AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 66

1. SUBJECT CLASSIFICATION	A. PRIMARY Food production and nutrition	AP12-0000-GG40
	B. SECONDARY Drainage and irrigation--Near East--South Asia	

2. TITLE AND SUBTITLE
Proceedings

3. AUTHOR(S)
(101) NESA Regional Irrigation Practices Sem. 1st, Izmir,1956

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1956	93p.	ARC NEA 631.7 R336 1956

7. REFERENCE ORGANIZATION NAME AND ADDRESS
AID/NE/TECH

8. SUPPLEMENTARY NOTES (*Sponsoring Organization, Publishers, Availability*)

9. ABSTRACT

10. CONTROL NUMBER PN-AAE-281	11. PRICE OF DOCUMENT
12. DESCRIPTORS Meetings Near East Personnel development South Asia	13. PROJECT NUMBER 14. CONTRACT NUMBER ~~AID/NE/TECH~~ 15. TYPE OF DOCUMENT

AID 590-1 (4-74)

UNITED STATES OF AMERICA
INTERNATIONAL COOPERATION
ADMINISTRATION

REGIONAL IRRIGATION PRACTICES
LEADERSHIP SEMINAR
IZMIR, TURKEY

Preface

Moisture from precipitation over the Middle East and neighboring countries is distributed by season and amount in such a pattern that wide - scale irrigation is destined to play a leading role in country development. Spending for large scale works to develop and distribute water for irrigation has reached the magnitude of billions of both local currency and foreign exchange during the past decade. Most countries of the region have large programs, developed by their own engineering forces or by consulting engineering firms, or both.

Unfortunately, however, very little thought and effort is being placed on the use of irrigation water on the farms. The policy of neglecting the agricultural phase of irrigation can only lead to ruin, both for the farmers in water-logged and eroded soil and poor crops, and to a nation in abandoned structures and investments. Both engineers and agriculturists must devote their wholehearted attention to sound and efficient irrigation practices and techniques on the farms if the task is to be accomplished. In spite of the contrary opinion held by many, water use is a science which must be approached in a sound and practical manner.

As a means of creating interest and developing a better understanding on the subject of water use, a Regional Irrigation Practices Leadership Seminar was conducted in Izmir, Turkey from September 3 thru September 8, 1956.

Participants included agriculturists, engineers and educators. The Seminar was under the joint sponsorship of the International Cooperation Administration and the Turkish Ministry of Agriculture. The Proceedings of the Seminar is being reproduced so that engineers, agriculturists, educators and planning officials of the Middle East and neighboring countries may have an opportunity to make use of the information presented and studied at the Seminar.

Carl M. Forsberg
Seminar Leader

INDEX

	Page
Chapter I: Country Reports	
Afghanistan	2
India	4
Iran	6
Iraq	7
Pakistan	8
Lebanon	11
Turkey	14
Chapter II: Subject Matter Papers	
Dangers and Results of Poor Irrigation	20
Irrigation Efficiencies	24
Water Supply and Delivery Factors	30
Irrigation Methods	33
Relationship of Drainage to Irrigation	42
Economic and Farm Management Factors	45
Farm Needs and Farmer Interest Surveys	51
Extension or Service Organization	62
Training Needs and Courses	64
Chapter III: Field Workshops	72
Chapter IV: Reports of Panel Groups	
Group 1: Land Preparation	77
Group 2: Irrigation Research	78
Group 3: Land Classification	78
Group 4: Extension Service Programs	80
Group 5: Farm Water Delivery	80
Chapter V: Country Follow-up Statements	
Afghanistan	82
India	83
Iran	84
Iraq	86
Lebanon	86
Turkey	87
Resolutions	87
Seminar Agenda	88
Roster of Delegates	89

Chapter 1

Country Reports on Irrigation Situation

Irrigation In Afghanistan

A.T. Petersen, Irrigation Engineer, F.A.O. and Saiffudin Shansab.

The area of Afghanistan is estimated to be about 65 million hectares with a population of about 12 million people. The arable land area is estimated to be about 7 or 8 million hectares of which only about 50 per cent is estimated to be under irrigation.

Due to the lack of workable maps of the country accurate statistics are also not available covering the various crop areas but the estimated areas of the principal crops grown are as follows :

Wheat	*2,025,000*	*hectares*
Barley and Corn	*700,000*	,,
Rice	*180,000*	,,
Cotton	*540,000*	,,
Tobacco	*20,000*	,,
Potatoes	*10,000*	,,
Sugar Beets	*4,000*	,,
Total	*3,479,000*	,,

The country of Afghanistan has a climate predominantly continental but the monsoon influence is occasionally present in Jalalabad to the east and in Kandahar to the south-west, and as far north as Kabul. Annual precipitation varies from 7 or inches in the Helmand Valley basin, 10 to 15 inches in the north-western basin of the Oxus River, and about an average of 10 or 15 inches in the Kabul River basin. These estimates do not include the high, mountainous areas of the basins where precipitation may exceed 40 inches.

The three basins mentioned above comprise the main drainage systems of the country and are divided by the Hindu Kush range of mountains which extend in a south west direction from the main Himalaya mountains in the north to the Helmand Valley to the south. All the principal rivers are fed by melting snows in the high mountains in which the maximum elevation is about 22,000 feet.

These river systems are the sources of the irrigation water supplies which to date have only been partially developed. The Helmand Valley basin receives annually a combined runoff of approximately 4 million acre feet of water, principally from the Arghandab, Helmand, and Farrah Rivers, which now serve about 400,000 acres with irrigation water. Present plans are to develop the necessary conveyance systems with land preparation for an additional 600,000 acres of new land made possible by a conservation program of which two reservoirs comprise the most important features. On the Helmand River the Kajakai dam provides for a reservoir of 3.5 million acre feet ultimate capacity and on the Arghandab River the Arghandab dam has made possible a reservoir of 390,000 acre feet capacity. These two dams also provide for a total ultimate hydro-electric power generation of 120,000 Kva at the Kajakai dam and 60,000 Kva at the Arghandab dam.

Two smaller storage reservoirs have been constructed in recent years on the Ghazni River, a tributary of the Arghandab River. These are the Seraj and Sardi dams which serve some 10,000 acres each with irrigation water.

Much of the older, irrigated areas along the Helmand River have had to be abandoned due to salinization from high water tables. This has come about due to the lack of proper subsurface drainage and partly due to the improper location of some of the main canals. In consequence, only about one-half the arable land served by the existing canal system is farmed at any one time. When the surface salt concentrations have been reduced sufficiently by natural leaching by rainfall during periods of fallow these areas are again cropped and the other land which has become salty from irrigation is then retired. In general both the older irrigated areas as well as new land that is to be developed will need some provision for ground water drainage if the irrigation system is to be successful.

It is notable that any new land proposed for agricultural development is given a thorough study to determine its suitability for irrigation. These studies consist mainly of soil surveys, drainage and salinity investigations and is classified according to its suitability for irrigation. For the purpose of determining the irrigation water requirements, soil moisture relationships are also being determined and finally, a variety of crops are being grown to determine their environmental suitability.

The Kabul River basin includes the Kabul River and its tributaries of which the Kunar, Surkhab, Logar, and Panjshir Rivers are the principal streams. Drainage is discharged into the Indus River in Pakistan. The estimated irrigated area in the Kabul River basin is about 300,000 acres and is located principally in the Kabul, Logar, Cherikar and Jalalabad areas. No records are at hand covering the annual discharge of the basin but it will probably reach about 2 million acre feet. While there are no storage reservoirs in the basin at present there appears to be an ample supply of water in most years in the lower reaches at Jalalabad without regulation of the discharge by the use of storage reservoirs. In the upper reaches of the Kabul River above Jalalabad there is often not sufficient water during the hot summer months to supply all the needs of the irrigated areas served by the present system of diversions. In the south east a preliminary survey is now underway to investigate the feasibility of opening up an additional 100,000 acres of new land for irrigation in the vicinity of Barikab.

The most highly developed irrigated areas of Afghanistan are located in the Kunduz, Kokcha, and Dara-Band-i-Baba River basins bordering on the Oxus River in northwestern Afghanistan. It is estimated that some 700,000 acres are at present under irrigation for growing sugar beets, cotton, wheat, tobacco, rice, and other field crops. Here as elsewhere in the country water is obtained by diverting from the main rivers with temporary diversion dams. During seasons of deficient flows there is insufficient water to meet agricultural demands while total annual runoff may greatly exceed the agricultural needs. Peak flows occur during the months of June and July when often one-half of the annual discharges occur with variations of 100 per cent from the mean. This erratic flow is reflected in an unstable agriculture as crop yields are frequently seriously affected due to the lack of water during the critical growing season. In order to provide a firm irrigation water supply a program of conservation is urgently needed not only for the present demand but to provide for additional acreages such as sugar beets and cotton which are of great economic importance to the country.

PROGRAM FOR IRRIGATION IMPROVEMENT

Helmand Valley

As indicated earlier the major improvement in irrigation in recent years has been in the Helmand Valley in southwest Afghanistan. The magnitude of the project together with the problems of finance and administration has brought about the creation of a single administrative agency called the Helmand Valley Authority patterned somewhat after the Tennessee Valley Authority in the United States.

By the construction of the Kajakai and Arghandab reservoirs a firm irrigation water supply has been brought about for some 400,000 acres of land already under irrigation in addition to furnishing a potential new supply for an additional 500,000 acres of new land. The old, existing canals have been provided with permanent steel and concrete drops, gates, and turnouts so as to make it possible to proberly regulate and distribute the water where needed.

