	23.2
	31.1	31.7	29.1	26.9	21.2	16.3	23.6
Average	30.8	31.6	29.4	26	21.3	16.7	23.4

Source:- Met.Dept. and various.

TABLE 1.8. Mean, maximum and minimum temperatures (^{o}C).: Analysis of six stations over six years (1961-1966).

Summer (July).

Northern Valley

Station	Elevation m.	Highest Absolute Temperature	Lowest Absolute Temperature	Range	Mean Maximum Temperature	Mean Minimum Temperature	Range
Northern Shuneh	-205	45	16	29	37.5	23.2	14.3
Wadi Jurum	-180	42.5	17	25.5	37	22.3	14.7
Deir Alla	-224	43.9	19.5	24.4	38.9	22.2	16.7
Average					37.8	22.5	15.3

Southern Valley

Southern Shuneh	-230	44	17	27	38.7	25.1	13.6
Jericho	-276	45.8	18.5	27.3	39	23.3	15.7
Dead Sea North	-387	43.5	20	23.5	38.5	24.4	14.1
Average					38.7	24.3	14.4

TABLE 1.8. - Continued:

Winter (January)

Northern Valley

Station	Elevation m.	Highest Absolute Temperature	Lowest Absolute Temperature	Range	Mean Maximum Temperature	Mean Minimum Temperature	Range
Northern Shuneh	-205	26.5	2.5	24	19	8.2	10.8
Wadi Jurum	-180	24.5	-0.5	25	18.5	8.6	9.9
Deir Alla	-224	25.4	0.5	24.9	19.5	9.9	9.6
Average					19	8.9	10.1

Southern Valley

Station	Elevation m.	Highest Absolute Temperature	Lowest Absolute Temperature	Range	Mean Maximum Temperature	Mean Minimum Temperature	Range
Southern Shuneh	-230	27	3.7	23.3	19.8	11.2	8.6
Jericho	-276	25.4	0	25.4	19.6	8.7	10.9
Dead Sea North	-387	25	2	23	20.3	9.5	10.8
Average					19.9	9.8	10.1

Source:- Met.Dept. and Various.

TABLE 1.9.

Mean monthly of Relative Humidity (%) in the Jordan Valley and the neighbouring regions.

Station	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Coastal Plain Jaffa (1896-1905) (obsns. 7,13,21 hs).	76	75	71	71	71	73	74	72	70	70	71	73	72
Mountains Jerusalem (1918-34) obsns. 8 hours.	78	72	60	52	44	46	50	55	60	58	62	73	59
Jordan Valley Degania (1 year obsns.)	74	75	66	58	60	59	63	65	62	49	63	68	63
Beisan (9 years'obsns.)	73	76	68	58	58	56	55	55	59	53	66	54	60
Jericho (1921-34) (obsns. 8,14,20 hs).	70	68	56	48	43	44	45	46	52	54	59	66	54
Dead Sea North (1928-1943)	72	69	62	59	59	60	54	56	56	55	65	65	61
Eastern Plateau Amman (1924-41) (obsns. 8,14 hrs.)	68	64	52	42	30	31	33	36	40	39	53	63	46

Source:- Met.Dept. and various.

TABLE 1.10. Mean monthly of Relative Humidity (%): Observations 08,00, 14,00, 20,00 hrs. Analysis of six stations over six years (1961 - 1966).

Northern Valley

Station	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Northern Shuneh	70	69	60	55	48	47	50	52	54	51	59	67	57
Wadi Jurum	74	72	66	60	52	50	54	58	60	58	62	70	61
Deir Alla	68	67	63	58	47	46	46	50	51	47	50	61	54
Average	71	69	63	58	49	48	50	53	55	52	57	66	57

Southern Valley

Wadi Fari'a	69	68	61	56	48	44	47	50	48	47	52	64	54
Southern Shuneh	65	62	57	53	44	43	44	42	47	43	50	59	51
Wadi Hisban	65	64	63	52	50	45	48	49	52	49	52	60	54
Average	66	65	60	54	47	44	46	47	49	46	51	61	53

Source:- Met.Dept. and various.

TABLE 1.11a. Selected stations from the coastal plain, the hill region and the Jordan Valley. Analysis of five stations over five years (1943 - 1947).

Station	April-September (Dry)		October-March (Rainy)		Yearly Total	
	No.dew nights	Total dew mm.	No. dew nights	Total dew mm.	No.dew nights	Total dew mm.
Lod Airport	111	9.7	89	15.7	200	25.4
Ramalla	88	16.0	66	11.4	154	27.6
Degania A	97	4.8	74	8.8	171	13.6
Beit Alpha	81	3.2	75	7.4	156	10.6
Jericho	26	0.4	89	4.3	115	4.7

Source:- Met.Dept. and various.

TABLE 1.11b. Half-yearly and yearly totals of dew for the rainy and dry seasons in the Jordan Valley. Analysis of three stations over three years (1963 - 1965).

Station	April-September (Dry)		October-March (Rainy)		Yearly Total	
	No.dew nights	Total Dew mm.	No.dew nights	Total Dew mm.	No.dew nights	Total Dew mm.
Northern Shuneh	38	2.7	127	13.1	165	15.8
Wadi Fari'a	13	0.6	124	9.8	137	10.4
Jericho	5	0.2	131	15.3	136	15.5

TABLE 1.12. Number of Raindays per Annum (Northern Valley)

Station	Period of Record	0-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	Over 70	Total
Adasiyeh	1947 - 1966	-	-	-	1	4	7	5	1	-	
Baqoura	1937 - 1966	-	-	1	3	10	5	7	-	-	
Northern Shuneh (W.Arab)	1950 - 1966	-	-	-	1	5	5	5	-	-	
Wadi Ziglab	1950 - 1966	-	-	-	2	3	7	4	-	-	
Wadi Jurum	1950 - 1966	-	-	-	1	7	7	1	-	-	
Wadi Kufringa	1951 - 1966	-	-	-	2	7	6	-	-	-	
Deir Alla N.R.A.	1950 - 1966	-	-	-	5	3	7	1	-	-	
Total				1	15	39	44	23	1		123
Percentage				0.8	12.2	31.7	35.8	18.7	0.8		100

TABLE 1.12. - Continued:

(Southern Valley)

Station	Period of Record	0-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	Over 70	Total
Ghor Fari'a P.Post	1952 - 1966	-	1	4	2	4	1	1	-	-	
Shunet Nimrin (Southern Shuneh)	1954 - 1966	-	-	2	5	4	1	-	-	-	
King Husein Bridge	1953 - 1965	-	-	4	4	3	-	-	-	-	
Jericho	1954 - 1966	-	-	2	5	5	-	-	-	-	
Kufrein	1944 - 1966	-	-	7	9	3	1	1	-	-	
Total			1	19	25	19	3	2			69
Percentage			1.5	27.5	36.2	27.5	4.4	2.9			100

Source:- Met.Dept. and various.

TABLE 1.13.

Annual maximum daily rainfall during the period of record 24 hours rainfall in mm.

(Northern Valley)

Station	Period of Record	0-20	21-40	41-60	61-80	81-100	Total
Adasiyeh	1947-1966	1	6	8	2	1	
Baqoura	1937-1966	1	10	10	4	1	
Northern Shuneh (W.Arab)	1950-1966	1	7	6	1	1	
Wadi Ziglab	1950-1966	2	7	3	3	1	
Wadi Jurum	1950-1966	1	10	5	-	-	
Wadi Kufrinja	1951-1966	2	7	4	2	-	
Deir Alla N.R.A.	1950-1966	-	12	3	-	1	
Total		8	59	39	12	5	123
Percentage		6.5	48	31.7	9.8	4.0	100

(Southern Valley)

Ghor Fari'a P.Post	1952-1966	4	5	2	1	1	
Southern Shuneh	1954-1966	4	5	3	-	-	
King Husein Bridge	1953-1965	7	4	-	-	-	
Jericho	1954-1966	7	5	-	-	-	
Kufrein	1944-1966	7	11	3	-	-	
Total		29	30	8	1	1	69
Percentage		42	43.5	11.5	1.5	1.5	100

TABLE 1.14. Intensity classes plotted against the number of rain day observations
Seven Stations 1961 - 1967
Intensity mm./24 hours.

Northern Valley.

Station	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
Adasiyeh	128	60	27	28	8	10	5	1	1	0	
Baqoura	134	57	32	17	7	14	10	1	0	1	
Wadi Ziglab	132	53	31	14	13	9	3	1	0	1	
Deir Alla	115	43	29	23	5	7	1	0	1	0	
Total	509	213	119	82	33	40	19	3	2	2	1022
Percentage	49.8	20.8	11.7	8	3.2	3.9	1.9	0.3	0.2	0.2	100
Southern Valley.											
Southern Shuneh	117	43	10	6	4	3	0	0	1	0	
Kufrein	98	46	10	4	6	5	0	0	0	1	
King Husein Bridge	102	30	3	9	2	3	1	0	0	0	
Total	317	119	23	19	12	11	1	0	1	1	504
Percentage	62.9	23.6	4.5	3.8	2.4	2.2	0.2	0	0.2	0.2	100

Source:- Met.Dept. and various.

TABLE 1.15. Total rainfall in each intensity class
Seven Stations 1961-1967
Intensity mm./24 hours.

Northern Valley

Station	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55
Adasiyeh	320	454	358	455	182	82	196	36	85	94	0
Baqoura	295	433	433	263	155	329	132	35	85	45	52
Wadi Ziglab	275	409	374	240	284	142	65	75	0	142	52
Deir Alla	224	312	365	400	107	80	63	0	41	0	51
Total	1114	1608	1530	1358	728	633	456	146	211	281	155
Percentage	12.5	18.0	17.2	15.2	8.1	7.1	5.1	1.6	2.4	3.2	1.7

	56-60	61-65	66-70	71-75	+75	Total
	55	64	0	0	79	
	117	65	69	0	84	
	0	0	0	74	0	
	0	0	0	0	83	
Total	172	129	69	74	246	8910
Percentage	2.0	1.5	0.8	0.8	2.8	100

TABLE 1.15. - Continued:

Southern Valley.

Station	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	
Southern Shuneh	266	311	124	103	90	0	30	0	84	45	0	
Kufrein	209	306	130	72	139	26	69	40	0	93	0	
King Husein Bridge	247	194	53	158	43	26	67	36	0	0	0	
Total	722	811	307	333	272	52	166	76	84	138	0	
Percentage	24.4	27.4	10.3	11.2	9.2	1.8	5.6	2.6	2.8	4.7	0	

	56-60	61-65	66-70	71-75	+75	Total
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Total	0	0	0	0	0	2961
Percentage	0	0	0	0	0	100

Source:- Met.Dept. and various.

TABLE 1.16.

Annual rainfall totals by water years in mm. 1951/52 - 1966/67.

Station	51/52	52/53	53/54	54/55	55/56	56/57	57/58	58/59
Adasiyeh	409	455	518	272	474	423	378	276
Baqoura	402	448	497	219	437	397	425	250
N.Shuneh (W.Arab)	382	444	491	231	446	388	397	259
Wadi Ziglab	377	391	492	248	479	459	436	227
Wadi Jurum	234	328	363	198	403	361	367	244
Wadi Kufrinja	356	269	334	209	385	350	278	187
Deir Alla N.R.A.	308	270	378	137	432	332	252	213
Ghor Fari'a P.Post	-	196	252	97	322	170	268	220
S.Shuneh	-	-	-	115	176	198	127	102
King Husein Bridge	-	X	132	74	144	130	97	87
Jericho Agr.St.	-	X	X	89	172	212	122	107
Kufrein	246	129	126	121	246	228	102	X

Station	59/60	60/61	61/62	62/63	63/64	64/65	65/66	66/67	Mean annual rain-fall mm.	Period of the mean
Adasiyeh	X	406	461	312	468	442	304	491	406	51-67
Baqoura	220	411	465	322	450	434	366	528	388	"
N.Shuneh (W.Arab)	218	357	434	270	395	378	310	516	391	"
Wadi Ziglab	210	388	453	239	368	387	229	447	357	"
Wadi Jurum	210	295	281	247	323	364	264	460	349	"
Wadi Kufrinja	130	333	254	174	330	283	206	371	285	"
Deir Alla N.R.A.	118	290	284	233	337	304	185	398	291	"
Ghor Fari'a P.Post	32	229	138	95	282	252	-	272	220	52-67
S.Shuneh	(41)	244	142	(63)	299	213	139	199	175	54-67
King Husein Bridge	X	170	99	45	236	149	X	127	134	53-67
Jericho Agr.St.	52	175	115	48	239	156	107	143	138	23-67
Kufrein	59	207	127	79	345	220	135	184	178	47-67

Source:- Met.Dept.