The current construction program will include the extension of the Boghra Canal to serve about 20,000 acres of new land in the Marje area with land preparation by levelling and ditching; provide drainage for some 20,000 acres in the Nad-i-Ali tract and also some drainage facilities in the Shamalan tract along the Helmand River. A new diversion dam in the Arghandab River and canal improvement will serve the existing irrigated lands comprising about 180,000 acres in the Arghandab Valley and Tarbak area near Kandahar. Present plans also include the construction of hydro-electric stations for power generation at Arghandab and Boghra Canals totaling some 4,000 Kva.

Kabul River Basin

Plans for the improvement of the present irrigation systems in the Kabul River Basin at present are centered in the development of some new land in the vicinity of Batikat for the expansion of sugar cane production and general agriculture. Cropping patterns, however, must be geared to the seasonal river discharge so as to take advantage of the water supply when available. This has limited the variety of crops that can be grown especially in the upper reaches of the Kabul River system. During August and September there is frequently no water available in the streams so crops must be matured before this time ordinarily. No plans have been announced for conservation of the present supply in the Kabul River at present but there appears to be several dam sites that could be exploited for holdover storage.

Oxus River Basin

In the northern provinces preliminary surveys are now being conducted to determine the various acreages under irrigation and to appraise the available water supplies with the view to develop plans for permanent improvements. Careful attention will be given to the existing soil and water resources to determine the deficiency in the supply of water as well as the seasonal demands of the present agricultural development. These surveys will include hydrological investigations of the various streams, soil surveys, land use surveys, and engineering studies of various damsites, canals, and distribution systems.

Other areas are also under consideration as offering possibilities for expanding the irrigated areas. The limiting factor, however, in all cases is the available water supply. It can be stated that no further expansion of irrigated areas can be safely undertaken without the construction of hold over storage facilities in the upper reaches of the rivers. The development of a ground water supply might also offer some possibility for expansion of the irrigated areas but so far nothing has been done to exploit this resource.

Fortunately, there are a number of damsites with good reservoirs in the various streams where relatively cheap dams can be constructed with local materials.

The most pressing needs for improvements are found in the small diversion dams and in the main canals. These diversion dams are temporary structures and subject to annual destruction. They should be replaced with permanent structures and provided with gates to control the flows into the main canals to prevent overflowing their banks during times of flood flows in the rivers. The main canals are usually without any structures such as drops, turnouts, gates, or protective measures at natural stream crossings. Each year major repairs are needed due to complete destruction of the canals at these stream crossings throughout the northern provinces. The distribution systems to the individual farms are usually open ditches without control structures that often cut deep gullies and ruin the land on the steeper slopes. Most improvements to the canals and distribution systems can be made with local labor supplied by the farmers themselves with local materials. What is needed most is the advice and assistance of trained engineers so that the improvements will be designed and constructed on the basis of sound engineering principles.

Irrigation Application

The foregoing discussion has been concerned with the problems relating to water supply and the main conveyance and distribution systems. A brief note should be added concerning the various methods of irrigation water application and some of the problems encountered.

Most crops are grown and irrigated by either the basin or furrow method of irrigation. There appears little room for improvement in the basin method as the land has been levelled and divided into small paddies by benches and terraces. Water is introduced into the uppermost terraces and then allowed to flow down succeeding basins flooding each in turn.

In the furrow method of irrigation there appears to be distinct room for improvements. In the first place the relationships of the various factors of slope, size of stream, movement of the soil moisture, percolation rates as they relate to growing crops has yet to be introduced by trained experts. For the most part irrigation applications are made when and if water is available in amounts to suit the individual irrigator's ideas of need in crude furrows made entirely by hand. Opportunities for improvements appear to be in the introduction of modern devices such as underground concrete pipe lines with gates and valves, portable surface pipes, furrow tubes, and siphon tubes, all of which effect better control and distribution of the water. Contour furrowing and border strip methods of irrigation can also be introduced which will often eliminate the expensive construction of terraces and benches The introduction of animal drawn furrowing tools will eliminate the enormous labor requirements for making furrows by hand labor. At the same time this will also serve as the forerunner for the eventual mechanization for production of such rowcrops as sugar beets and cotton.

Current Irrigation Situation In India

M. P. Mathrani

Past History of Irrigation

Irrigation in India has an ancient heritage. Systematic development of irrigation has, however, taken place only since the 19th century.

During the British regime, two canals from Jamuna in the U. P. (1820) and the Cauvery Delta system in Madras were remodelled so as to extend irrigation to new tracts. The Upper Bari Doab Canal in the Punjab was built in 1850. The Upper Ganga Canal carrying a discharge of 8,000 cusecs was constructed in 1854 with 568 miles of main canals and 3390 miles of distributaries. Then came the Godavari and Krishna Delta developments in 1855. These were followed by many projects such as Son Canal System in Bihar (1870), Khadakvasla (Bombay, 1879), Periyar (Madras, 1897), Bhatgar (Bombay, 1928), Sutlej Valley (Punjab, 1928), Sukkar Barrage (Sindh, 1932), Krishnaraj Sagar (Mysore, 1932) and Mettur (Madras, 1934).

By about 1850, the area under irrigation was only about 3 million acres which increased to about 69 million acres by 1945 in whole of then India.

With the partition of the country in 1947 about 20 million acres of well developed canal irrigated area went over to Pakistan leaving the remaining 49 million acres to Indian Union. The following statistical figures will be of interest.

Year	*Area irrigated in million acres*
1895	*29*
1905	*33*
1915	*40*
1925	*43*
1935	*44*
1945	*49*

Rainfall Conditions and Necessity for Irrigation

The necessity for irrigation in this country has been emphasized by the vagaries of rainfall. Even though the average rainfall in the country is about 50", the regional studies indicate that it varies from less than 10" in Rajasthan to 500" per annum in Assam.

Besides this, the rainfall is seasonal in behavior and for most part it is concentrated during a few months, i.e. from July to September and October to December. The winter rains are in general very poor.

About 80 % of the people of India live in villages with agriculture as their main occupation. For proper growth and yield crops require some optimum moisture in the soil and generally this moisture is supplied by the rain. Failure or inadequate rainfall in any tract disturbs the equilibrium of soil moisture relationship and their yield.

Water Resources

The work of estimating the water potential of the country is still in progress. The following approximate particulars in regard to the estimated average annual surface flow in the rivers in India, utilization for existing irrigation, for irrigation schemes on completion of first and second Five Year Plans would be of interest.

		Million acre ft.
(i)	Estimated average annual surface flow in the rivers in India	1400
(ii)	Water expected to be utilized by pre-plan irrigation schemes (1950-51)	119
(iii)	Water expected to be utilized by the minor irrigation schemes in the Ist and 2nd Plan periods	44
(iv)	Water expected to be utilized by the Ist Plan major schemes on their completion	61
(v)	Water expected to be utilized by the 2nd Plan Schemes on their completion	42
	Total	266

Thus out of the total annual extimated flow of 1400 million acre ft. the expected utilization for irrigation purposes up to the end of Second Five-Year Plan will be of the order of about 266 million acre ft., i.e. 19 % only. There is thus still vast scope for further development of irrigation.

Physical Features

India is a sub-continent having a total geographical area of about 811 million acres. The following statistical figures for 1949-50 (just before the commencement of the Ist Five-Year Plan) will be of interest.

	Area in million acres	% of total area
Total geographical area	810	100
Classified area	581	71.8
Culturable area	371	45.8
Net area sown	266	32.8
Area irrigated by canals & tanks	28	3.5
Area irrigated by wells	13	1.6
Area irrigated by other sources	8	1.0

According to the figures available, the population in 1951 was 357 millions. In 1956 the population, it is expected, will increase to 384 millions. By 1961, the population is estimated to increase to 410 millions.

Food Production

Total production of food in 1951 was of the order or 55 million tons against a requirement of 58.5 million tons. There was thus a deficit of 3.5 million tons. By 1956, on account of increase of population, as indicated, an additional production of 7 million tons was called for. By 1961, the additional production required is of the order 11.2 million tons.

First Five Year Plan

With a view to meet the deficit in food production, India has been importing very large quantities of food grains from outside countries which has involved considerable amount of foreign exchange. During 5 years prior to 1950 we have had to import nearly 14 million tons of food grains costing nearly Rs. 500 crores. This considerable demand on foreign exchange for food stuff has been hampering the industrial and other development of the country. Soon after the independence of the country in 1947, it was realized that unless the food deficit was reduced considerably, other aspects of the development of the country cannot progress. For this purpose very great stress was laid on Irrigation Schemes in the First Five-Year Plan. The total cost of the first Five-Year Plan which has just been completed amounts to Rs. 2356 crores, out of which Rs. 418 crores have been spent on Irrigation Schemes. This amounts to 18 % of the total First Five-Year Plan.

The first Five-Year Plan included about 200 major and minor irrigation schemes costing approximately Rs. 706 crores, of which Rs. 418 crores have been spent on major and medium Irrigation Projects. These schemes included a number of multi-purpose projects such as Bhakra-Nangal Project, Damodar Valley Project, Hirakund, Tungabhadra, Kosi, Chambal, Nagarjunasagar, etc.

The irrigation benefits of the First Five-Year Schemes are expected to be 22 million acres of which about 6.3 million acres are expected to be brought under irrigation in the First Plan period, 9 million acres in the Second Plan period and rest subsequently.

The deficit at the end of the First Five-Year Plan had been very considerably reduced. However, as the food production in India depends considerably upon the vagaries of the monsoon, the shortages are still being felt.

Second Five Year Plan

The Second Five-Year Plan therefore also places a considerable stress on food production though not to the same extent as the First Five Year Plan did.

The Second Five Year Plan period has commenced from Ist April 1956, with another big programme. It provides for major and medium irrigation schemes for a total cost of Rs. 412 crores and consists mainly of medium schemes. The allocation of expenditure for the Second Plan period will be Rs. 382.6 crores consisting of Rs 161 crores for new schemes of the Second Plan and Rs. 221 crores towards continuing schemes.