TABLE 1.17. Mean Monthly evaporation (in mm. Piche method).

Station	Elevation mm.	Period of Record	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Beisan	-118	1926-1938	88	85	150	192	267	300	302	285	245	217	130	115	2377
Jericho	-260	1943-1951	117	122	202	217	367	345	362	335	292	260	177	132	2932

Source:- Various.

TABLE 1.18a. Mean Daily evaporation (in mm. Piche method).

Station	Elevation mm.	Period of Record	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Beisan	-118	1926-1938	3	3.1	4.8	6.5	8.8	10	9.9	9.3	8.3	7.1	5	3.8
Jericho	-260	1943-1951	4.2	4.9	6.9	9.5	11.8	12.7	12	11.9	10.6	7.7	6.5	4.7

Source:- Various.

TABLE 1.18b. Mean daily evaporation (24 hrs. mm. Piche method).
Analysis of eight stations over the years
(1961 - 1965).

Northern Valley.

Station	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Northern Shuneh	3.2	3.4	4.8	6	7.9	9.6	9.5	9	8	6.9	5.9	3.7
Wadi Jurum	2.3	2.9	3.4	4.9	7.3	8.7	7.9	6.7	6.1	5.5	3.6	2.7
Wadi Yabis	2.0	2.5	3.6	5.3	8.5	10.7	10.1	9.6	8.3	6.5	4.5	2.7
Deir Alla	4.0	4.0	5.9	7.7	11.3	10.3	9.8	8.9	8.5	8.3	7.8	5.0
Average	2.9	3.2	4.4	6.0	8.8	9.8	9.3	8.6	7.7	6.8	5.5	3.5

Southern Valley.

Southern Shuneh	3.9	4.7	5.9	7.5	11.9	17	13.7	14.1	12.5	10.9	8	4.9
Wadi Hisban	3.7	4	4.6	5.6	7.7	9.7	8.9	9.7	8.3	7.7	7.4	4.8
Jericho	3.9	5.3	7.2	9.9	14.3	17.8	16.8	15.8	13.7	11.5	8.9	5.3
Dead Sea North	6.5	7.3	11.4	13	17.2	19.7	19.4	18.1	15.9	14	12.7	9.7
Average	4.5	5.3	7.3	9	12.8	16	14.7	14.4	12.6	11	9.3	6.2

Source:- Met.Dept. and various.

TABLE 1.19. Tentative monthly water balances for the Dead Sea (all terms in cm.).

Month	Evaporation	Change of level	Total inflow	Jordan at King Husein Bridge	Rainfall	Dry-weather surface inflow south of K. Husein Bridge and underground inflow.	Storm-water inflow
Jan.	7.5	+ 12.5	20	14.5	2.5	1.25	1.75
Feb.	6	+ 16	22	16	1.5	1.25	3.25
Mar.	8.5	+ 11	19.5	14	1	1.25	3.25
Apr.	9	+ 3.5	12.5	10	0.5	1.25	0.75
May.	11.5	- 0.5	11	9.25	-	1.25	0.5
June.	14.5	- 5	9.5	8.25	-	1.25	-
July.	18.5	- 9	9.5	8.25	-	1.25	-
Aug.	20	- 10.5	9.5	8.25	-	1.25	-
Sept.	19	- 9.5	9.5	8.25	-	1.25	-
Oct.	17	- 7.5	9.5	8.25	-	1.25	-
Nov.	13.5	- 3.5	10	8.25	0.5	1.25	-
Dec.	10	+ 2.5	12.5	9.25	1.5	1.25	0.5
Annual	155	0	155	122.5	7.5	15	10

Source:- Neumann (1958).

TABLE 1.20.

Water Balance during the active growth period at various stations in Jordan.

Station	Period active growth	Water storage before period Wst (1)	Water storage before period Wst (2)	Rainfall during period.	$WSt+\bar{P}$ (1)	$WSt+\bar{P}$ (2)	ETP during period	ETA during period	$\frac{WSt+\bar{P}}{ETP}$	$\frac{WSt+\bar{P}}{ETA}$
Deir Alla	1/II - 15/IV	3	33	110	113	143	191	172	0.59	0.83
Irbid	1/III-15/V	148	226	126	274	352	260	234	1.05	1.39
Mafraq	1/III-15/V	0		48	48	48	300	270	0.16	0.18
Amman	1/III-15/V	169	224	106	275	330	302	272	0.91	1.12

(1) Calculated with ETP.
(2) Calculated with ETA.

Source:- F.A.O., A study of agroclimatology in Semi-arid and arid Zones of the Near East (1962), p.142.

TABLE 1.21. Daily, Monthly and Annual values of Potential Evapotranspiration compared with Monthly and annual values of Precipitation (mm.).

Station		I		II		III		IV		V		VI		VII		VIII	
		P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP
Deir	1)	59	56	59	64	45	99	17	141	5	186		230		238		226
Alla	2)		1.8		2.3		3.2		4.7		6.0		7.7		7.7		7.3
Amman	1)	68	34	62	50	41	87	12	135	4	170		200		208		189
	2)		1.1		1.8		2.8		4.5		5.5		6.7		6.7		6.1
Irbid	1)	115	4.0	91	56	90	80	29	111	8	161		186		198		182
	2)		1.3		2.0		2.6		3.7		5.2		6.2		6.4		5.9
Mafraq	1)	36	34	32	50	29	87	11	135	5	170		198		210		189
	2)		1.1		1.8		2.8		4.5		5.5		6.6		6.8		6.1

		IX		X		XI		XII		Year	
		P	ETP	P	ETP	P	ETP	P	ETP	ETP	ETP-P
Deir	1)		183	5	143	44	96	60	68	1730	1438
Alla	2)		6.1		4.6		3.2		2.2	4.7	
Amman	1)		144	4	108	32	60	48	43	1428	1157
	2)		4.8		3.5		2.0		1.4	3.9	
Irbid	1)		135	13	108	62	60	74	50	1364	882
	2)		4.5		3.5		2.0		1.6	3.7	
Mafraq	1)		141	6	108	21	60	33	45	1427	1254
	2)		4.7		3.5		9.0		1.5	3.9	

1) Monthly and yearly averages.
2) Average daily value.

Source:- F.A.O., A study of agroclimatology in Semi-arid and arid zones of the Near East (1962), p.175.

TABLE 1.22.

Consumptive Use Coefficients (K) for irrigated crops in the valley.

Crop	K	Crop	K
Cereal Crops:-		Industrial Crops:-	
Wheat	0.85	Sugar Beet	0.80
Barley	0.80	Sesame	0.80
Corn	0.85	Peanuts	0.65
Sorghum	0.80	Sunflower	0.80
Truck Crops:-			
Tomatoes	0.80		
Potatoes	0.75		
General Vegetables	0.80		
		Fruit:-	
Forage Crops:-		Bananas	1.30
		Citrus	0.65
Alfalfa	0.85	Dates	1.20
Berseem	0.85	Other fruits	0.65
Silage	0.80		

Source:- Baker and Harza (1955).

TABLE 1.23a.

Irrigation Requirements for Northern Valley (in mm.).

Month	Effective Rainfall (mm).	Numerical Values for "K" Consumptive Use Coefficient.						
		0.65	0.70	0.75	0.80	0.85	1.20	1.30
Jan.	54	15	20	26	31	37	74	85
Feb.	46	21	26	32	37	42	78	89
Mar.	34	53	59	66	73	79	126	139
Apr.	-	102	109	117	125	133	187	206
May.	-	124	133	143	152	162	229	248
June.	-	133	143	154	164	174	246	266
July.	-	140	150	161	172	183	258	279
Aug.	-	135	146	156	166	177	250	270
Sept.	-	116	125	134	143	152	214	232
Oct.	-	104	112	120	128	136	193	209
Nov.	32	50	57	63	70	76	120	133
Dec.	63	8	14	19	25	30	69	80

TABLE 1.23b.

Irrigation Requirements for Southern Valley (in mm.).

Month	Effective Rainfall (mm.)	Numerical Values for "K" Consumptive Use Coefficient.						
		0.65	0.70	0.75	0.80	0.85	1.20	1.30
Jan.	29	41	46	52	57	63	100	111
Feb.	21	47	52	57	62	67	104	115
Mar.	-	88	95	101	108	115	162	176
Apr.	-	103	111	119	127	135	190	206
May.	-	126	136	145	155	165	233	252
June.	-	135	145	156	166	177	249	270
July.	-	140	151	162	173	184	259	281
Aug.	-	136	146	157	167	177	250	271
Sept.	-	117	126	135	144	153	216	234
Oct.	-	104	112	120	128	136	193	209
Nov.	-	84	90	96	103	109	154	167
Dec.	28	44	50	55	61	66	105	117

Source:- Energoprojekt Cons.Eng.Comp. (1964).

TABLE 1.24a.

Diversion Requirements for Northern Valley (in mm.).

Month	Numerical Values of "K" Consumptive Use Coefficient						
	0.65	0.70	0.75	0.80	0.85	1.20	1.30
Jan.	23	31	40	48	56	114	130
Feb.	33	41	49	57	65	121	137
Mar.	81	91	101	112	122	194	214
Apr.	156	168	180	192	204	288	312
May.	191	205	220	235	249	352	381
June.	205	221	237	252	268	378	410
July.	215	231	248	264	281	396	429
Aug.	208	224	240	256	272	384	416
Sept.	179	192	206	220	233	330	357
Oct.	161	173	185	198	210	296	321
Nov.	78	87	97	107	117	185	205
Dec.	13	21	30	38	47	106	122

TABLE 1.24b.

Diversion Requirements for Southern Valley (in mm.).

Month	Numerical Values of "K" Consumptive Use Coefficient						
	0.65	0.70	0.75	0.80	0.85	1.20	1.30
Jan.	63	71	80	88	96	154	170
Feb.	72	80	88	96	104	160	176
Mar.	135	146	156	166	177	249	270
Apr.	159	171	183	195	207	292	317
May.	194	209	224	239	254	358	388
June.	208	236	240	256	272	383	415
July.	216	236	249	266	282	399	432
Aug.	209	225	241	257	273	385	417
Sept.	180	194	208	221	235	332	360
Oct.	161	173	185	198	210	296	321
Nov.	129	139	148	158	168	237	257
Dec.	68	77	85	94	102	162	179

Source:- Energoprojekt Cons.Eng.Comp. (1964).

APPENDIX 3.

TABLE 3.1. Monthly Discharge of the Yarmouk for the Period 1926/27 - 1931/32.

	1926-27	1927-28	1928-29	1929-30	1930-31	1931-32
October	22.0	19.4	26.0	24.0	15.6	18.2
November	11.2	19.2	18.5	28.0	29.5	15.6
December	32.2	13.8	17.2	20.5	38.6	21.5
January	46.7	14.3	57.0	28.7	86.0	19.2
February	242.0	94.0	355.0	89.0	231.0	138.0
March	82.5	27.0	104.0	39.7	71.0	26.0
April	43.0	12.0	108.0	26.2	35.0	23.4
May	12.7	13.0	102.0	26.0	29.0	23.4
June	21.6	7.5	50.0	26.7	23.0	23.0
July	25.0	13.0	23.4	24.0	21.0	23.0
August	18.8	15.6	13.8	24.0	19.0	23.0
September	18.0	19.4	18.2	24.0	16.0	22.0
Yearly Total	575.7	268.5	893.1	380.8	614.7	376.3

Sources: 1) M.G. Ionides (1939), Report on the water resources of Transjordan.
2) M. MacDonald (1951), Report on the proposed extension of irrigation in the Jordan Valley.

TABLE 3.2. Monthly discharge of Jordan at Deganya for the period 1926/27-1931/32 (mcm.).