The benefits of the Second Plan schemes will be 14.86 million acres of which 3 million acres will be attained in the Second Plan period and the balance in subsequent Plan period.

On full development of the First and Second Five-Year Plan Projects, the irrigation figures will have thus reached 107 million acres utilizing about 19 percent of water from the total annual flow through rivers estimated approximately 1400 million acre feet.

	Million acres
Preplan Irrigation	51.52
First Plan schemes on full development	22
Second Plan schemes on full development	14.86
Minor Irrigation Schemes of First plus Second Plan	19
Total	107.38

The Irrigation Situation And Problems In Iran

H. Vessal

I am representing the Irrigation Bongah, which is a governmental establishment. Their responsibility is the development of Irrigation projects and water facilities. It was established about 15 years ago.

Let's first say something about the climate and regions of Iran. Iran has a variety of climate and soil conditions accounting for a wide variety and types of crops.

.The precipitation is around three feet per year. The intermountain valleys extending from Azerbayjan down to the Persian Gulf in the Khouzestan area have abundant rainfall during the winter and spring. Snow remains on the higher mountains until late in the summer and there are a number of sizeable rivers which do not dry up during the year.

Throughout the rest of Iran, covering the great desert areas and the coastal area of the south and southeast, precipitation seldom amounts to 8 inches in any local area. However, a number of high mountain ranges in these areas receive snowfall which feeds the underground water supply for "ghanats", the principal sources of supply for domestic and irrigation water.

Only one other area requires special mention at this time, that is the plain area of the Seistan, of which Zabol is the principal town. This is one of the great desert areas of Iran; actually, it extends into Afghanistan. The Hirmand river which rises in Afghanistan discharges large quantities of water into a series of lakes and marshes. Over the centuries, intensive agriculture has been practiced in this area, using water diverted from the Hirmand. Precipitation is abut 2 inches per year in this area.

Historical Water Developments

The oldest dams built in Iran are near Shushtan and the Karun River. These dams date from the time of Shahpur the first, more than 1700 years ago. Two of the three dams are still in good condition. On the historical time table the next are Band-Amir dam, built about 1700 years ago on Kor River near Shiraz; Saveh dam or Bandi Shah Abbas, built on Ghareh Chai River and the Korassan dams, etc.

In addition to the surface water, Iranians have been using the underground water by means of Ghanats. Ghanats are developements peculiar to the Middle Eastern countries including Pakistan, Afghanistan, Iraq and Syria. Ghanat is a tunnel dug by specialists called "Moghannis." This tunnel, dug partly in pervious ground, collects the underground water, conducting it to the lands to be irrigated. In order to have ventilation and provide facilities for excavation, they dig vertical wells to the underground galleries. The length of the Ghanat and the depth of the last well called the "mother well" is quite variable. It can be said that its length ranges from several hundred to tens of thousands of meters and the depth of the mother well reaches from ten to several hundred meters.

Actual Water Development

Irrigation developments are made as in the past by means of building dams, canals and digging or mostly repairing Ghanats. However, many deep wells have been also dug at different parts of the country. Now let's go into more detail about these three means of water development for irrigation.

1. *Dams and Canals* : The Irrigation Bonagh has built many dams as Seistan Dam, Bampoor Dam, etc. There are three major irrigation developments on which construction had been started by the Irrigation Bonag, which were made cooperative projects by the Iranian government and the Point IV. These are : Golpayegan Dam, Kuhrang Tunnel and Karkheh Dam. The main problem in this respect is the beneficial use of water after the completion of dam and irrigation system.

More care should be taken as the outlets and checks are concerned, especially for existing canals for which generally such structures are not built. An excess application of irrigation water on lands which have high salinity in lower layers brings up the contained salt and is the source of much trouble in Iran.

2. *Deep wells :* Deep wells have very seldom been drilled for the purpose of irrigation. The Irrigation Bongah got some experience in Ghayenat where deep wells were drilled. I can say briefly that deep wells are not very economical in Iran. Some specialists suggest to drill deep wells by LAYNE method which they pretend would be convenient for the fullfilment of agricultural works. The principal point about this method seems to be the introduction of several hudred cubic feet of gravel into the bottom of well which increases the percolation of water to the pump.

3. *Ghanats :* The number of Ghanats dug in Iran during the past 20 centuries amounts to 30,000. Of this number some 22,000 are still useable and the rest, that is 8,000, are ruined or dried up. Of the estimated 50,000 villages in Iran, 18,000 receive their supply of water for irrigation by Ghanats. The total amount of water discharged by Ghanats in operation is estimated to be about 40,000 Sangs (19,600 c/s. or 560 m^3/S). The Cross Section of Ghanats almost throughout the Country is uniform and in such a manner that a man of ordinary stature can pass through the tunnel easily by bending his body comfortably in standing position. There are Ghanats in Iran, that owing to the presence of rocks, the completion of its excavation has taken as long as three generations.

Lack of technical personnel, lack of basic of maps and basic data are preventing early development of additional water projects and also the proper utilization of existing water facilities.

This is the situation in a country which is now using not more than 20 per cent of its surface water resources.

Land area	678,000	square miles	401,920,000 acres
Population	20	million	
Dry-farmed cropped	41,000,000	acres	
Irrigated	3,500,000	acres	
Potentially irrigable	——		
Water available for	7,000,000	acres	

Irrigation Situation In Iraq

Fathalla Said Orege

Mr. Chairman, ladies and gentlemen : Iraq is happy to be invited to this conference and welcomes this opportunity to discuss its problems and development program with you.

Iraq's program for agricultural development revolves around the complete control and utilization of the waters of the Tigris and Ephrates rivers. Our total land area which is suitable for agriculture by any means amounts to about 5.5 million hectares. One half of this area will be developed through irrigated agriculture. At the present time about one-half of our arable lands are irrigated in one way or another. Our program in Iraq is directed towards developmant of 2½ million hectares of desert land and improving the agriculture and irrigation on the 3 million hectares now under irrigation.

The present irrigated area utilizes the useable natural supplies in the river; therefore, future development is dependent on the construction of storage. Towards this objective, we have planned four large storage sites on the Tigris River and its tributaries and two on the Euphrates River. Two of the dams in the Tigris basin are under construction and one on the Euphrates is completed. The remaining two sites in the Tigris basin are in an advanced stage of design. The remaining site on the Euphrates is in the planning stage. When all of these dams are completed, we will have complete control of the waters on both streams.

Our program for utilizing these waters has progressed at a sloower rate chiefly because building irrigation systems and the settling of people progresses at a slower rate than does the building of dams.

The first project to be settled under the new development program amounts to about 65 thousand hectares and will provide new farms for about 2800 families. Water will be delivered to this project next month. I might mention here that we have an innovation on this project as far as Iraq is concerned. There will be a complete project drainage system installed before water is delivered to any of the land. We plan to follow this scheme on all new developments.

Drainage and salinity have been and will continue to be one of our major problems. Our rivers are parched and thereby make it easy to irrigate but also make it difficult to remove any water by drainage. Before any large amount of land can be drained, it is necessary for us to construct outfall drains some hundreds of kilometres in length, virtually new rivers, to carry away the drainage water. 'The framework of project and farm drainage will follow and conform to the pattern set by the outfall drains. We expect to spend, exclusive of the dams, as much or more money on drainage works than we will spend on the irrigation systems.

The development of agriculture and the program for improved irrigation practices will be carried to the farmers through an extension service according to present plans. This may well be inadequate and other arrangements may be necessary as the program develops. We have an established extension service but the service has not extended its activities into the irrigation practices field. We have recently introduced the subject into the Agricultural College and we hope it will grow from there.

Our development program is entirely financed by funds derived from oil revenue. The money is administered by an agency called the Development Board. About one-half of the money available to the Development Board is allocated to water resource development and while the program is projected five years in advance, we expect it will be 20 years or more before it is fully accomplished.

The Irrigation Situation In Pakistan

B. A. Malak

Poor irrigation practice shall give poor yields. The consequences can be very dangerous because it may render the region deficient in food grain and may result in widespread famine or may cause a heavy drain on the financial resources of the country if food grains are to be imported. Besides, poor irrigation practice may injure the lands temporarily or permanently by rendering them saline.

West Pakistan has mostly an arid climate and about 80 per cent of its population lives on agriculture. There are three main methods of irrigation: (1) rainfall, (2) sailab and wells, and (3) canals.

Unfortunately, rainfall is not a dependable source because most of the area does not receive sufficient and timely rainfall. If there is good rainfall, a good crop may result, otherwise, the entire tract may have to face famine conditions.

Irrigation by sailab is done on a comparatively smaller scale and it also depends upon the flood levels of the river and is not a reliable method for irrigation. Wells are, more or less, a dependable source of irrigation, but their scope is extremely limited. Areas served by wells can receive, more or less, ensured supply but the out-turn is uneconomical and meager.

Irrigation by canals is being practiced in West Pakistan, on a very large scale and perhaps is the best in the world. West Pakistan has a large network of canals which are fed by the rivers through diversion weirs. Some of the canals take off directly from the rivers and can irrigate areas depending upon the river levels. Water is carried to the field through distributaires and minors. The whole area is divided into suitable plots of lan fed by outlets put in the banks of the distributing channels. Each outlet has a specified area to serve called a 'chak.' The farmers owning lands in the 'chak' become shareholders of the outlet and take their share of supply by rotation. Each holding gets supply according to its size. The farmers irrigate their fields by cuts in the water-course emanated from the outlets. Sometimes they have to excavate subsidiary water-courses to take water to their fields lying away from the water-course.

The main canal and distributaires along with the diversion weirs are maintained and operated by the Government, while the water-courses are maintained by the farmers themselves. Legislation in the form of Canal Act exists which empowers the Government officers to prevent wastage of water and unauthorized irrigation.

In the modern practice the whole area to be covered by a canal Project is carefully surveyed and divided into rectangles. The usual size of the rectangle is 25 acres. These rectangles are sub-divided into suitable size of plots. The usual percentage of area to be irrigated is 60 per cent. The areas are further divided in the ratio of 35 and 25 for winter and summer crops respectively. Usually, this percentage of area has increased with the development of irrigation on account of population pressure on land in the region and sometimes it becoms more than 100 per cant.

Out of the three methods of irrigation, well irrigation can perhaps be more efficient but it has limited scope. So far canal irrigation has proved to be very efficient but there is a lot of scope for further improvement. Efficiency gets impaired in canal irrigation due to limited supply in the rivers. The farmer tries to spread available supply over a comparatively larger area with the result that poor crop yields occur. Besides, this practice of thin irrigation encourages rise of salts, with consequent damage to soil crest. Efficiency can be improved with the increased water allowance, salvage of transmission losses and with the use of fertilizers coupled with improved methods of agriculture..

For lack of sufficient supplies in the rivers the water allowance of the existing developed areas cannot be appreciably increased. On the partition of the Indo-Pakistan Sub-continent the head-reaches of most of our rivers went to India. She began to extract higher supplies than her due share and thus depriving the developed canals in Pakistan of their preparatitioned share. This has resulted in decrease in out-turn in the irrigated areas and inefficient irrigation because of short supplies passed down by India. The efficiency can be improved in the irrigated areas of West

Pakistan by ensuring continued adequate supply from India and building up storages for improving existing supplies.

We have huge tracts of land awaiting development, and even with all the possible stored supply we will not be able to meet the needs of the areas. We are trying to tap underground water reservoir, but this form of supply is very uncertain and the surveys carried out so far have not shown encouraging results.

Almost all the agriculture population of this country is illiterate. It becomes very difficult to teach them improved methods of irrigation and agriculture. They are accustomed to old methods and try to stick to them. Any change in their outlook can only be brought about by enacting suitable legislation, as persuasion methods take very long time to enfo rce new ideas. Use of skilled labour may improve agriculture output as is done in the industrial field. This shall need training of farm labour. This can be done by setting up village schools and experimental farms giving training in the economic use of water, and improved methods of irrigation, agriculture and use of fertilizers. They can also be educated in planning proper cropping pattern so that the farmers can get better returns by sowing more of cash crops. Land owners should also get similar training at such field centers. The training shall have to be essentially a field course as no scope can there be for class room work because of uneducated people. The courses should be short, having more of practical and demonstration work and timed to the agricultural operations, i.e., the courses should be initiated when the farmers can be free from their fields. These courses should be easily accessible and centers locally located so that people can be encouraged to attend these without difficulty and without being absent from their farms for a long time. In the higher agricultural institutions only those students should be admitted who have definite aptitude for farm work and would like to do manual work by their own hands. The job of the technician is to begin from the field. The main object of these institutions should be training in the economical use of water, improved methods of irrigation and agriculture and the use of proper seeds and fertilizers. Educated farmers can afford good examples for others to follow in their areas of influence. The farmers who are able to get higher yields should be encouraged by suitable awards and may get Government patronage. This will infuse interest and enthusiasm in the other people and a sort of competition can thus be created. This can be done by arranging local fairs at the end of each crop season where people can demonstrate their yields and a prize distributing event can take place.

The Government, on the other hand, should build dams for augmenting supply of water, provide farmers with good quality of seeds and cheap fertilizers. Minimum floor price for the agricultural crops should also be fixed so that the farmers are ensured of minimum return for their out-turn. Uneconomical holdings should be eliminated and maximum size of each holding fixed. The present system of keeping bullocks, etc., for ploughing is very uneconomical. This can be replaced by modern mechanical agriculture equipment and improved implements. This equipment, being beyond the capacity of the individual farmers, can be maintained by the village Co-operative Societies and made available to the farmers at cheap rates. The present Credit Co-operative Societies can perform this function very well.

Communication should also be improved to facilitate easy and cheaper transportation of agriculture produce to the market. The markets themselves will have to be regulated to ensure correct weights and rates to the farmer.

Due to the unhygienic conditions and lack of amenities in the village life the rural population generally tend to flock to urban areas which causes loss of intellegensia amongst the farmers. This can be discouraged by improving hygienic condtions and opening up social centers and primary schools for free education. This is now being tackled by the Village-Aid-Programme being initiated in this country. It is expected that after some time definite improvement may occur in the rural areas of West Pakistan resulting in increased economic, hygienic and social conditions in the village.

ATTACHMENT

Questions	Replies
(a) Danger and results of poor irrigation practices.	*(a) The danger of poor irrigation as has been found in West Pakistan, results in the rise of injurious salts to the surface. If these lands are not reclaimed by washing out these salts, valuable areas of land go out of cultivation and the out-turn becomes very low.*
(b) Irrigation efficiency.	*(b) Irrigation efficiency depends on the obtaining of maximum yield with minimum delta.*

Efficiency

System of Irrigation	Existing Intensity	Proposed Intensity	Remarks
1. Sullage	400 %	400 %	—
2. Wells-open.	200 to 250 %	300 %	With one well for 8 - 10 acres and heavy doses of fertilizers.
(a) Near town	—	—	
(b) Moffasils Supplemented with non-perennial canal water.	100 to 150 %	200 %	With wells for 12 to 15 acres and heavy doses of fertilizers.
(c) Tube-wells	200 %	300 to 400	With heavy manure and fertilizers.
3. Canal			
(a) Perennial	100 to 125 %	200 to 225 %	If the water is available and doses of fertilizers are given to the land.
(b) Non-perennial	50 to 60 %	100 %	If the water is available and doses of fertilizers are given to the land.
(c) Sailab	100 %	—	—
(d) Barani (rain crops)	150 to 200 %	—	With areas having rainfall evenly distributed and more than 35 inches.

(c) Irrigation methods

(c) There are the following methods of irrigation:

1. *rainfall*
2. *sailab (inundation from river)*
3. *wells open and tubewells*
4. *canals - perennial, non-perennial, inundation.*

(d) Water supply and delivery as related to

(d) To get the best results from artificial irrigation like wells and canals the plot should be level and in the case of well the field should be divided by ridges into plots of about 1/16th of an acre. The main water-course leading to the plots should have about 3" of working head. In the case of canal irrigation normal plot is of 1 acre which should be divided into two plots. The water-course from the outlet to the point of delivery should be made water tight and be capable of creating at least 3" of working head between the watercourse and field. There are various methods of making water courses water tight. One is by plastering the inside of the water-course by puddled earth containing wheat straw. The other is lining it with soil cement i.e. 5 % cement, 95 % clay. Inlets to the field should be of masonry with shutters and situated at the ridge sites.

(e) Farm and farmer's interest surveys. efficient water use.

(e) We have got several farms but no farmer's interest surveys has been undertaken. These surveys will certainly help the Government and the farmer alike in the matter of forecast of produce and price.

(f) Extension or service organization to work with farmer.

(f) The practice in Pakistan, especially in self-cultivation, is that a helping hand is employed by the farmer. Like other trades the helping hand should be trained by the service organization in the latest methods of cultivation and water uses. The training centers should be at convenient distances and the teachers should give practical instructions.

(g) Training needs and courses.

(g) Farmers are generally hereditary and know their job very well. What they really want to be initiated into is the modern use of fertilizers and good seeds. If the farmer has got a big holding then he will certainly need training in the use of mechanical equipment. There should be centers where training facilities should exist in the use of mechanical equipment and facilities for spare parts and repairs within easy reach of the farmer.

(h) Cropping system and practices

(h) We have divided the year into two parts. One we call Rabi, that is winter; and the other is Kharif, that is summer season. Our major Rabi crops are wheat grain and oil seeds, while the Kharif crops are cotton, rice, pulses, sugarcane, maize and chillies, etc.

(i) Farm equipment and structures for irrigation needs.

(i) We do not need much farm equipment where the holding is small, but where the holding is big enough to work mechanically, or on cooperative basis the various implements will be required for farming, namely 2 tractors. One will of course be stand-by with plough tiller and disc harrow will be needed. So far as structures are concerned a couple of godowns with residential accomodation for the farmer along with the sheds for the safe-storage of machinery will be needed, also a shed for the milching animal.

Lebanon Country Report

E. A. Chaya

Location

Lebanon, situated on the Eastern shores of the Mediterranean Sea, is a small country 10,000 square kilometers in area, half of which are rocks, sand, roads, cities, beaches... Its length in a North-South direction is 190 kilometers and its maximum width 75 kilometers. Syria lies to the North and East and Palestine to the South. The population is 1,500,000 with a yearly increase of 25,000.

History

Modern successor of ancient Phoenicia, Lebanon retained its national individuality throughout centuries of conquest and domination by Egyptians, Assyrians, Babylonians, Persians, Greeks, Romans, Byzantines, Arabs, European crusaders, and Turks. The historic frontiers of the country, reduced by the Turks, were restored in 1920 when, following World War I, it was placed under French Mandate. In 1943 its independence was recognized by the world powers, and Lebanon has taken a leading position in the affairs of the Near and Middle East since that time. Lebanon is a member of the United Nations and of the Arab League. Here, Christians and Moslems live peacefully together sharing their responsibilities as citizens. Literacy is high, over 80 per cent, even in the mountain villages and many people speak Franch, English, Spanish or Italian, in addition to the native Arabic.

Form of Government

Lebanon is a Republic with a Unitary form of government. Sovereignity is vested in a unicameral parliament of 44 deputies directly elected by the people for a term of 4 years. Parliament elects the President, the chief executive of the country for a term of 6 years.