	1926-27	1927-28	1928-29	1929-30	1930-31	1931-32
October	6.5	1.3	13.0	7.3	10.4	(10.3)*
November	7.0	8.3	2.3	15.6	8.0	13.0
December	39.2	8.4	25.5	38.5	20.0	16.8
January	59.0	20.5	65.5	45.0	42.5	18.2
February	97.0	58.0	200.0	83.5	153.0	90.0
March	152.0	130.0	227.0	110.0	156.0	58.0
April	120.0	95.0	134.0	80.0	111.0	(10.3)*
May	84.0	63.5	92.5	59.2	76.0	11.2?
June	50.2	38.6	64.5	42.5	49.5	11.4?
July	21.3	26.0	41.5	26.0	35.5	12.5
August	7.3	13.0	29.4	17.1	21.2	13.5
September	5.6	3.9	20.0	11.6	14.0	14.5
Yearly Total	648.7	466.5	915.2	536.3	697.1	-

* Computed flow through the sluice of the barrage.

Sources:- 1) M.G.Ionides (1939), Report on the water resources of Transjordan.
2) M. MacDonald (1951), Report on the proposed extension of irrigation in the Jordan Valley.

TABLE 3.3.

Jordan River Basin.
Yarmouk River at Adasiyeh.
Total flow in millions of cubic metres.

Water Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Total.
1925/26	x	x	x	x	x	x	x	26	18	15	15	12	x
1926/27	12	11	33	48	230	85	43	13	22	26	19	18	560
1927/28	23	19	14	15	91	28	12	13	7.5	13	16	19	270
1928/29	20	18	18	58	330	110	100	100	50	24	14	18	870
1929/30	27	28	21	30	83	41	26	27	28	25	25	24	380
1930/31	25	30	40	88	210	73	35	30	23	21	20	16	610
1931/32	16	16	22	20	130	27	23	24	23	24	24	22	370
1932/33	20	20	22	22	43	20	17	17	13	17	18	22	250
1933/34	19	20	21	22	67	28	25	25	25	25	25	26	330
1934/35	23	22	39	62	250	36	40	25	20	24	24	21	590
1935/36	23	25	28	26	31	24	21	21	20	21	22	22	280
1936/37	24	32	55	130	90	30	26	22	21	20	20	20	490
1937/38	25	32	24	69	160	78	27	26	22	21	21	20	520
1938/39	22	40	31	50	84	96	42	19	18	18	19	20	460
1939/40	18	21	32	160	62	45	20	17	16	18	19	19	450
1940/41	22	24	33	94	76	64	25	20	18	19	18	18	430
1941/42	19	21	33	110	82	110	27	20	17	17	18	18	490
1942/43	19	22	21	96	90	110	89	28	22	22	22	27	570
1943/44	39	27	24	120	59	34	26	23	20	22	26	25	440
1944/45	26	39	69	240	160	68	29	21	20	19	21	21	730

TABLE 3.3. - Continued:

Water Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Total
1945/46	24	23	25	25	130	46	20	19	13	11	14	16	370
1946/47	19	19	23	80	78	24	14	14	12	11	12	12	320
1947/48	14	20	24	27	110	100	24	20	18	18	18	17	410
1948/49	18	19	33	60	86	81	81	20	19	19	18	18	470
1949/50	19	19	35	77	63	58	37	25	20	21	20	19	410
1950/51	20	21	23	26	36	23	20	18	18	18	17	17	260
1951/52	27	23	150	100	200	160	25	19	18	18	18	22	780
1952/53	23	24	26	58	100	220	76	16	15	15	16	17	610
1953/54	23	27	34	160	220	50	46	22	19	20	21	22	660
1954/55	25	25	29	29	24	30	23	20	20	21	22	21	290
1955/56	22	30	63	100	57	43	28	26	22	22	22	22	460
1956/57	23	22	25	40	68	59	24	19	19	20	21	20	360
1957/58	22	22	36	110	33	24	22	23	21	19	20	21	370
1958/59	23	21	23	27	44	42	23	20	19	19	20	21	300
1959/60	22	21	22	27	22	23	21	16	15	18	18	19	240
1960/61	19	22	23	28	53	24	21	27	18	18	18	18	289
1961/62	22.0	23.5	78.8	52.7	74.4	27.8	18.0	18.6	18.2	17.8	18.1	19.8	390
1962/63	20.7	16.3	23.7	52.9	53.7	47.5	20.8	22.0	15.9	16.5	17.9	18.4	326

Notes: May 1926 through April 1948: Palestine Electric Corporation records.
May 1948 through April 1953: Record synthesized by Baker-Harza.
May 1953 through December 1953: Baker-Harza records.
January 1954 through December 1959: Jordan Irrigation Department records.
January 1960 through September 1961: Central Water Authority records.
October 1961 through September 1963: Central Water Authority and East Ghor Canal Authority records.

TABLE 3.4a.

Jordan River Basin

Jordan River at King Husein Bridge.

Total flow in millions of cubic metres.

Water Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Total
1932/33	29	30	34	36	43	33	27	30	31	32	30	25	380
1933/34	49	45	46	58	94	50	42	46	49	49	61	58	650
1934/35	54	53	110	160	370	100	130	110	84	110	120	110	1500
1935/36	100	85	74	57	53	68	60	75	57	58	68	64	820
1936/37	73	130	75	280	210	70	48	71	83	83	86	80	1300
1937/38	95	120	82	93	170	110	89	96	83	85	88	89	1200
1938/39	82	130	100	96	120	150	78	83	79	83	87	81	1200
1939/40	76	68	94	130	180	85	75	76	65	68	80	80	1100
1940/41	86	73	86	130	120	100	82	91	86	84	88	82	1100
1941/42	76	64	100	150	120	200	92	100	94	93	94	88	1300
1942/43	100	82	78	110	210	210	260	150	110	110	110	110	1600
1943/44	110	85	76	140	100	61	64	70	69	70	76	75	1000
1944/45	80	88	87	270	180	190	110	90	85	88	88	84	1400
1945/46	90	70	62	61	140	86	50	59	63	78	84	76	920
1946/47	74	74	77	120	120	78	70	70	69	68	69	69	960
1947/48	70	75	78	80	140	140	54	72	84	77	36	34	940
1948/49	50	77	83	59	150	270	260	130	69	63	62	59	1300
1949/50	75	66	76	200	130	79	67	56	41	55	50	67	960
1950/51	80	79	82	60	49	35	28	22	19	17	16	17	500
1951/52	24	26	130	150	220	270	92	70	50	53	70	74	1200

TABLE 3.4a. - Continued:

Water Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Total
1952/53	60	66	46	58	79	280	200	72	45	48	58	62	1100
1953/54	77	92	120	220	290	240	170	140	83	66	60	60	1600
1954/55	77	110	93	60	38	39	30	26	24	26	27	29	580
1955/56	49	93	150	160	120	71	63	56	59	51	66	52	990
1956/57	45	50	78	60	96	110	93	53	48	48	46	45	770
1957/58	61	67	110	170	170	47	33	33	33	32	35	39	830
1958/59	53	65	50	46	63	67	35	34	30	30	29	32	530
1959/60	35	37	x	x	x	28	23	18	16	16	16	18	x
1960/61	x	x	x	x	x	x	x	x	x	x	x	x	x
1961/62	x	x	x	x	x	65.8	26.3	23.3	20.1	21.7	23.4	23.9	x
1962/63	38.5	35.7	41.7	55.1	12.5	126	47.8	73.0	28.6	19.4	12.7	13.5	617

Note: October 1932: Synthesis by Central Water Authority.
November 1932 through September 1933: Taken from the Water Resources of Trans Jordan and their Development by M.G. Ionides.
October 1933 through September 1944: Palestine Irrigation Service "Water measurements prior to October 1944"
October 1944 through September 1945: Palestine Irrigation Service "Water measurements 1944/45".
October 1945 through September 1946: Palestine Irrigation Service "Water measurements 1945/46".
October 1946 through March 1948: Synthesis by Central Water Authority.
April 1948 through September 1963: Central Water Authority records.

TABLE 3.4b.

Annual Discharge of the Jordan at King Husein Bridge for the period 1926 - 1946.

(Adapted from Table 23, Goldschmidt, Cvi and Kornic, 1947).

Hydrological year*	Mean annual precipitation amounts (in mm.) over the whole river basin.	Mean annual precipitation amounts in (mm.) over the river basin south of Lake Tiberias (in round figures)	Annual charge (mcm.) recorded or estimated.
1926 - 1927	(450)**	(396)**	(1,410)**
1927 - 1928	(289)	(243)	(890)
1928 - 1929	(548)	(414)	(1,680)
1929 - 1930	(344)	(321)	(1,090)
1930 - 1931	(379)	(310)	(1,550)
1931 - 1932	(250)	(208)	(770)
1932 - 1933	252.9	230	(800)***
1933 - 1934	274.6	225	648
1934 - 1935	434.0	346	1,494
1935 - 1936	273.9	224	823
1936 - 1937	421.4	358	1,289
1937 - 1938	507.3	426	1,198
1938 - 1939	461.2	422	1,182
1939 - 1940	399.6	351	1,082
1940 - 1941	371.0	305	1,105
1941 - 1942	373.5	307	1,279
1942 - 1943	541.2	465	1,650
1943 - 1944	361.2	294	1,001
1944 - 1945	646.9	587	1,444
1945 - 1946	392.7	335	919

* In the hydrological records of Palestine the "hydrological year" begins October 1st.

** Brackets signify estimated values.

*** The following figures were recorded after the construction of the barrage.

TABLE 3.5. Average Water Analyses.

Location	Temp. °F.	pH	EC$\times 10^6$	TDS	Milliequivalents per Litre								
					Na	Ca	Mg	Cl	CO_3	HCO_3	SO_4	NO_3	B
Jordan River at Wadi Malih	68	7.4	992	706	5.76	2.85	2.35	6.54	-	3.11	1.18	0.21	-
Jordan River at King Husein Bridge	68	7.9	2402	1681	15.74	5.11	7.86	21.66	.09	3.58	3.35	-	-
Yarmouk River near Adasiyeh	63	7.5	681	485	2.24	1.90	1.71	1.72	.03	3.21	0.83	0.16	-
River Zarqa near Deir Alla	60	7.4	849	621	2.80	3.49	2.68	3.18	.08	3.99	1.41	0.54	-
Wadi Arab	65	7.4	680	550	1.26	3.30	3.10	1.43	.08	4.88	1.14	0.46	-
Wadi Ziglab	69	8.2	781	547	0.65	3.75	3.60	1.69	.87	5.11	0.31	-	-
Wadi Yabis	64	7.5	400	369	0.78	2.55	1.64	0.84	-	3.67	0.12	0.32	-
Wadi Kufrinja	62	7.5	458	321	0.48	2.40	1.48	0.73	-	3.20	0.17	0.24	-
Wadi Rajib	62	7.4	487	341	0.43	2.55	1.56	0.68	-	3.44	0.25	0.24	-
Wadi Shueib	70	8.3	478	335	0.48	2.65	1.80	0.79	0.40	2.84	0.33	-	-
Wadi Auja	64	8.1	464	325	0.43	2.35	1.88	0.79	0.57	3.20	0.10	-	-

TABLE 3.5. - Continued:

Location	SSP	SAR	Class
Jordan River at Wadi Malih	52.6	3.6	C3-S1
Jordan River at King Husein Bridge	54.8	6.2	C4-S2
Yarmouk River near Adasiyeh	38.3	1.7	C2-S1
River Zarqa near Deir Alla	31.2	1.6	C3-S1
Wadi Arab	16.4	0.8	C2-S1
Wadi Ziglab	8.1	0.4	C3-S1
Wadi Yabis	15.7	0.5	C2-S1
Wadi Kufrinja	11.0	0.3	C2-S1
Wadi Rajib	9.5	0.3	C2-S1
Wadi Shueib	9.7	0.3	C2-S1
Wadi Auja	9.2	0.3	C2-S1

Source:- Baker-Harza (1955).

TABLE 3.6. Chemical Composition of water samples collected from streams used for irrigation of the valley.