Topography

The Lebanon mountain range paralleling the coast line, rises almost from the sea to a height of over 2250 meters. Along the Eastern side of Lebanon another mountain range, the Anti-Lebanon, parallels the Lebanon range at a distance of some 40 km. Eastward of these mountains, is Syria. Between the two ranges is the Bekaa, a high flat valley 10 to 12 km. in width. The Bekaa is separated near Baalbek by a low, flat divide. The North Bekaa is drained by the Orontes River which flows northward across the frontier through Syria to empty into the Mediterranean sea in Turkey. The South Bekaa, about 60 km. long and 10 km. wide, is drained by the Litani River which flows in a North-South direction then turns sharply westward to empty into the Mediterranean Sea between Tyr and Sidon.

Geology

The Lebanon and Anti-Lebanon Mountains and the Intervening Bekaa section represent long. narrow, crustal blocks, separated by faulting.

These blocks have been uplifted differentially b great tectonic movements. The faults along which these tectonic movements occured are the northward continuation of major crustal breaks which form the African and Palestinian rifts. They extend from the North of Lebanon along the sides of the Bekaa southward from Lebanon through Jordan along the Dead Sea and on southward into Africa. The major fault along the West side of the Bekaa is the Yammouno fault along which great massifs of Jurassic limestone have been uplifted. The exposed rock formations represent the geologic age sequence from Jurassic up through the Cretaceous, Tertiary and Quaternary.

Seismicity

The network of major and minor faults which exist throughout the country are ample evidence of the great crustal disturbance and associated seismic activity which has occured during Tertiary and recent geologic time.

The faults which pass near or through the Litani Basin should be considered as still active and subject to movements which would cause strong carthquakes. The Jezzine tunnel proposed in the latest development scheme of the Litani river, will pass through this fault and it has been given all the required consideration during the design.

Climate

Mediterranean-type climate, with cool, wet winters and warm dry summers, prevails in this area. The steep slopes of the mountains produce very marked orographic efforts and result in wide variations in average annual rainfall as well as in individual storms.

Average annual precipitations varies from 500 to 1500 mm. Most of this precipitation occurs between November and April, with January the wettest month. During winter moderately low temperatures occur at the higher elevation and snow falls on both the Lebanon and Anti-Lebanon mountains.

Soils

Are quite variable, depending to a large extent on climatic, topographic and geologic factors.

On the coastal plain they consist of relatively deep alluvial deposits, predominantly reddish brown or dark brown clay. Upland soils are derived largely from underlying limestone or marl. On the plateaus they usually consist of dark brown clays, while on steeper slopes the soils are shallow, gray to white silt or clay loams.

The Beeka is made up largely of deep loams and clay loams of alluvial origin. Small areas of organic soils, formed from plant decomposition, are found in swampy, poorly drained sectors.

On steep slopes, terrace walls of dry rubble are laboriously raised by hand and must be constantly maintained to prevent erosion of the meager soil.

Vegetation

The irrigated coastal plain being almost totally under cultivation, supports only a minimum number of native species of vegetation. On the uplands not under cultivation are found a variety of drought resistant trees, shrubs, and grasses. Fine trees are found on the sandy areas near the coast and in the higher mountains. The cultivated type, Pinus pinea, is generally found near the coast while those growing at higher altitudes, have an edible nut and give to Lebanon a typical mountal sight.

Like the coastal plain the Bekaa is largely under cultivation and supports only scattered areas of native vegatation. Along the stream banks and canals, poplar trees and willows are prevalent. The spurge weed (Genus Euphorbia) is very prevalent in cultivated areas.

Resources

1) Agricultural land is our major resource. Agricultural products furnish the greater part of the raw materials used in industries and comprise a major item of Lebanese exports.

The land configuration, the type of soil and the climate are well suited to the production of diversified agricultural crops: citrus fruits, bananas, vegetables, olives, grapes, deciduous fruits and cereals.

Lebanon has abundant surface water, but very little use has been made of it for either domestic or hydroelectric purposes. Nearly all lands considered for irrigation projects are now being cropped. Irrigation will increase yield and broaden crop adaptability but will not add appreciably to the cultivated area. This is also true of drainage projects, for the area of uncropped swamps is very limited. Rushes and swamp grasses are harvested from even this small area. For the most part, agricultural methods are primitive. The land is plowed by ox team with iron-shod wooden plows or dug up by hand.

The cultivated area is estimated at 300,000 hectares, 115,000 ha. are irrigable but only 45,000 ha. are now receiving part or full season irrigation.

Irrigated trees cover 13,000 ha. of land divided as follows :

Coastal plain

5,000 ha. producing 100,000 tons of orange and lemon .

1,500 ha. producing 20,000 tons of banana.

Mountain and Bekaa

6,500 ha. producing 45,000 tons of various fruits, mainly apples (starking and golden varieties).

As to non-irrigated trees 40,000 ha. produce 40,000 tons of olives, 80,000 tons of grapes, and for local consumption, figs and almonds.

The Litani project will irrigate 30,000 ha. in 1967. The four irrigation projects: Kasmieh, Akkar, Yammounch and Kaa will cover most of the remaining irrigable area.

It is estimated that after irrigation, the income will increase fivefold for general crops, and tenfold for fruit trees.

The total forest area at present is 80,000 hectares. The value of forests is not limited to their products, but extends to the roles they play in soil and water conservation, as well as to the attraction of tourists.

Minerals, with the exception of limestone, and some bituminous shale, do not exist in useful quantities. Small quantities of lignite and iron have been found.

Industry is estimated to contribute about 18 % to the national income. The capital invested in the industry is estimated at 200,000,000 pounds (USCY $ 1.00 = 3.2 Lebanese liras). The Labor force is no doubt our chief industrial asset. Lebanon is well suited for the development of secondary and light industries as well as for transformation and assembling plants.

Two important cement factories exist. The development of the agriculture will probably require the erection of a super-phosphate factory using the Jordanian phosphate and the Cyprun pyrite. The nitric manure will be imported.

The prevailing moderate climatic conditions are favorable for industrial pursuit in the field of agriculture, salt production and hides and leather, to mention only a few.

Lebanese industry had its beginnings in the fields of handicrafts (textiles, iron and copper work), food-stuffs, and confections. World War II and the resulting breakdown of communications with supplier countries served as an impetus to the Lebanese industries, especially in the field of textiles, electric bulbs, manufacturing beverages, food processing, soap, oil refining, cement production and building materials.

Commerce, internal and external, constitutes an important factor of the Lebanese national income. Agricultural products are the major item of internal trade. The major exports of the country are agricultural products and by-products : 65,000 T. costing 25 millions L. L. are exported from irrigated trees; apples, and bananas are exported to Egypt, Saudi-Arabia and Italy; citrus are exported to Mediterranean countries. 60,000 tons of wheat are produced every year. This amount represents one third of the present consumption. In Lebanon the yield per ha. is 8 quintals; in Egypt 24; in Belgium and Holland 32. Modern irrigation methods in the villages of Hoche-el-Omara and Rayak have resulted in a yield of approximately 24 quintals per ha. The number of livestock is not sufficient for the country, consequently large numbers of livestock and large quantities of meat products are imported annually (for 35 millions L. L.) from Syria, Irak and Turkey, to meet local consumption.

Other imports are primarily petroleum and petroleum products, cereal, wood, weaving and other machines, automobiles, raw cotton and many a luxury items.

The geographic positions on the cross roads of three continents, the topography, the climate and the historic places, combine to make Lebanon attractive for tourists. With the newly opened Beirut International Airport, the tourist industry is increasing tremendously.

Highway network is well developed. The main highways are the Beirut - Damascus highway and the Saida - Beirut Tripoli - Homs highway. There is heavy automobile traffic on these highways, particularly trucks and oil-tankers. Transportation of passengers by busses is popular since rail-roads are old, inadequate and rarely used. The public transportation system in Beirut consists of several tramlines linking major portions of the city. The tram cars are overcrowded and obsolete. Late model automobiles serving as taxis provide adequate urban and interurban transportation.

The Beirut seaport has become one of the busiest and best equipped on the Eastern Mediterranean. It has become the main port of entry for Lebanon and the neighboring countries.

The opening of the International Airport near Beirut made of this city the physical center of all the Middle-East, and a major link between East and West.

THE LITANI RIVER PROJECT

The project is the largest in Lebanon and the per capita investment $ 70; in America this would correspond to a $ 10.5 milliard project. It is presumed that construction will begin within three months.

The project will take eleven years to complete and the first phase costing 170,000,000 L.L. will be finished in 1962. The completion of the first phase will result in the irrigation of 9,000 ha, and the annual production of 450,000,000 kwh, with an installed power of 103,000 kw.

The second phase, due to be completed in 1967, will cost 150,000,000 L.L. and will be financed by revenue produced by the first phase of the project. Both phases of the project will produce 800,000,000 kwh; an installed capacity of 180,000 kw, and result in the irrigation of 30,000 ha.

A Report On The Existing Irrigation Situation In Turkey

Âdem Karaelmas

HISTORY.

Irrigation has been practiced in Turkey for probably thousands of years as evidenced by the old ruins that are found in various sections of the country that were at one time heavily populated areas. This is particularly true along the Mediterranean coast near such old cities as Efes, Antalya and Antakya, where there are remains of old aquaducts that were used for transporting water for domestic use as well as for irrigation.

Further evidence of early irrigation being practiced can be noted along the Firat River, near the town of Nizip and Gaziantep where there are ruins of water distribution systems. Most of these historic developments have been destroyed during periods of conflict and are no longer in use.

GENERAL SITUATION OF THE TURKISH CROPS.

About 2,000,000 hectares of the cultivated land is irrigated each year. Surveys indicate an opportunity to develop another two million hectares of land for irrigation.

The irrigated land is distributed over most of Turkey, as shown by Table I. This table shows that there is some irrigated land in all of the 66 provinces of Turkey.