Stream	Site	Date of Sample	$ECx10^6$ at 25°C	TDS PPM.	Total Cations Me./litre	Milliequivalent Per Litre						
						Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	SO_4	CO_3
R.Jordan	Qattaf	4.1.68.	1400	896	13.65	3.07	3.17	7.00	0.41	9.05	2.00	0.00
R.Jordan	Wahadineh	9.2.68.	1400	896	14.06	2.80	3.70	7.25	0.31	8.37	2.25	0.26
R.Jordan	King Husein Bridge	5.7.67.	3500	2240	34.49	4.73	10.07	19.00	0.69	25.76	5.45	0.00
R.Yarmouk	Adasiyeh	7.1.66.	725	464	7.80	2.40	2.10	3.30	?	2.50	1.80	0.10
R. Yarmouk	Adasiyeh	8.7.66.	760	486	8.04	2.40	2.20	3.44	?	2.90	2.14	0.15
R. Zarqa	Jerash Area	9.7.68.	1130	723	11.66	3.2	4.2	4.00	0.26	4.45	2.80	0.11
R. Zarqa	Deir Alla Area	10.7.66.	1500	960	15.25	3.40	4.10	7.75	?	7.50	4.55	0.10
Wadi Arab	Entrance to Ghor	3.9.64.	580	371	5.8	1.20	3.10	1.50	?	1.70	1.60	0.35
Wadi Ziglab	Entrance to Ghor	11.7.66.	650	416	6.75	2.80	2.90	1.05	?	1.40	0.65	0.000
Wadi Shueib	Entrance to Ghor	18.9.61	580	371	5.80	2.10	2.30	1.40	?	1.90	1.10	0.10
Wadi Kufrein	Entrance to Ghor	18.6.60	1130	723	11.40	2.40	4.00	5.00	?	5.00	3.45	0.25

TABLE 3.6. - Continued:

Millequivalent Per Litre				Class
HCO_3	$Na_{\%}$	SAR	pH	
2.78	51.28	3.96	7.70	C_3 S_1
2.90	51.56	4.00	7.90	C_3 S_1
3.57	55.09	6.97	7.50	C_4 S_2
3.40	42.00	2.20	7.90	C_2 S_1
2.85	43.00	2.30	8.30	C_3 S_1
4.18	34.30	2.07	8.00	C_3 S_1
3.10	51.00	4.2	8.00	C_3 S_1
2.15	25.80	0.90	8.70	C_2 S_1
4.70	16.00	0.5	7.90	C_2 S_1
2.70	24.10	0.90	8.30	C_2 S_1
2.70	43.86	2.8	8.20	C_3 S_1

Source:- Field work.

TABLE 3.7. Well water chemical composition: Analysis of 17 random samples taken from wells of the Jordan Valley in May 1967.

Area	Well No.	EC micromhos/ cm.	TDS PPm.	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	SO_4^{--}	CO_3^{--}	HCO_3
Adasiyeh	20/23/14	2200	1408	5.94	5.12	10.50	0.45	9.98	4.60	0.00	7.28
Kreiyima	20/18/3	1780	1139	5.47	2.68	8.75	0.91	8.78	2.10	000	6.90
Karameh	20/15/17	3800	2432	6.74	13.02	17.00	1.38	23.28	7.20	000	7.43
"	20/15/48	3800	2432	6.74	12.36	17.00	1.80	30.50	2.50	000	4.63
"	20/15/11	4700	3008	13.30	10.49	22.00	1.40	25.92	5.55	000	6.17
Southern Shuneh	20/14/32	1950	1248	5.32	7.41	5.75	0.59	13.63	1.05	000	4.73
"	20/14/95	3700	2368	9.41	11.20	15.00	0.98	28.48	2.85	000	5.11
"	20/14/48	1150	736	4.18	3.80	3.20	0.26	4.86	1.65	000	4.53
"	20/14/13	5250	3360	11.88	15.39	24.50	1.54	43.36	4.05	000	5.60
"	20/14/56	3700	2368	9.32	11.65	15.00	1.50	27.64	3.00	000	6.21
"	20/14/14	4500	2280	12.40	14.70	23.38	?	25.70	19.63	000	5.15
Kufrein	20/13/27	780	499	3.40	2.80	1.97	?	2.70	1.02	000	4.45
"	20/13/63	1990	1274	5.28	6.41	7.75	0.56	9.69	2.70	000	7.49
"	20/13/51	3200	2048	8.30	7.22	14.50	1.28	22.34	1.70	000	8.35
"	21/13/22	1209	774	4.56	4.46	3.05	0.32	4.32	2.10	000	5.60
Rameh	20/13/50	1800	1152	5.70	5.12	7.25	0.59	8.91	3.35	000	5.89
"	20/13/5	1900	1216	3.11	6.20	8.00	1.91	9.83	2.00	000	7.17

TABLE 3.7. - Continued:-

pH	Na%	SAR	Class
7.22	47.7	4.5	C_3 S_2
7.50	49.1	4.3	C_3 S_1
7.70	44.5	5.4	C_3 S_2
7.60	44.9	5.6	C_4 S_2
7.00	46.6	6.4	C_5 S_2
7.32	30.2	2.3	C_3 S_1
7.10	40.9	4.6	C_4 S_2
7.28	28	1.6	C_3 S_1
7.00	46	6.8	C_5 S_2
7.30	40	4.60	C_4 S_2
7.4	46.4	6.7	C_4 S_2
7.7	24.11	0.90	C_3 S_1
7.28	38.7	3.18	C_3 S_1
7.18	46.3	5.20	C_4 S_2
7.10	24.6	1.6	C_3 S_1
7.18	38.9	3.1	C_3 S_1
7.20	41.6	3.70	C_3 S_1

Source:- Fieldwork.

TABLE 3.8.

Usable waters of streams flow after construction of storage dams.

Stream flow	Usable waters mcm.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.
Arab	32.4	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Ziglab	10.2	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8
Jurum	12.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Yabis	5.0	0.3	0.3	0.6	0.1	0.5	0.5	0.4	0.3	0.3	0.2	0.3	0.2
Kufrinja	4.9	0.4	0.4	0.8	1.1	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.4
Rajib	3.6	0.2	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.2	0.1	0.2	0.1
Zarqa	72.0	5.0	5.0	5.0	5.0	7.0	7.0	7.0	7.0	7.0	7.0	5.0	5.0
Shueib	6.3	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Kufrein	12.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Hisban	5.6	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
Total	164.0	12.3	12.5	13	14	15.8	15	14.6	14.4	14.2	14	12.2	12.0

Source:- Development Board of Jordan, Report on El-Mukheibeh Dam - Amman 1964.

TABLE 3.9.

Water Requirements for the Lower Jordan Valley.

Months of Winter	Monthly requirement Cubic metres per dunum.	Months of Summer	Monthly requirement Cubic metres per dunum.	Annual Total Cubic metres per dunum.
Nov.	113.9	April	161.4	
Dec.	61.6	May	154.1	
Jan.	36.8	June	162.0	
Feb.	45.7	July	167.0	
March.	84.3	August	170.2	
		Sept.	183.0	
		Oct.	160.0	
Total winter requirement	342.3	Total Summer requirement	1157.7	1,500

Source:- Hays Report: "T.V.A. on the Jordan", 1947.

TABLE 3.10. Required water quantities of the valley in Cubic Metres per dunum per year.

Crop	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Total
Forage(33%) and Cereal (67%)	90	100	50	20	70	65	10	60	70	70	70	50	725
Fruit	200	150	60	40	60	60	130	130	140	200	250	250	1670
Vegetables	190	110	80	50	80	100	175	210	230	250	250	210	1935
Sugar-beets	210	200	100	60	80	160	-	-	-	-	-	-	810

Note:- Forage, fruit and vegetables require waters all round the year.

Source:- EGCA.

TABLE 3.11. Required water for the 120,000 dunums of East Ghor Irrigation project in Million Cubic Metres.

Crops	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Total
1) Food Crops and Forage	1.35	1.5	0.75	0.3	1.05	1	0.15	0.5	0.5	0.5	0.4	0.3	
2) Fruit	6	4.5	1.80	1.2	1.80	1.8	3.90	3.9	4.2	6.0	7.5	7.5	
3) Vegetables	5.70	3.3	2.40	1.5	2.40	3.0	5.25	6.9	6.9	7.5	7.5	6.3	
4) Sugar-Beets	9.45	9	4.50	2.7	3.60	7.2	-	-	-	-	-	-	
Totals	22.50	18.3	9.45	5.7	8.85	13	9.30	11.3	11.6	14	15.4	14.1	153.5

Note:-1 Line 1 Winter 15,000 dunum, Summer 5,000 dunum.
Line 2 30,000 dunum perennial.
Line 3 30,000 dunum in winter, and perhaps 35,000 dunum in summer.
Line 4 45,000 dunum October to March inclusive.

Note:-2 The above mentioned is the Cropping pattern of the East Ghor Canal Authority (E.G.C.A.)

Source:- EGCA.

APPENDIX 5

TABLE 5.1.

Thick alluvium over Marl. Reddish Brown.

Co-ordinate and Hole No.	Layer depth cm.	pH Paste	pH 1:5	TSS %	$ECx10^3$	ES Me./100g.	CEC Me./100g.	ESP %	SP %
227.5./208	0 - 30	-	9.0	0.05	-	0.83	46	1.8	-
7	30 - 90	-	9.3	0.09	-	3.4	46	7.5	-
	90 -150	-	9.1	0.20	-	5.5	46	12	-
226/218	0 - 30	-	8.8	0.05	-	0.60	-	-	-
13	30 - 60	-	9.1	0.04	-	1.4	40	3.6	-
	60 -105	-	9.4	0.10	-	3.8	39	9.8	-
	105-150	-	9.2	0.17	-	5.6	38	15	-
220/208	0 - 15	7.7	8.5	0.08	0.53	0.21	30	0.7	46
1	15 - 30	7.8	8.7	0.08	0.64	0.58	29	2.0	47
	30 - 45	7.8	8.8	0.08	0.64	0.53	28	1.9	48
	45 - 60	8.0	8.9	0.07	0.60	0.39	28	1.4	53
	60 - 90	7.9	9.0	0.07	0.62	0.31	25	1.2	54
	90-120	8.0	9.0	0.06	0.51	0.13	26	0.5	58
	120 -150	8.0	8.8	0.07	0.53	0.34	27	1.3	58

TABLE 5.1. - Continued

Gyp Me./100g.	HC mm./hr.	IR mm./hr.	DP %''	Sand %	Silt %	Clay %	Texture
-	-	0.5	-	-	-	-	C
-	-		-	-	-	-	C
-	-		-	-	-	-	C
-	-	0.5	-	-	-	-	C
-	-		-	-	-	-	C
-	-		-	-	-	-	C
-	-		-	-	-	-	C
-1	22.6	68.6	56	24	47	29	CL
-1	11.2		68	23	47	30	CL
-1	9.9		56	27	39	34	CL
-1	30.5		46	29	37	34	CL
-1	30.5		54	28	40	32	CL
-1	-		77	24	41	35	CL
-1	-		68	19	46	35	SicL

TABLE 5.1. Thick alluvium over Marl. Reddish Brown.

Coordinate and Hole No.	Layer depth cm.	pH		TSS		ES	CEC	ESP	SP	Gyp
		Paste	1:5	%	ECx10^3	Me./100g.	Me./100g.	%	%	Me./100g.
217/208	0 - 15	7.9	9.0	0.07	0.51	0.20	26	0.8	49	-1
6	15-30	7.8	8.8	0.06	0.51	0.21	25	0.8	51	-1
	30-60	7.8	8.8	0.07	0.47	0.20	25	0.8	54	-1
	60-90	8.0	8.9	0.06	0.52	0.40	22	1.8	58	-1
	90-120	8.1	9.0	0.08	0.57	0.73	22	3.3	60	-1
	120-150	8.1	8.8	0.12	1.3	1.4	25	5.7	58	-1
181/208	0 - 15	7.5	8.3	0.04	0.78	0.34	22	1.5	42	-1
17	15- 30	8.1	8.4	0.06	-	-	-	-	-	-
	30- 60	7.9	8.5	0.06	-	-	-	-	-	-
	60- 90	8.1	8.3	0.06	0.70	0.74	25	3.0	38	-1
	90-120	8.3	8.8	0.07	-	-	-	-	-	-
	120-150	8.0	8.9	0.07	-	-	-	-	-	-
179.5/210	0 - 15	7.7	8.2	0.11	1.9	0.65	21	3.1	45	-1
12	15- 30	7.9	8.5	0.06	-	-	-	-	-	-
	30- 60	7.9	8.4	0.07	-	-	-	-	-	-
	60- 90	8.0	8.7	0.06	0.80	0.73	20	3.6	50	-1
	90-120	8.1	8.7	0.06	-	-	-	-	-	-
	120-150	8.1	8.9	0.06	-	-	-	-	-	-

TABLE 5.1. - Continued:

HC	IR	DP	Sand	Silt	Clay	Texture
mm./hr.	mm./hr.	%	%	%	%	
21.3	5.1	62	9	61	30	SiCL
53.3		59	7	56	37	SiCL
78.7		59	9	52	39	SiCL
71.1		46	8	52	40	SiC
121.9		38	10	44	46	SiC
61.0		43	9	50	41	SiC
13.5	7.6	65	26	51	23	SiL
19.0		57	16	50	34	SiCL
53.3		55	16	49	35	SiCL
50.8		69	15	55	30	SiCL
45.7		72	8	58	34	SiCL
33.0		73	16	55	29	SiCL
15.2	5.1	59	29	43	28	CL
38.1		59	19	48	33	SiCL
27.9		58	19	44	37	SiCL
45.7		65	21	45	36	SiCL
66.0		66	22	45	33	CL
61.0		56	21	45	34	CL

TABLE 5.11 Thick alluvium over Marl. Greyish Brown.

Co-ordinate and Hole No	Layer depth	pH		TSS		ES	CEC	ESP	SP	Gyp.
	cm.	Paste	1:5	%	$ECx10^3$	Me./100g.	Me./100g.	%	%	Me./100g.
164.5/206	0 - 15	7.6	8.7	0.04	0.92	0.13	10	1.3	31	-1
17	15- 30	7.9	8.8	0.03	-	-	-	-	-	-
	30- 60	7.6	8.7	0.03	-	-	-	-	-	-
	60- 90	8.1	9.0	0.03	1.2	0.13	1.5	20	20	-1
	90-120	8.0	8.8	0.03	-	-	-	-	-	-
	120-150	8.1	9.0	0.03	-	-	-	-	-	-
145/206	0 - 15	7.1	7.9	+3.0	102	6.0	14	43	40	6
26	15- 30	7.2	7.9	+3.0	85	6.0	18	33	47	32
	30- 45	7.2	8.0	+3.0	93	5.0	12	42	48	46
	45- 60	7.0	7.8	+3.0	93	7.0	11	64	59	29
	60- 75	7.0	7.5	+3.0	85	6.0	13	46	63	13
	75- 90	6.7	7.9	+3.0	73	9.0	13	69	68	8
	90-120	6.8	7.8	+3.0	73	6.0	12	50	63	5
	120-150	6.9	7.7	+3.0	73	8.0	10	80	59	4

TABLE 5.1. : Continued:

HC mm./hr.	IR mm./hr.	DP %	Sand %	Silt %	Clay %	Texture
2.8	20.3	63	15	56	29	SiCL
3.0		68	46	35	19	SiL
10.9		71	68	21	11	SL
30.5		64	81	11	8	LS
101.6		58	91	5	4	S
18.3		68	63	27	10	SL
11.9	27.9	-				CL
13.7		-				CL
13.7		-	Flocculated			SiL
13.2		-				CL
10.4		-				CL
9.1		-				CL
7.6		-				CL
4.8		-				CL

TABLE 5.1. Thick alluvium over Marl. Greyish Brown.

Co-ordinate and Hole No.	Layer depth cm.	pH		TSS		ES	CEC	ESP	SP	Gyp.
		Paste	1:5	%	$ECx10^3$	Me./100g.	Me./100g.	%	%	Me./100g.
145/206	0 - 15	7.2	7.9	+3.0	114	4.0	-	-	47	38
27	15- 30	7.1	7.8	+3.0	79	4.0	10	40	56	38
	30- 45	7.1	7.8	+3.0	102	2.0	9	22	62	30
	45- 60	7.0	7.7	+3.0	85	6.0	12	50	69	20
	60- 75	7.1	7.9	+3.0	57	2.0	11	18	65	12
	75- 90	7.1	7.8	+3.0	54	0.42	11	3.8	73	7
	90-120	7.5	8.2	+3.0	56	12	15	81	65	10
	120-150	7.3	8.3	+3.0	71	11	15	75	60	5
134.5/208	0 - 15	6.9	7.7	+3.0	188	2.4	10	24	32	8
20	15- 30	7.2	7.6	+2.8	113	2.2	13	17	36	-
	30- 60	7.3	7.9	+2.8	92	1.5	10	15	31	7
	60- 90	7.4	8.0	2.0	61	2.7	10	27	31	-
	90-120	7.4	8.3	2.2	49	4.1	13	32	47	4
	120-150	7.7	8.1	1.2	31	4.3	14	32	51	-
	150-180	7.7	8.4	1.6	38	5.2	15	34	52	4

TABLE 5.1. : Continued:

HC mm./hr.	IR mm./hr.	DP %	Sand %	Silt %	Clay %	Texture
7.6	12.7	-				CL
6.6		-				L
4.3		-				CL
5.3		-	Flocculated			CL
6.6		-				CL
8.1		-				CL
16.0		-				CL
13.0		-				SiCL
16.8	75.4	-				CL
11.4		-				SiCL
17.0		-				CL
14.7		-	Flocculated			SCL
11.9		-				CL
8.4		-				CL
6.9		-				CL

TABLE 5.1. Thin alluvium over Marl. Reddish Brown.

Co-ordinate and Hole No.	Layer depth cm.	pH Paste	pH 1:5	TSS %	TSS ECx10^3	ES me./100g.	CEC me./100g.	ESP %	SP %	Gyp. me./100g.	HC mm./hr.
224.5/206	0 - 15	7.8	8.7	1.0	1.9	0.18	37	0.5	54	-1	6.6
6	15- 30	7.9	8.8	1.1	0.58	0.35	38	0.9	57	-1	16.5
	30- 45	7.9	8.8	1.2	0.66	0.32	37	0.9	56	-1	27.9
	45- 60	8.0	8.8	0.09	0.40	0.42	39	1.1	59	-1	20.8
	60- 75	7.7	8.6	0.18	1.5	0.66	35	1.9	63	-1	13.6
	75- 90	8.0	8.5	0.08	0.45	0.55	34	1.6	66	-1	16.3
	90-105	8.0	9.1	0.07	0.46	0.65	31	2.1	63	-1	18
	105-120	8.1	8.9	0.08	0.53	0.91	30	3.0	65	-1	21.8
	120-150	7.9	8.8	0.31	1.0	1.3	32	4.9	70	-1	140
214/206 4	0 - 15	8.1	8.4	0.05	0.63	0.12	27	0.5	53	-1	4.8
	15- 30	8.0	8.4	0.06	0.50	0.32	26	1.2	50	-1	17.3
	30- 60	8.1	8.5	0.07	-	-	-	-	-	-	24.9
	60- 90	8.1	8.7	0.11	1.8	1.2	22	5.5	57	-1	58.4
	90-120	8.4	9.2	0.09	1.7	1.3	20	7.6	57	-1	18.3
	120-150	8.4	9.2	0.08	-	-	-	-	-	-	18.8

TABLE 5.1. Continued.

IR mm./hr.	DP %	Sand %	Silt %	Clay %	Texture
5.1	70	8	56	36	SiCL
	56	11	49	40	SiC
	48	9	46	45	SiC
	42	12	47	41	SiC
	44	10	50	40	SiC
	45	10	46	44	SiC
	54	11	50	39	SiCL
	43	12	49	39	SiCl
	57	8	53	39	SiCl
"	65	16	54	30	SiCL
	62	17	47	36	"
	55	17	47	36	"
	57	16	45	39	"
	70	17	44	37	"
	72	17	47	36	"

TABLE 5.1. Thin Alluvium over Marl. Reddish Brown.

Co-ordinate and Hole No.	Layer depth	pH		TSS		ES	CEC	ESP	SP	Gyp.
	cm.	Paste	1:5	%	$ECx10^3$	me./100g.	me./100g.	%	%	me./100g.
208/206 13	0 - 15	8.0	8.9	0.04	0.72	0.27	21	1.3	51	-1
	15- 30	8.1	8.5	0.04	0.63	0.11	18	0.7	46	-1
	30- 60	7.9	8.5	0.04	-	-	-	-	-	-
	60- 90	8.0	8.6	0.05	0.63	0.21	15	1.4	49	-1
	90-120	8.0	8.6	0.04	-	-	-	-	-	-
	120-150	8.0	8.6	0.06	-	-	-	-	-	-
205/206 5	0 - 15	7.8	8.1	0.04	1.6	0.19	24	0.8	46	-1
	15- 30	7.9	8.2	0.04	-	-	-	-	-	-
	30- 60	8.0	8.4	0.04	0.76	0.29	21	1.4	49	-1
	60- 90	7.8	8.5	0.03	-	-	-	-	-	-
	90-120	7.9	8.5	0.04	0.60	0.32	14	2.3	45	-1
	120-150	7.8	8.5	0.05	-	-	-	-	-	-
200.5/206 9	0 - 15	7.7	8.4	0.08	1.1	0.30	25	1.2	49	-1
	15- 30	7.9	8.5	0.06	-	-	-	-	-	-
	30- 60	7.8	8.4	0.07	0.76	0.31	25	1.2	50	-1
	60- 90	8.0	8.6	0.08	-	-	-	-	-	-
	90-120	8.1	8.7	0.07	0.82	0.46	22	2.0	48	-1
	120-150	8.1	8.7	0.07	-	-	-	-	-	-

TABLE 5.1. Continued:

HC mm./hr	IR mm./hr.	DP %	Sand %	Silt %	Clay %	Texture
23.6	40.6	52	20	53	27	SiL
23.4		67	19	50	31	SiCL
30.5		76	26	44	30	CL
45.7		74	24	45	31	"
48.3		77	24	44	32	"
55.9		78	21	45	34	"
14.7	61.0	60	35	47	18	L
20.3		49	36	45	19	"
12.7		61	30	49	21	"
27.9		68	33	45	23	"
40.6		66	32	42	26	"
33.0		69	29	43	28	"
8.9	17.8	69	17	57	26	SiL
10.2		69	16	55	29	SiCL
33.0		61	16	50	34	"
45.7		56	19	50	31	"
40.6		58	20	47	33	"
30.5		63	18	48	34	"

TABLE 5.1. Thin Alluvium over Marl. Reddish Brown.

Co-ordinate and Hole No.	Layer Depth.	pH		TSS		ES	CEC	ESP	SP	Gyp.	HC
	cm.	Paste	1:5	%	$ECx10^3$	me./100g.	me./100g.	%	%	me./100g.	mm./hr.
197.5/206	0 - 15	7.8	8.5	0.07	0.60	0.26	37	0.71	44	-1	5.8
6	15 - 30	7.9	8.5	0.08	-	-	-	-	-	-	8.4
	30 - 60	7.9	8.8	0.08	0.62	1.0	35	2.9	57	-1	11.4
	60 - 90	8.1	9.1	0.07	-	-	-	-	-	-	16.3
	90 -120	8.2	9.2	0.07	0.63	2.1	25	8.4	60	-1	11.4
	120-150	8.2	9.2	0.08	-	-	-	-	-	-	5.8
196/206	0 - 15	7.7	8.5	0.05	0.74	3.2	21	1.6	39	-1	7.4
8	15 - 30	7.4	8.6	0.05	-	-	-	-	-	-	21.3
	30 - 60	7.9	8.6	0.04	0.47	0.82	19	43	46	-1	8.9
	60 - 90	7.8	8.4	0.18	-	-	-	-	-	-	9.9
	90 -120	7.6	8.7	0.60	9.3	4.2	23	18	62	-1	5.3
	120-150	7.7	8.7	0.65	-	-	-	-	-	-	6.1
190/206	0 - 15	7.8	8.1	0.05	0.88	0.41	19	2.1	36	-1	5.6
29	15 - 30	7.8	8.2	0.04	-	-	-	-	-	-	7.9
	30 - 60	7.9	8.5	0.07	-	-	-	-	-	-	7.6
	60 - 90	7.9	8.3	0.15	2.6	0.55	19	3.0	54	-1	15.5
	90 -120	7.9	8.3	0.14	-	-	-	-	-	-	11.9
	120-150	7.8	8.4	0.16	-	-	-	-	-	-	8.4

TABLE 5.1. - Continued:

IR mm./hr	DP %	Sand %	Silt %	Clay %	Texture
10.2	71	10	70	20	SiL
	59	10	53	37	SiCL
	58	10	51	39	"
	60	10	50	40	"
	76	10	54	36	"
	88	7	58	35	"
25.4	72	20	61	19	SiL
	64	20	57	23	SiL
	61	17	58	25	SiL
	69	12	60	28	SiL
	84	8	62	30	SiCL
	86	18	57	25	SiL
20.3	70	30	49	21	L
	65	29	46	25	L
	53	26	49	25	SiL
	67	16	55	29	SiCL
	78	17	56	27	SiL
	89	11	62	27	SiL

TABLE 5.1. Thin Alluvium over Marl. Reddish Brown.