TABLE I

IRRIGATED AREA BY PROVINGES

in hectares (1)

Province	*1951*	*1952*	*1953*	*1954*	*1955*
Adiyaman	(2)	(2)	(2)	12,980	20,791
Afyon	11,268	11,868	16,368	20,980	20,588
Ağri	31,000	31,890	38,500	35,297	57,581
Amasya	55,224	31,890	64,191	66,933	69,150
Ankara	39.710	38,653	55,473	40,000	55,473
Antalya	33,020	51,805	55,601	49,482	58,231
Aydin	38,899	50,867	47,355	50,867	54,869
Balikesir	9,055	9,403	8,686	8,291	11,341
Bilecik	27,400	14,716	15,440	13,430	10,045
Bingöl	31,732	31,026	11,888	11,888	7,894
Bitlis	10,790	10,790	9,613	13,800	2,567
Bolu	28,150	20,165	8,736	14,762	12,586
Burdur	49,100	(2)	33,016	33,620	36,200
Bursa	25,640	27,340	32,653	27,163	24,160
Çanakkale	2.738	3,170	2,350	2,382	3,893
Çankiri	14,760	15,136	14,308	14,659	17,964
Çorum	(2)	710	767	1,750	550
Çorum	20,700	26,300	42,366	34,798	37,837
Denizli	40,221	37,988	28,994	33,811	30,805
Diyarbakır	16,800	44,405	18,343	17,574	17,574
Edirne	9,255	14,365	10,865	13,484	14,641
Elâzığ	60,690	75,326	72,114	76,996	64,244
Erzincan	54,330	10,870	58,460	46,027	66,729
Erzurum	56,100	57,000	59,500	58,965	67,485
Eskişehir	14,106	18,587	21,207	22,183	30,877
Gaziantep	27,700	36,799	24,001	42,184	24,880
Giresun	1,585	2,390	8,214	8,642	84,777
Gümüşane	31,600	28,852	37,715	39,978	731
Hakâri	5,150	5,200	1,240	1,988	2,356
Hatay	46.619	60,139	55,260	55,330	55,310
İçel	59,300	36,015	21,900	25,412	41,422.5
Isparta	13.514	17,608	149,000	9,000	10,060
Istanbul	3.606	3,930	4,039	7,850	8,874
Izmir	32,943	45,682	61,421	41,019	41,019
Kars	65.000	96,255	77,743	23,058	51,773
Kastamonu	19,115	17,305	37,856	40,000	16,950
Kayseri	37,750	35,870	70,833	88,683	92,272
Kirklareli	9,115	6,165	4,442	5,384	8,808
Kirşehir	10,900	14,280	17,250	(2)	(2)
Kocaeli	8,928	5,268	5,268	490	16,453
Konya	124,080	94,102	123,949	154,158	160,587

Province	*1951*	*1952*	*1953*	*1954*	*1955*
Kütahya	*(2)*	*21,602*	*19,192*	*17,358*	*29,572*
Malatya	*107,900*	*109,010*	*95,782*	*57,248*	*81,394*
Manisa	*29,228*	*45,139*	*39,045*	*36,019*	*50,926*
Maraş	*135.440*	*107,240*	*87,740*	*99,017*	*119,740*
Mardin	*10,600*	*24,750*	*26,255*	*1,318*	*11,108*
Muğla	*66,180*	*28,880*	*20,773*	*30,178*	*32,101*
Muş	*16,300*	*15,360*	*18,188*	*8,592*	*5,740*
Nevşehir	*(2)*	*(2)*	*(2)*	*19,905*	*21,390*
Niğde	*31,450*	*42,535*	*79,844*	*30,965*	*47,228*
Ordu	*200*	*450*	*896*	*1,089*	*1,242*
Rize	*50*	*85*	*335*	*(2)*	*(2)*
Sakarya	*(2)*	*(2)*	*(2)*	*15,550*	*4,780*
Samsun	*15,972*	*16,591*	*139,034*	*9,162*	*9,242*
Seyhan	*22,135*	*21,077*	*22,229*	*29,059*	*24,386*
Siirt	*2,594*	*2,594*	*4,505*	*5,380*	*3,740*
Sinop	*5,475*	*5,945*	*8,268*	*11,326*	*14,906.5*
Sivas	*45,000*	*41,869*	*44,549*	*81,932*	*56,092*
Tekirdağ	*885*	*1,285*	*1,871*	*2,070*	*2,129*
Tokat	*55,350*	*64,790*	*58,330*	*60,085*	*54,781*
Trabzon	*450*	*450*	*(2)*	*240*	*350*
Tunceli	*8,960*	*12,600*	*9,340*	*14,184*	*33,027.6*
Urfa	*9,560*	*10,432*	*4,896*	*4,894*	*35,705*
Uşak	*(2)*	*(2)*	*4,253*	*4,836*	*8,625*
Van	*22,580*	*92,218*	*30,358*	*39,002*	*36,250*
Yozgat	*32,700*	*(2)*	*35,950*	*29,475*	*81,955.5*
Zonguldak	*5,700*	*5,500*	*3,875*	*5,017*	*6,785*
TOTAL :	*1,812,302*	*1,810,532*	*2,182,433*	*1,870,191*	*2,183,594.1*

(1) Ministry of Agriculture statistics.
(2) No data available.

The major crops that are irrigated are wheat, barley, vegetables, orchards, cotton, corn, sugar beet, pasture, vineyards, potatoes, beans, tobacco, rice, alfalfa, etc., as shown by Table II.

TABLE II
MAJOR CROPS IRRIGATED (3)

Crops	*Irrigated area*
Wheat	*310,803*
Barley	*214,125*
Mixture of grains	*185,811*
Vegetables	*165,364*
Orchard	*163,762*
Cotton	*157,335*
Corn	*95,953*
Sugar beet	*84,028*
Pasture	*64,561*
Vineyard	*59,501*
Melon and watermelon	*50,619*
Potatoes	*49,291*
Beans	*42,951*
Tobacco	*31,371*
Rice	*29,803*
Alfalfa	*26,851*

(3) Data taken from Ministry of Agriculture as reported by field offices, 1954.

Irrigation as practiced by most of the farmers in Turkey is still very inefficient. Water is distributed over the dikes and ditches. In other cases water is allowed to flood across the fields with no control, resulting in over-irrigation in some places and no irrigation in other areas. Adequate surface drainage of surplus water is often lacking. The most efficient irrigation practices are found in orchards and veretable growing areas. However, crops such as cotton, sugar beets, bean and potatoes are irrigated in most areas by flooding.

SOURCES OF WATER FOR IRRIGATION.

Irrigation as practiced in Turkey consists in many cases of rather simple diversions that have been made from streams. These diversions are often crudely constructed and water is distributed to the field for irrigation purposes in a very inefficient manner. There are a large number of underdeveloped rivers, springs, and underground waters that are available as a water supply in many years. The mountainous terrain of much of Turkey provides those sources of water supply which accumulate during periods of heavy precipitation.

Along many of the larger rivers water is pumped with the use of water wheels. Several thousand centrifugal pumps have been installed during the past ten years to lift water from the rivers. In areas where underground water is available, farmers have dug shallow wells and are lifting the water with horse powered water lifting devices. Most of the present land that is irrigated has been developed by the farmers either alone or in groups. Irrigated land developed by the government comprises a very small percentage of the total area as shown by Table III.

TABLE III

AREAS IRRIGATED BY DIFFERENT WATER SOURCES

in hectares (4)

	Area
1. *Land irrigated by Government-constructed irrigation systems* ...	72,542
2. *Land irrigated by farmers' systems*	1,599,603
3. *By pumping*	214,784
4. *By water wheels*	19,314
5. *By horse-powered water lifting devices*	28,882
6. *By artesians*	22,806
	1,952,921

(4) *Data taken from the Ministry of Agriculture as reported by field offices in 1954.*

GOVERNMENT AGENCIES WORKING ON IRRIGATION AND THEIR RESPONSIBILITIES

Responsibities for irrigation in Turkey are divided between the State Hydraulic Works Department within the Ministry of Public Works, and the Ministry of Agriculture. The Hydraulic Works Department has responsibility for the planning, construction and operation of large scale irrigation works. The Ministry of Agriculture is responsible for extension irrigation, research on soil moisture - plant relations, crop rolations, fertilization, drainage of farm lands, and efficient use of water on farms. Since this seminar deals with irrigation practices, I will go into detail on the Ministry of Agriculture's irrigation program.

The Ministry of Agriculture established an irrigation section in 1952 and has provided an irrigation program to help farmers on farm irrigation activities, education and small irrigation developments.

At the time the irrigation section was created there were no Turkish personnel who had experience in carrying on a farm irrigation program. This made it necessary to train personnel for all of the positions and activities that were to be undertaken.

Since the irrigation program was initiated, seven training schools of two and three months' duration have been held for the training of technicians for field activities. These training courses have provided personnel for irrigation specialists in forty provinces and for the establishment of eight technical irrigation groups to serve irrigated regions in Turkey. Other activities during these past years have included on-the-job training, program development, farm demonstrations and irrigation research.

The Ministry of Agriculture's program for irrigation at the national level was designed to provide technical guidance to the field programs so that the farmers will be able to improve irrigation practices and water use for increased production and improved living conditions on farms and villages. The present irrigation organization at the national level, although with limited personnel, is making good progress to serve this function.

The present irrigation organization consists of: A Director who is responsible for irrigation, soils and fertilizers. He has two subdivisions in irrigation as follows:

I. *Operations* : This sub-division is responsible for technical supervision and training of field personnel and for development of programs in the field to help farmers improve present irrigation practices. It is also responsible for development of small irrigation projects. This sub-division also provides equipment and materials and educational work.

A. Provincial irrigation specialists.

Provincial irrigation specialists have been assigned to forty different provinces within the last four years. These men are administratively responsible to the Agriculture Director in each province. Technical guidance and supervision is provided from the national level by the irrigation section.