Co-ordinate and Hole No.	Layer depth cm.	pH Paste	pH 1:5	TSS %	TSS $ECx10^3$	ES me./100g.	CEC me./100g.	ESP %	SP %	Gyp. me./100g.
184/206 30	0 - 15	7.8	8.4	0.08	0.99	0.18	21	0.87	45	-1
	15 - 30	7.8	8.4	0.05	-	-	-	-	-	-
	30 - 60	7.9	8.4	0.04	-	-	-	-	-	-
	60 - 90	7.8	8.3	0.03	0.43	0.21	14	1.5	39	-1
	90 -105	8.1	8.6	0.03	-	-	-	-	-	-

Thin Alluvium over Marl. Grey Solonchak.

Co-ordinate and Hole No.	Layer depth cm.	pH Paste	pH 1:5	TSS %	TSS $ECx10^3$	ES me./100g.	CEC me./100g.	ESP %	SP %	Gyp. me./100g.
163/204 10	0 - 15	7.5	8.4	+ 3	52	4.0	16	24	42	2
	15 - 30	7.6	8.3	+ 3	36	5.1	18	26	47	1
	30 - 60	7.5	8.4	+ 3	37	5.0	19	26	53	6
	60 - 90	7.6	8.4	+ 3	40	7.3	21	36	57	7
161.5/204 12	0 - 15	7.2	7.8	+2.5	59	5.1	25	21	40	3
	15 - 30	7.6	8.0	+2.5	55	4.7	25	16	45	3
	30 - 45	7.4	8.1	+2.5	47	6.2	26	24	49	8
	45 - 60	7.8	8.1	+2.5	40	3.1	25	12	66	14
	60 - 75	7.8	8.0	+2.5	29	4.7	27	17	71	8
	75 - 90	7.8	8.1	+2.5	43	7.9	27	26	72	4

TABLE 5.1. - Continued:

HC mm./hr.	IR mm./hr	DP %	Sand %	Silt %	Clay %	Texture
10.7	10.2	60	21	58	21	SiL
11.2		68	19	55	26	SiL
18.5		77	23	52	25	SiL
19.0		78	23	56	21	SiL
33.0		83.	44	40	16	L
3.0	17.8	-				CL
2.5		-				SCL
7.6		-		Flocculated		CL
10.7		-				CL
6.4	1.0	-				CL
6.1		-				SiC
30.5		-		Flocculated		"
27.9		-				"
27.9		-				"
12.7		-				"

TABLE 5.1. Thin Alluvium over Marl. Grey Solonchak.

Co-ordinate and Hole No.	Layer depth cm.	pH Paste	pH 1:5	TSS %	TSS $ECx10^3$	ES me./100g.	CEC me./100g.	ESP %	SP %	Gyp. me./100g.
145/206	0 - 15	7.3	8.1	+ 3	62	9.1	14	67	47	60
28	15 - 30	7.2	8.2	+ 3	77	5.8	15	39	42	47
	30 - 45	7.4	8.2	+ 3	71	3.9	12	31	45	60
	45 - 60	7.4	8.1	+ 3	77	9.4	19	49	44	45
	60 - 75	7.5	8.2	+ 3	67	8.9	20	44	44	44
	75 - 90	7.6	8.2	2.5	56	-	16	-	67	68
139/206	0 - 15	7.5	7.9	+ 2.8	117	3.2	11	29	37	43
10	15 - 30	7.2	7.8	+ 2.8	99	4.1	16	27	43	-
	30 - 45	7.3	7.7	1.8	66	0.3	14	2.1	45	53
	45 - 60	7.3	7.7	1.8	56	1.0	15	6.7	45	-
	60 - 75	7.6	7.9	1.4	51	1.6	14	11	45	55
	75 - 90	7.5	7.8	2.8	53	2.3	15	16	41	-
140.5/206	0 - 15	7.2	7.7	1.4	44	3.2	14	23	35	-
22	15 - 30	7.3	7.9	2.2	50	3.9	16	25	36	6
	30 - 60	7.4	7.8	+ 3	52	2.4	18	14	44	-
	60 - 90	7.5	8.0	+ 2.8	61	0.9	15	6.1	46	57
	90-120	7.5	7.7	+ 2.2	65	7.5	11	68	28	-

TABLE 5.1. - Continued:

HC mm./hr	IR mm./hr.	DP %	Sand %	Silt %	Clay %	Texture
19.8	10.2	-				L
21.8		-				L
8.6		-		Flocculated		SL
16.5		-				L
5.6		-				L
16.0		-				SL
11.7	1.0	-				SCL
24.9		-				CL
16.0		-		Flocculated		SL
15.0		-				SCL
8.6		-				SL
40.6		-				L
5.8	10.2	-				SL
8.4		-		Flocculated		L
15.2		-				CL
11.9		-				CL
23.9		-				L

TABLE 5.1 . Recent Zor Alluvium. Zor North.

Co-ordinate and Hole No.	Layer depth cm.	pH		TSS		ES	CEC	ESP	SP	Gyp.	HC
		Paste	1:5	%	$ECx10^3$	me./100g.	me./100g.	%	%	me./100g.	mm./hr.
220/206 2	0 - 30	7.9	8.5	0.11	1.1	0.67	34	2.0	59	-1	6.1
	30 - 60	7.9	8.6	0.11	1.2	0.85	29	3.0	57	-1	9.4
	60 - 90	7.9	8.5	0.28	4.0	2.8	26	11	59	-1	43.2
	90 -105	8.1	8.8	0.15	2.3	1.1	24	4.4	61	-1	16.8
	105-120	8.1	8.7	0.12	2.5	0.82	21	4.0	52	-1	50.8
	120-150	8.2	8.9	0.16	2.4	0.42	17	2.5	66	-1	33.0
	Recent Zor Alluvium. Zor South.										
137.5/204 24	0 - 15	7.6	7.7	+ 3	161	2.0	13	22	40	-	16.0
	15 - 30	7.8	7.9	+2.8	117	1.7	15	11	41	27	19.6
	30 - 45	7.3	7.8	+2.8	70	4.6	14	32	40	-	2.8
	45 - 60	7.9	8.3	1.4	46	1.2	8	14	34	20	17.3
	60 - 90	7.8	7.8	0.40	19	0.2	2	10	23	-	37.1
	90 -120	7.4	7.5	0.34	14	0.6	6	10	31	20	42.2
	Residual from Marl. Katar.										
140.5/206 22	0 - 15	7.2	7.7	1.4	44	3.2	14	23	35	-	5.8
	15 - 30	7.3	7.9	2.2	50	3.9	16	25	36	6	8.4
	30 - 60	7.4	7.8	+ 3	52	2.4	18	14	44	-	15.2
	60 - 90	7.5	8.0	+2.8	61	0.9	15	6.1	46	57	11.9

TABLE 5.1 . - Continued: Recent Zor Alluvium. Zor North.

IR mm./hr.	DP %	Sand %	Silt %	Clay %	Texture
15.2	39	10	51	39	SiCL
	43	12	43	45	SiC
	41	14	42	44	SiC
	48	19	44	37	SiCL
	62	23	44	33	CL
	73	27	43	30	CL
	Recent Zor Alluvium. Zor South.				
124.5	-				SL
	-				SL
	-		Flocculated		L
	-				SL
	-				S
	-				S
	Residual from Marl. Katar.				
10.2	-				SL
	-		Flocculated		L
	-				CL
	-				CL

APPENDIX 6.

TABLE 6.1. Land Classification Summary Yarmouk-Jordan Valley Project.

Area	Arable				Class 4	
	Class 1 dunums	Class 2 dunums	Class 3 dunums	Total Class 1,2,3 dunums	1 dunums	2 dunums
East Ghor North						
Ghor above Canal	9,867	18,759	13,077	41,703	-	-
Ghor below Canal	59,071	43,605	9,019	111,695	1,060	2,063
Zor below Canal	4,677	8,689	3,774	17,140	200	314
Total Ghor and Zor below Canal	63,748	52,294	12,793	128,835	1,260	2,377
Grand Total East Ghor North	73,615	71,053	25,870	170,538	1,260	2,377
East Ghor South						
Ghor above Canal	12,055	11,705	8,368	32,128	298	317
Ghor below Canal	29,721	23,498	11,608	64,827	33,808	27,554
Zor below Canal	985	8,343	2,789	12,117	1,732	2,212
Total Ghor and Zor below Canal	30,706	31,841	14,397	76,944	35,540	29,766
Grand Total East Ghor South	42,761	43,546	22,765	109,072	35,838	30,083

TABLE 6.1. - Continued:

Class 4 3 dunums	Total Class 4 dunums	Non-Arable Class 6 dunums	Total All Classes dunums
-	-	44,159	85,862
315	3,438	46,706	161,839
254	768	6,267	24,175
569	4,206	52,973	186,014
569	4,206	97,132	271,876
470	1,085	45,985	79,198
13,677	75,039	93,297	233,163
200	4,144	5,342	21,603
13,877	79,183	98,639	254,766
14,347	80,268	144,624	333,964

Note: Class 6H and 6I (not shown) amounts to 8,823 dunums or 2% of the total class 6 area; most of which is found on the West Ghor.

Source: Baker and Harza (1955).

TABLE 6.2.

Specifications of Land Classification for the Yarmouk-Jordan Valley Project.

Factors Evaluated	Arable SOILS Class 1	Class 2
Texture	Sandy loam to very permeable clay.	Loamy sand to permeable clay.
Depth to:		
Sand,gravel or cobble.	36" of fine sandy loam or heavier. 42" of sandy loam.	24" of fine sandy loam or heavier. 30"-36" of loamy sand.
Bedrock,shale or similar material	60"	36" depending on position and slope.
Residual marl	36"	24"
Modified marl	30"	18"
Alkalinity	Surface pH 9.0 Subsoil pH 9.2	pH 9.2 pH 9.4
Salinity	Surface .2% (may be higher in permeable soils) Subsoil .2% (soils with good drainage).	.5% (may be slightly higher in permeable soils). .5% (permeable soils with good drainage).
	TOPOGRAPHY	
Slopes	Up to 4% in same plane. Less if complex slopes.	Smooth slopes up to 8% or complex slopes up to 4%.
Surface	Regular enough to require only small amounts of levelling.	Moderate levelling and grading required. Estimated earth movement 200-500 M^3/ Dunum.
Cover (loose rock and vegetation).	Cost of clearing small or insufficient to modify cultural practices or reduce productivity.	Clearing required. May be equivalent in cost to Class 2 levelling.
	DRAINAGE	
Soil and Topography.	Requires only normal drainage with maximum permissible drain spacing as established from infiltration tests.	Additional drainage required. Conditions indicate slightly closer drain spacing than that established in Class 1.

Source:- Baker and Harza (1955).

TABLE 6.2. - Continued:

Potential Arable*		Non-Arable
Class 3	Class 4	Class 6
SOILS		
Fine sand to slowly permeable clay.	Fine sand to slowly permeable clay.	This includes all lands which do not meet the minimum requirements for arable land. This may include small bodies of arable land lying within larger areas of non-arable land.
18" of sandy loam or heavier. Fine sand permitted if underlain by heavier material.	18" of sandy loam or heavier. Fine sand permitted if underlain by heavier material.	
24" depending on position and slope.	24" depending on position and slope.	
18" 12"	18" 12"	
pH 9.4 pH 9.6	pH 9.4 pH 9.6	
.5% (may be slightly higher in permeable soils). .75% (higher in open permeable soils with good drainage).	In excess of Class 3 limits but susceptible of leaching to at least Class 3 percentages.	
TOPOGRAPHY		
Smooth slopes up to 12% or complex slopes less than 8%.	Smooth slopes up to 12% or complex slopes less than 8%.	
Heavy levelling and grading required. Estimated earth movement 500-800 M^3/Dunum.	May exceed Class 2 levelling but should not be the maximum allowable for Class 3.	
Heavy clearing necessary. May be equivalent in cost to Class 3 levelling.	May exceed Class 2 clearing but should not be the maximum allowable for Class 3.	
DRAINAGE		
Additional drainage required. Conditions indicate closer drain spacing than that required for Class 2.	Project drainage required as indicated for the potential arable class	

*Class 4 - Areas having soluble salts in excess of limits for Class 3 land, and with soils and topography such that reclamation is highly feasible. Land Class potential after leaching indicated by parenthetical symbols.