In developing the field program, the Ministry of Agriculture decided to utilize the existing organization known as Teknik Ziraat Teşkilâtı, which is organized under the general agriculture division under the Ministry of Agriculture. In this organization there is a director and stfaff of specialists, and in addition each province has county agents and village teachers.

Activities under this organization's program are concerned principally with crop and soil programs, livestock, irrigation, plant protection or other fields. Since this program was already in existence the Ministry of Agriculture requested directors in provinces where irrigation is a major activity to select an individual already on their staff who would make a good prospect for an irrigation specialist. These men then were given a three-months' basic training course. This course consisted of fundamentals in soils, water use, soil moisture relationships, irrigation methods and surveying. Upon completion of the course these men were assigned to provinces as irrigation specialists. This program has made a good start, and many of the specialists have accomplished many worthwhile activities in a short time.

B. Technical irrigation groups.

Eight technical groups have been established by the irrigation section to work on a regional basis covering several provinces. These technical groups are located in areas in Turkey where irrigation is concentrated. These groups operate as a team and concentrate their activities on providing personal service to farmers and villages. These groups are administratively responsible to irrigation station directors, and receive technical supervision from central office. The activities of the groups are coordinated with Agriculture Directors of the provinces.

It is the purpose of these groups to supplement the work of the provincial irrigation specialists by taking care of individual activities in the provinces, that require a higher degree of skill and ability than can usually be expected from a provincial specialist. These groups also have more equipment available to them and are able to devote more time to particular jobs. These technical groups have been very successful in the activities that they have conducted since they were established in 1952.

II. *Irrigation research :* This sub-division is responsible for supervising work of the irrigation experimental stations. The irrigation research program is responsible for carrying on research in water use as related to crop production.

The Ministry of Agriculture now has four main irrigation research stations and several sub-stations. The director of the irrigation research program in the Ministry is also Director of the Tarsus Station.

Irrigation stations conduct research in water use, time of applications, amount of water to apply, number of irrigations, soil moisture relationships, and drainage investigations.

COORDINATION BETWEEN HYDRAULIC WORKS DEPARTMENT AND MINISTRY OF AGRICULTURE:

Since the engineering and agricultural phases of irrigation are so closely related, the State Hydraulic Works and Ministry of Agriculture decided in 1946 to establish a formal agreement for coordination work. Briefly, the agreement was to the effect that State Hydraulic Works would purchase the land and construct the buildings for irrigation research stations and the Ministry of Agriculture would operate the stations, develop the necessary basic information and supply the results to State Hydraulic Works.

The first station was established at Tarsus, which is in the Seyhan area. This region is one of the most important agricultural sections of Turkey and where an extensive irrigation system was proposed by developing waters of the Seyhan, Berden, and Ceyhan Rivers. The most important crops grown in this region are : cotton, vegetables, citrus fruits, rice and other small grains.

Since the Tarsus Irrigation Station was established, much valuable information has been developed on amount of water and time of irrigation for different crops, adaptation of new cultivated and pasture crops, crop rotations, irrigation methods, land preparation and development, and drainage of irrigated lands, Also, the station has served as a training center for new irrigation technicians for research work and extension methods. The extension activities are necessary for bringing the results of experimental work and other known and proven irrigation practices to the farmers for efficient use of the soil and water resources.

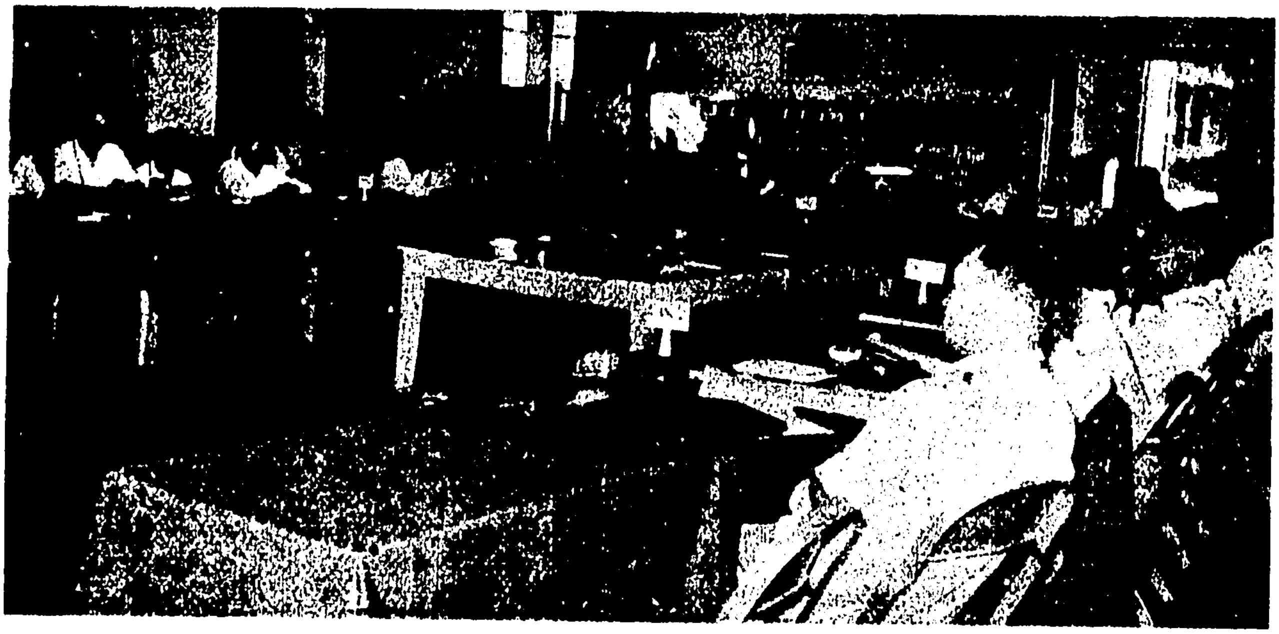
The positive results obtained at the Tarsus Irrigation Research Station made it seem desirable to establish additional irrigation research stations in other regions where large large scale irrigation projects were proposed and which were diferent from the agricultural and climatic standpoints. Therefore, in 1949 a station was established at Menemen in the Aegean Region where the most important crops are grain, cotton, grapes, corn, sesame, tobacco, beans and melons, In 1949 a station was set up at Çumra in the Konya basin. This is a closed, arid basin which has no outlet to the sea and has extensive drainage, water use and crop management problems. The major crops were small grains, orchard, melons, and vegetables. Recently, a beet sugar factory was opened at Konya and now sugar beets are a very important crop. Another station was established at Eskişehir in the Porsuk Valley in 1954 where sugar beets, grains and vegetables are grown.

The fact that each ministry has an investment and keen working interest in the irrigation research stations makes the coordinated efforts more feasible. In addition to close working relationships throughout the year, a joint annual meeting is held each winter between the State Hydraulic Works and Ministry of Agriculture. At these meetings each agency reviews the work of the past year and outlines the major proposed activities for the coming year. This provides an opportunity for a better understanding of the work of each department and to make suggestions and requests on certain related activities.

As another example of cooperation and coordination in Turkey, the State Hydraulic Works, with representatives of the Ministry of Agriculture and other ministries, work together toward the development of land and water resources on the basis of entire river basin units. According to Article 21 of Law No. 6200, State Hydraulic Works undertakes the development of irrigation projects and the order of construction priorities are established by a Temporary Committee composed of representatives of concerned governmental agencies.

On the preparation of irrigation projcts State Hydraulic Works and the Ministry of Agriculture have close cooperation. While SHW collects engineering, economic, hydrological, social and meteorological data, the Ministry of Agriculture prepares land classification maps or soil maps of the project areas. The Military Mapping Department, by supplying aerial photographs and topographic maps; the Meteorologic Service, by furnishing climatological data; and the Mineral Investigation and Research Institute, by providing geological data, also participate in this cooperative effort.

Between 1953 and 1955, soil surveys and maps were made of seven small valleys covering 200,000 hectares, and their irrigation projects and plans have been prepared.



The Seminar in plenary session. Scale models of irrigation equipment and structures on display on center table. Photo and color slide exhibit of irrigation practices is in the background.

Chapter II

Subject Matter Papers

Dangers And Results of Foor Irrigation Practices

M. P. Mathrani

History of Irrigation :

In India, as in other countries, rivers have had a powerful influence on National and Social life. From time immemorial, life and civilization in India have been dependa... largely on rivers. The earliest civilization developed along the banks of the Indus and the Ganga and their tributaries. Irrigation or the artificial application of water to crops in India is as ancient an art as its civilization. Several irrigation works are made mention in our great epics Hamayana and Mahabharata. Ma-gasthenes, the Greek Ambassador at the court of Sendro Kothas near Patna, writes that the whole country was prosperous under double cropping by irrigation during 300 B.C. Some of the reservoirs in South India are as old as 2,000 years. About 200 A. D. the Grand Anicut, a monument of engineering across Cauvery in Madras was built by the Chola dynasty for irrigation of about 600,000 acreas. The huge reservoirs created in Bhopal, with its 250 sq.miles of reservoir area was built in the eleventh century. A.D. by Raja Bhoj. The history of India is full of gigantic efforts by successive generations to utilize more and more water from rivers and artificial storage tanks for agriculture with the demand for increased production consequent on the increase in population.

India, The Leading Country :

India has become the most extensively irrigatted country in the world. The present area under irrigation is 50 million acres and is the largest irrigated area in any country of the world. India irrigates more than double the area irrigated in the United States of America (26.2 million acres) and about two and a half times that of Pakistan (21.3 million acres). The total mileage of India's canals is over 60,000 miles. As much as Rs, 418 crores have been spent during the First Five Year Plan 1951 - 1956 on 200 major and minor irrigation schemes bringing an additional area of 6.3 milions acres under irrigation. The total cost of new irrigation projects included in the Second Plan 1956 - 1961 is about rupees 412 crores on 195 new projects.