APPENDIX 9

TABLE 9.1.

The Monthly Cropping Patterns in the Project Area in 1966.
(Below the East Ghor Canal)

Crop	January 1966						February 1966					
	Section I		Section II		Section III		Section I		Section II		Section III	
	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%
Cereals	9259	37.19	13852	52.07	13501	29.59	8481	36.84	13852	51.30	14175	30.83
Vegetables	5952	23.91	7821	29.40	30723	67.33	4703	20.43	8220	30.44	30373	66.07
Citrus and Bananas	9501	38.17	4838	18.18	1400	3.06	9723	42.24	4838	17.92	1419	3.08
Berseem	99	0.39	42	0.15	-	-	21	0.09	42	0.15	-	-
Miscellaneous	80	0.32	45	0.16	-	-	88	0.38	45	0.16	-	-
	March 1966						April 1966					
Cereals	10163	40.67	14651	53.14	15197	35.99	9815	40.14	11497	47.80	14540	40.87
Vegetables	4614	18.46	7465	27.07	20766	49.18	3934	16.08	6066	25.22	19400	54.53
Citrus and Bananas	9836	39.36	5180	18.78	1557	3.68	9713	39.72	5509	22.90	1557	4.37
Berseem	115	0.46	-	-	-	-	128	0.52	57	0.23	-	-
Miscellaneous	260	1.04	272	0.98	4700	11.13	861	3.52	920	3.82	77	0.21

TABLE 9.1. - Continued:

Crop	May 1966						June 1966					
	Section I		Section II		Section III		Section I		Section II		Section III	
	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%
Cereals	1381	7.72	1457	11.95	13	0.07	2641	15.31	1209	13.41	71	0.70
Vegetables	4642	25.95	7471	45.36	16473	87.45	4354	19.57	2962	32.86	2037	20.23
Citrus and Bananas	11213	62.68	4616	27.91	1567	4.35	10450	60.58	4616	51.22	1648	16.36
Berseem	122	0.68	-	-	-	-	120	0.69	-	-	-	-
Miscellaneous	530	2.96	190	1.41	5073	24.62	660	3.82	225	2.49	6312	62.69
	August 1966						September 1966					
Cereals	5372	29.40	4897	31.60	7	0.02	3677	19.29	2960	19.37	20	0.06
Vegetables	2868	15.69	4521	29.18	22423	93.02	4588	24.07	6021	39.40	27343	94.16
Citrus and Bananas	9756	53.39	5992	38.67	1673	6.94	10577	55.51	6290	41.16	1673	5.76
Berseem	116	0.63	-	-	-	-	126	0.66	-	-	-	-
Miscellaneous	158	0.86	82	0.52	-	-	86	0.45	10	0.06	-	-

TABLE 9.1. - Continued:

Crop	October 1966						November 1966					
	Section I		Section II		Section III		Section I		Section II		Section III	
	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%	Area dunums	%
Cereals	310	1.89	385	2.74	18	0.08	692	3.97	8000	49.68	3272	12.42
Vegetables	6040	36.94	8198	58.38	18473	90.61	5366	30.84	4240	26.33	21046	79.92
Citrus and Bananas	9800	59.89	5402	38.47	1801	8.83	10961	63.01	3825	23.75	1776	6.74
Berseem	133	0.81	-	-	-	-	252	1.44	-	-	-	-
Miscellaneous	80	0.48	11	0.40	95	0.46	124	0.71	35	0.21	237	0.90

Source:- Irrigation Office of EGCA. and Extension Agents.

TABLE 9.2. Cropped areas in the East Ghor Project area (1966).

Crop	Winter (December 1966)					
	Section I		Section II		Section III	
	Area Dunums	% Dunums	Area Dunums	% Dunums	Area Dunums	% Dunums
Wheat and Barley	5859	25.32	10615	44.17	9897	51.65
Tomatoes	577	2.49	2170	9.03	2128	11.10
Eggplants (Aubergine)	1934	8.35	754	3.13	2138	11.15
Potatoes	104	0.44	705	2.93	302	1.57
Okra	-	-	-	-	-	-
Beans	682	2.94	1273	5.29	157	0.81
Peas	-	-	-	-	-	-
Green Peppers	123	0.53	82	0.34	2137	11.15
Cabbage	1389	6.00	1257	5.23	-	-
Cauliflower	926	4.00	1252	5.21	162	0.84
Marrow	274	1.18	454	1.88	166	0.86
Onions	4	0.01	-	-	191	0.99
Radishes	6	0.02	-	-	-	-
Spinach	21	0.09	-	-	-	-
Lettuce	322	1.39	93	0.38	35	0.18
Cucumbers and Squash	-	-	-	-	-	-
Watermelons	-	-	-	-	-	-
Mallow (Muloukhiyeh)	-	-	-	-	-	-
Peanuts	-	-	-	-	-	-
Sesame	-	-	-	-	-	-
Pomegranate	33	0.14	3	0.01	-	-
Olive	10	0.04	11	0.04	-	-
Eucalyptus	33	0.14	-	-	60	0.31
Maize	-	-	-	-	-	-
Berseem	234	1.01	82	0.34	-	-
Bananas	5450	23.55	1207	5.02	268	1.39
Citrus	5153	22.27	4072	16.94	1517	7.91
Total	23134	100	24030	100	19158	100

TABLE 9.2. - Continued:-

Crop	Summer (July 1966)					
	Section I		Section II		Section III	
	Area Dunums	%	Area Dunums	%	Area Dunums	%
Wheat and Barley	-	-	-	-	-	-
Tomatoes	15	0.08	309	2.11	-	-
Eggplants (Aubergine)	746	4.34	1991	13.61	265	5.16
Potatoes	-	-	-	-	-	-
Okra	116	0.67	203	1.38	25	0.48
Beans	-	-	2	0.01	23	0.44
Peas	55	0.32	89	0.60	13	0.25
Green Peppers	233	1.35	290	1.98	390	7.60
Cabbage	40	0.23	-	-	-	-
Cauliflower	-	-	-	-	84	1.63
Marrow	-	-	-	-	9	0.17
Onions	4	0.02	49	0.33	-	-
Radishes	-	-	-	-	-	-
Spinach	-	-	-	-	-	-
Lettuce	-	-	-	-	-	-
Cucumbers and Sqaush	72	0.41	530	3.62	2544	49.62
Watermelons	52	0.30	14	0.09	-	-
Mallow (Muloukhiyeh)	1094	6.37	90	0.61	116	2.26
Peanuts	61	0.35	-	-	-	-
Sesame	166	0.96	97	0.66	-	-
Pomegranate	14	0.08	6	0.04	-	-
Olive	46	0.26	13	0.08	-	-
Eucalyptus	24	0.13	19	0.12	-	-
Maize	3737	21.78	5615	38.39	54	1.05
Berseem	106	0.61	-	-	-	-
Bananas	5523	32.19	1183	8.08	301	5.87
Citrus	5053	29.45	4125	28.20	1302	25.39
Total	17157	100	14625	100	5126	100

Source:- Field work.

TABLE 9.3.

The average winter crop yield in Ghor Nimrin from 1961 to 1966.

Crop	1960/61 Average yield Kg./dunum	1961/62 Yield Kg./ Dunum	1962/63 Yield Kg./ Dunum	1963/64 Yield Kg./ Dunum	1964/65 Yield Kg./ Dunum	1965/66 Yield Kg./ Dunum
Wheat	40	100	100	-	150	80
Barley	70	120	120	-	160	90
Maize	-	-	-	-	200	81
Sesame	-	-	-	-	80	70
Sorghum	-	-	-	-	170	100
Tomatoes	1300	500	1300	1000	-	1200
Eggplants	1800	1100	1250	1010	-	1200
Cauliflower	1300	1360	1390	825	-	800
Cabbage	1350	1450	1460	1030	-	1000
Onions	1000	1000	1470	1000	-	1000
Garlic	500	500	600	480	-	500
Potatoes	898	-	1000	-	-	200
Marrow	1000	1000	600	607	-	-
Cucumbers	906	802	600	492	-	500
Raddish	1000	1000	1560	800	-	900
Carrots	1100	-	1200	506	-	-
Lettuce	1200	1080	1500	686	-	700
Mallow	2000	1500	1500	1010	-	1000
Peppers	1300	1250	1230	690	-	1000
Turnip	2000	-	-	-	-	-
Beans	800	825	1250	787	-	600
Green Broad beans	1200	1140	1210	618	-	800
Peas	700	658	800	458	-	500
Spinach	-	-	1250	-	-	-
Miscellaneous	1000	1000	-	500	-	600
Bananas	1715	1735	1735	-	-	1900
Citrus	611	320	318	-	-	400

Source:- Ministry of Agriculture.

TABLE 9.4.

The average winter crop yield in Ghor Kufrein from 1961 to 1966.

Crop	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
	Yield Kg./ Dunum	Yield Kg./ Dunum	Yield Kg./ Dunum	Yield Kg./ Dunum	Yield Kg./ Dunum	Yield Kg./ Dunum
Wheat	50	100	80	-	-	30
Barley	70	120	100	-	-	40
Maize	-	-	-	-	200	81
Sesame	-	-	-	-	80	61
Sorghum	-	-	-	-	170	100
Tomatoes	1300	500	1320	1010	-	1200
Eggplants	1800	1381	1347	1000	-	1200
Cauliflower	1300	1438	1250	880	-	800
Cabbage	1500	1425	1500	1300	-	1000
Onions	1000	1000	1500	1062	-	1000
Garlic	500	500	600	400	-	500
Potatoes	900	-	-	-	-	-
Marrow	1000	968	600	615	-	-
Cucumbers	800	792	600	495	-	500
Raddish	1000	1000	1600	1425	-	900
Carrots	1100	-	-	-	-	-
Lettuce	-	1086	1500	650	-	700
Mallow	1800	1500	1500	838	-	1000
Peppers	1300	1128	1250	585	-	1000
Turnip	-	-	-	-	-	-
Beans	800	778	1250	763	-	600
Green Broad Beans	1200	1190	1238	59	-	800
Peas	700	719	800	472	-	500
Spinach	-	-	1268	-	-	-
Miscellaneous	1000	1000	-	575	-	600
Bananas	2000	1670	1765	-	-	1900
Citrus	571	273	167	-	-	401

Source:- Ministry of Agriculture.

TABLE 9.5.

Summary of Farm Budget

Farm type: Fruit Farm.   Land Class: I, II.   Area: 30 dunums.

Average Income per Dunum in J.D. :- 29.46

Crops	Cropped Area	Yield in Kilograms		Price	Value
	Dunums	Yield per dunum	Total yield of the area	J.D/Kg.	J.D.
Bananas	8	1800	14400	0.05	720
Citrus	6	1500	9000	0.03	270
Wheat	5	170	850	0.03	25.50
Potatoes	3	1800	5400	0.03	162
Tomatoes	5	1700	8500	0.03	255
Eggplants	3	1800	5400	0.02	108
Channels, roads etc.	1				
Total	31				1540.50

	Crop Production cost J.D.	Capital Investment J.D.	Interest on the Investment J.D.	Gross Income of farm J.D.	Net Income J.D.
Bananas	200	1) Land (1800)	6%		
Citrus	168	2) Fruit trees			
Wheat	7.5	(535)			
Potatoes	47.4	3) Equipment			
Tomatoes	59	(65)			
Eggplants	30.6				
Channels, roads etc.	-				
Total	512.5	2400	144	1028	884

Source:- Information collected during the field work using the results of a 8- sample irrigated farms.

TABLE 9.6.

Summary of Farm Budget

Farm type:- Vegetable Farm. Land Class: I and II. Area:- 30 dunum

Average Income per dunum in J.D. :- 22.34

Crops	Cropped Area	Yield in Kilograms		Price	Value
	Dunums	Yield of dunum	Total yield of area	J.D./Kg.	J.D.
Tomatoes	6	1700	10200	0.03	306
Eggplants	5	1800	9000	0.02	180
Potatoes	4	1800	7200	0.03	216
Watermelons	3	1140	3420	0.013	44.46
Cabbage	2	2400	4800	0.017	81.60
Cauliflower	2	2500	5000	0.02	100
Cucumbers	3	1300	3900	0.025	97.50
Wheat	5	170	850	0.03	25.50
Channels, roads etc.	1	-			
Total	31	-			1051.06
	Crop expenses J.D.	Capital Investment J.D.	Interest on the Investment J.D.	Gross Income of farm J.D.	Net Income J.D.
Tomatoes	68.4	1) Land(1800)			
Eggplants	49.0	2) Equipment (40)	6%		
Potatoes	60.8				
Watermelons	18.0				
Cabbage	18.2				
Cauliflower	21.2				
Cucumbers	27.3				
Wheat	7.5				
Channels and roads etc.	-				
Total	270.4	1840	110.4	780.66	670.26

Source:- Information collected during the field work using the result of a 10 - sample irrigated farms.

TABLE 9.7.

Summary of Farm Budget.

Farm Type: General Farm. Land Class: I,II. Area: 30 dunums.

Average Income per dunum in J.D. :- 6.31

Crops	Cropped Area Dunums	Yield in Kilograms: Yield of dunums	Total yield of the area	Price J.D./Kg.	Value J.D.
Wheat	10	170	1700	0.03	51
Barley	2	180	360	0.02	(fed) 7.20
Seeds of Sorgho	5	200	1000	0.02	(fed) 20
Tomatoes	4	1700	6800	0.03	204
Eggplants	1	1800	1800	0.02	36
Berseem	6	1000	6000	0.015	(fed) 90
Livestock (Two cows)	2	Two veals+4000 Kg.milk			200
Channels,roads, etc.	1				
Total	31				491

	Crop production Cost J.D.	Capital Investment J.D.	Interest on the investment. J.D.	Gross income of the farm. J.D.	Net income J.D.
Wheat	20	1) Land (1800)	6%		
Barley	3	2) Livestock (100)			
Seeds of Sorgho	7.5	3) Equipment (40)			
Tomatoes	60				
Eggplants	13				
Berseem	12				
Livestock	70				
Channels,roads etc.,					
Total	185.5	1940	116	305.5	189.5

Source:- Information collected during the field work using the result of a 5-sample irrigated farms.

TABLE 9.8.

Summary of Farm Budget.

Farm Type:- Vegetable Farm. Land Class : III. Area: 50 dunums.

Average Income per dunum in J.D. :- 9.23

Crops	Cropped Area Dunums	Yield in Kilograms: Yield per dunum	Yield in Kilograms: Total yield of the area	Price J.D./Kg.	Value J.D.
Tomatoes	10	1300	13000	0.03	390
Eggplants	6	1200	7200	0.02	144
Potatoes	8	1200	9600	0.03	288
Watermelons	3	850	2550	0.013	33.15
Cabbage	4	1570	6280	0.017	106.76
Cauliflower	3	1500	4500	0.02	90
Wheat	8	130	1040	0.03	31.20
Sorghum	8	150	1200	0.02	24
Channels, roads etc.	2				
Total	52				1107.11

Crop	Crop production cost. J.D.	Capital Investment J.D.	Interest on the investment J.D.	Gross income of the farm. J.D.	Net Income J.D.
Tomatoes	142.0	1) Land (2250)	6%		
Eggplants	73.8	2) Equipment (50)			
Potatoes	152.0				
Watermelons	22.8				
Cabbage	45.6				
Cauliflower	39.9				
Wheat	15.2				
Sorghum	16.0				
Total	507.3	2300	138	599.81	461.81

Source:- Information collected during the field work using the result of a 10-sample irrigated farms.

TABLE 9.9.

Summary of Farm Budget.

Farm Type: General Farm. Land Class: III. Area: 50 dunums.

Average Income per dunum in J.D. :- 2.25

Crops	Cropped Area	Yield in Kilograms		Price	Value
	Dunums	Yield per dunum	Total yield of the area	J.D./ Kg.	J.D.
Wheat	17	130	2210	0.03	66.30
Barley	5	140	700	0.02	(fed) 14
Sorghum	8	150	1200	0.02	24
Tomatoes	5	1300	6500	0.03	195
Cucumbers	5	1000	5000	0.025	125
Berseem	8	800	6400	0.015	(fed) 96
Livestock (Two cows)	2	Two veals+4000 Kg.milk			200
Channels, roads etc.	2				
Total	52				610.30

Crops	Crop production Cost. J.D.	Capital Investment J.D.	Interest on Investment J.D.	Gross income of the farm J.D.	Net Income J.D.
Wheat	35.70	1) Land (2250)	6%		
Barley	10	2) Livestock (100)			
Sorghum	16	3) Equipment (40)			
Tomatoes	112.50				
Cucumbers	90				
Berseem	20				
Livestock	70				
Total	354.20	2390	143.4	256.10	112.70

Source:- Information collected during the field work using the results of a 5-sample irrigated farms.

TABLE 9.10.

Summary of Farm Budget.

Farm Type:- Unirrigated (Rainfed) General Farm. Land Class III, IV.

Area: 50 dunums.

Average Income per dunum in J.D. : 1.63.

Crop	Cropped Area	Yield in Kilograms		Price	Value
	Dunums	Yield per dunum	Total yield of the area	J.D./Kg.	J.D.
Wheat	25	80	2000	0.03	60
Barley	15	100	1500	0.02	30
Tomatoes	3	600	1800	0.015	27
Watermelons	7	800	5600	0.013	72.80
Total	50				189.80

Crop	Crop production cost J.D.	Capital Investment J.D.	Interest on the investment J.D.	Gross income of the farm J.D.	Net Income J.D.
Wheat	25	1) Land (500)	6%		
Barley	9.90				
Tomatoes	15				
Watermelons	28				
Total	77.90	500	30	111.90	81.9

A

Source:- Information collected during the field work using the results of a 5-sample non-irrigated farms.

TABLE 9.11.

Summary of Chicken Farm Budget (Winter)

Type:- Meat Chicken Time: Winter Period:- Two months.

Farm Type	Number of Chicks	Yield in Kilograms	Price in J.D./Kg.	Value of production J.D.
Small farm	500	650	0.29	188.50
Medium farm	1000	1300	0.29	377
Large farm	2000	2600	0.29	754

Farm Type	Cost of production J.D.	Capital Invest- ment J.D.	Interest on the investment J.D.	Gross Income of the farm J.D.	Net Income J.D.	Net Income per year J.D.
Small farm	157	10	0.60	31.50	30.90	185.40
Medium farm	315	20	1.20	62	60.80	364.80
Large farm	630	40	2.40	124	121.60	729.60

Summary of Chicken Farm Budget (Summer)

Type:- Meat Chicken Time: Summer Period:- Two months.

Farm Type	Number of Chicks	Yield in Kilograms	Price in J.D./Kg.	Value of production J.D.
Small farm	500	550	0.23	126.50
Medium farm	1000	1100	0.23	253
Large farm	2000	2200	0.23	506

Farm Type	Cost of production J.D.	Capital Investment J.D.	Interest on the investment J.D.	Gross Income of the farm J.D.	Net Income J.D.	Net Income per year J.D.
Small farm	115	10	0.60	11.50	10.90	65.40
Medium farm	230	20	1.20	23	21.80	130.80
Large farm	460	40	2.40	46	43.60	261.60

Source:- Information collected during the field work using the results of a 50 - sample farms.

APPENDIX 10

TABLE 10.1.

Selected Paragraphs of Articles VIII and X of Law No.13 1962. E.G.C.A. Law.

Article VIII:- A :- In determining the size and layout of farm units, the minimum size of a farm unit shall be approximately thirty (30) dunums of irrigable land of Class 1 and 2, and fifty (50) dunums of Class 3, and the maximum size of a farm unit shall be two hundred (200) dunums of irrigable land. Under no circumstances can a farm unit once established, be subdivided or parcellated to units smaller in size than the minimum size allowed as stated under this law.

B :- The present landowner in the project area owning thirty (30) dunums or more of irrigable land in the project area, retains the right to claim a farm unit in accordance with the following formula:-

Dunums of Irrigable Land held prior to the project.	Dunums of irrigable land to be alloted to Land Owners.
30 - 50	To be alloted in full.
50 - 100	50 dunums shall be alloted plus 25% of area exceeding 50 dunums.
100 - 500	62 dunums shall be alloted plus 17% of area exceeding 100 dunums.
501 -1000	130 dunums shall be alloted plus 12% of area exceeding 500 dunums.
1000 and above	200 dunums shall be alloted.

C :- The Landowner owning less than thirty (30) dunums shall receive from the Authority by sale or lease, additional land until his farm unit approximately equals the minimum size farm unit of approximately thirty

(30) dunums of Class 1 and 2, and fifty (50) dunums of Class 3.

Article X :- F - The Farmers' Selection Committee shall select the farm family for settlement on irrigable land within the project area with the priority for selection being as follows:-

First Priority:-	Holders who themselves exploit their lands in the project area.
Second Priority:-	Professional farmers residing in the project area.
Third Priority:-	" " from District inhabitants.
Fourth Priority:-	" " " inhabitants of other Districts.
Fifth Priority:-	Holders who utilize their land by lease or share cropping within project area.

Law No.131, 1965.

The following two articles were enacted in the Official Gazette in 30.12.1965 as follows:-

Article II :- The cultivation of banana trees, rice, permanent forage and culturing of fish is banned in the project area without a licence from Agricultural Managers in the area.

Article IV :- Water charges are one fils per cubic metres up to an application rate of 1800 m^3. of water. and two fils per cubic metre must be paid for any amount of water more than 1800 m^3.

TABLE 10.2.

Farm Operations in the project area, by Sections and Villages.

Section	Village	Resident Land Owner-operator		Resident Landowner-share-cropper.	
		Number	Area in Dunums	Number	Area in Dunums
Section I	Adasiyeh	11	289	4	120
	Baqoura	36	1212	4	68
	Sukhour el Ghor	267	8966	82	1048
	Maad	5	56	..	..
	Makhrabeh	34	154	3	3
	Taybeh	193	4093	33	381
	Qla'at	50	1282	33	459
	Hamra	28	8079	8	184
Total of Section 1.		624	24131	167	2263
Section II	Buseileh	17	1295	11	330
	Harrawiya	31	1241	8	140
	Abou Ziad	90	1913	11	35
	Hammeh	108	1858	15	46
	Jirm	67	6680	13	562
	Auja Shamaliyeh	82	1456	27	155
	Auja Janoubiyeh	160	3996	48	401
	Rasiyeh	12	460	1	49
	Kufr Abil	26	90	6	20
	Ghor Farah	296	10127	51	713
Total of Section II.		889	29116	191	2451
Section III	Ghor Wahadineh	117	8174	39	899
	" Balawineh	196	4799	33	360
	Deir Alla	354	9444	30	218
	Tawal	383	20149	34	326
	Ghor Damia-Al Shaqaq	72	5619	10	138
Total of Section III.		1122	48185	146	1941
Grand Total of the Project Area		2635	101432	504	6655

TABLE 10.2. - Continued:

	Absent Landowner inside Jordan		Absent Landowner outside Jordan	
	Number	Area in Dunums	Number	Area in Dunums
	16	935	15	3671
	17	896	3	271
	90	487	7	376
	..	...	10	313
	1	2	..	...
	12	1022	1	56
	8	427	2	98
	6	230	..	...
Total	150	8382	38	4785
	..	...	..	
	..	...	..	
	3	25	..	
	..	...	..	
	9	753	..	
	2	40	..	
	59	1876	..	
	1	159	..	
	2	14	..	
	27	937	1	255
Total	103	4804	1	255
	66	4552	1	998
	5	57		
	38	3977		
	56	5579		
	73	14528		
Total	228	28636	1	998
Grand Total	491	41879	40	6038

Source:- EGCA. (1967).

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