Necessity for Irrigation

Since nearly 80 % of the population of India is agricultural and since rainfall means crops and crops mean food, the rainfall distribution determines the supporting power of the land. The geographical situation of India and the rainfall conditions are such that for successful cultivation, irrigation in one form or other is necessary in all parts of the country where the mean annual rainfall is less than 50 inches. Where the rainfall is less than 12" artificial irrigation is a necessity to mature the crops. But where the rainfall is more than 20 inches and below 50 inches there is a tendency on the part of the cultivators to rely on rainfall, but their hopes are mostly frustrated due to the vagaries and erratic nature of the rainfall.

Irregular Distribution

The chief characteristics of the rainfall in the subcontinent are its unequal distribution over the country, its irregular distribution throughout the seasons and its liability to failure or serious deficiency. The normal annual rainfall varies from 460 inches at Cherrapunji in the Assam hills to less than three inches in Western parts of Rajasthan.

Unequal Distribution

The second important characteristic of the rainfall is its unequal distribution throughout the seasons. Except in the South-East of the Peninsula where the heaviest precipitation is received from October to December, by far there is always the greater portion of the rainfall during the South-West monsoon between June and October all over the country. During the winter months the rainfall is comparatively small, the normal amount varying from half an inch to two inches, while during the hot weather, from March to May or June, is practically rainless. Consequently, it happens that in one season of the year the greater part of the country is deluged with rain and is the scene of the most wonderful, and rapid growth of vegetation; in another period the same tract becomes a dreary, sun-burnt waste.

Pattern of Rainfall

It is interesting to note that while the relief rain in India gives the heaviest downpour, it is the cyclonic type which, on account of its more even distribution, is of greater economic value. The North-Western parts get some rain during January and February and that only helps in growing Rabi, but Rabi irrigation is a necessity in the Punjab and Uttar Pradesh but in Bihar it grows practically without irrigation. After the harvesting of the "Rabi" (Spring) crop, the heat and drought make this a period of compulsory fallow in most parts, comparable to "charaqui" in Egypt. Assam and Bengal grow rice and jute, relying on the rains. From June to October there is rain everywhere, though less in North-West than elsewhere. This is the chief growing season of India, when the land, cleansed by the hot season fallow and watered by the Monsoon, yields fruitfully rice, millets, maize or cotton according to rainfall or soil conditions. These are the "Kharif" (Autumn) crops, watered by the Monsoon rains and ripened by the hot, sunny weather which follows the departure of Monsoon.

Intensity of Rainfall

The success of agriculture is dependent on adequate rainfall from the Monsoon, adequate both in amount and distribution. In this connection it is important to realize the phenomenal rate of fall of much of the Monsoon rain, downpours being usual in which runoff is so rapid that only a small proportion is effective for vegetation or irrigation. As about 85 % of the total rainfall occurs in a short period of about 4 months, there are often severe torrential falls. These torrential falls are powerful agents of denudation, causing great soil waste on slopes and sometimes washing away roads, railways and bridges. Much of the rain which falls is thus unnecessary and incapable of utilization, but given storage, it provides a margin of safety in the event of partial failure, while it is those areas which have just enough which are the most subject to drought and famine when the rains are below normal.

It is precisely in this zone of just adequate rainfall that havoc may be wrought by deficiency, and the danger is greater or less in these areas according to the reliability of the rain. The percentage variability is naturally greatest where the rainfall is least, and stations in Rajasthan sometimes receive three years' rainfall in 24 hours; but between the critical figures of 12 inches and 50 inches there is a considerable range of reliability.

Water Potentialities

The total river water resources based on an empirical formula correlating the river flow in each basin with its rainfall and temperature in India were computed a few years ago at about 1,400 million acre-feet. The river flow that can be used for irrigation depends on topography, flow characteristics, climate, rainfall and soil conditions of the region, and differs from river to river. On the Cauvery which is the most developed river in India about 60 % of the annual flow is utilized while on the Brahmaputra the utilization is almost nil. Of the available supplies, it is estimated that approximately 450 million acre feet could be put to beneficial use. Only about 119 million acre-feet or 8.5 % of total resources had, however, been utilized up to 1951. Additional supplies are proposed to be utilized by the projects taken up in the first and second plan, as a result of which the percentage of water used will rise to 19 % in 1961.

The rivers in the North and North-West part further utilized is governed largely by the extent to which monsoon flows can be stored. Storage projects, by their nature, are more costly than diversion projects. There are, however, two important features of these projects which offset their high cost, viz., the possibilities of hydro-electric generation at the dams, and the protection afforded against flood damage.

India is lucky to have a good many rivers, which through canals either taken out directly from the rivers or from reservoirs irrigate large tracts of country and make India pre-eminently an agricultural country

The rivers in the North and North-West part of India are snow fed from the Himalayas and therefore perennial. Those in Central parts and Southern parts depend for their water supply on rains, spring water and seepage. During summer rains, they bring down large volumes of flood water heavily silt laden at times and innundate large areas of surrounding countries while in other seasons the discharge is poor and may be even nil. The fluctuating silt charge makes the designs of canals difficult and is practically the source of most of the troubles in the maintenance of the canals. Weirs across rivers have been built in almost all parts of the country. Since the last 25 - 30 years we are building barrages across the rivers for efficient control of supply.

In Central and South Indian rivers this supply is very fluctuating. Most of the big Reservoirs such as Hirakud across Mahandi, Rehand across a tributary of River Son, Tungbhadra, Mottur, Lower Bhavani, Chambel, Malampuza, Krishnaransajar, etc., are built in this part.

Tubewells

Subsoil waters have been used in India for irrigation from time immemorial by means of ordinary percolation wells. Almost every part of the country is studded with numerous holes in the soil for water. The total area irrigated from wells alone in India is 12.96 million acres, which is 26.49 percent of the total area irrigated in the country. The technique of using water for irrigation purposes from wells has also progressed with the time. In the early days the Latha and Kunri and other similar devices of a primitive nature were used. Lately "mot" and Persian wheels came in the picture which still hold the field where power lifting has not reached yet. During recent years, electrically driven tubewells have opened up a new method of utilizing ground waters on extensive scale.

There were about 2,500 tubewells in India prior to 1951, about 2,300 of which were in the Uttar Pradesh. These tubewells irrigated about a million acres. The first plan provided for the construction of 2,650 further tubewells under the Indo-U.S. Technical Cooperation Programme, 700 tubewells under the grow more food programme of the union and 2,480 tubewells in the development plans of different States. As a result of technological advance in tubewell engineering the possibilities of exploitation of underground waters have appreciably increased. The second plan provides for the construction of 3,581 tubewells at an estimated cost of about Rs. 20 crores, and the irrigation expected therefrom is 916,000 acres.

Tubewell irrigation is generally more costly than irrigation by gravity canals from diversion projects. But for areas not otherwise commanded it is a useful means of irrigation in regions with good underground supplies. Tubewells are also being used as a measure against water logging and deterioration of land as in East Punjab canal tail reaches.

Danger of Irrigation

The irrigation is not an unmitigated blessing. Unless proper precautions are taken at the time of design, construction and subsequent maintenance, very harmful results may arise which may not only affect the efficiency of the works, but may also affect the health and welfare of the people expected to be benefitted from such irrigation schemes.

Most of the troubles that follow after the construction of the weirs and barrages or dams have their origin (1) either in the bad design or in the (2) improper attention to constructional methods or (3) bad operational methods, which result in water logging, salt accumulation, scour, soil depletion, etc., etc.

Design :

(a) *Selection of Intensity of Irrigation :* This is an important point. This is dependent on the pattern of crop in the area and its fertility and the topography of the commanded area. In a flat and sandy country like Sind the Kharif intensity is as low as 27 % while the Rabi is only 54 %. In U.P. and the Punjab the Kharif intensity varies from 40 % to 50 % and the Rabi from 50 to 60 %. In Bihar where the soil is better drained than U.P. or the Punjab the Kharif intensity is at places higher than even 60 % and there is no water logging. There are certain soils which can stand irrigation of only one crop a year due to their finances and slow sub-soil drainage. While there are certain parts in the State like Bihar, Madras, U.P., where two crops grow and can stand irrigation very well without any adverse effect.

Before designing the canals great attention has, therefore, to be paid to the question of intensity of irrigation to be adopted.

Design of Earth Channel

Indian engineers have been continuously faced with the design of earth channels that should be stable viz., nonsilting and non-scouring. The flow of water in open channels from the view point of bed scour and carriage of detritus is of utmost importance in the design of channels. If a channel is not properly designed it causes scour of bed or side, apart from considerable expenditure in maintenance, the losses are considerably increased, which often cause water-logging.

Considerable studies have been made in India regarding the design of earth channels. As early as in 1895 Kennedy established a relationship between velocity and depth of flow in a channel for non-scouring and non-silting conditions. This represented an outstanding advance which has saved lakhs of rupees in repeated silt clearance alone of irrigation channels.

Originally Kennedy was of the opinion that width of channel was immaterial, but experience showed that some channels were obviously too wide as they contracted their width by silt deposition on the berms. Various investigations produced empirical relationship between bed-widths and depths for different discharges and Lindley in 1919 suggested that "the dimensions, width, depth and gradient of a channel carrying a given supply loaded with a given silt charge were all fixed by nature.

The Lacey equations, which appeared in 1930 were based on a wide range of data found from canals in the Punjab and U.P. showed that the slope of any channel was dependent on the discharge bed width, depth and the mean diameter of the silt transported in the canal water. Lacey's equations did not take into consideration the quantity of the silt load transported. Moreover, his equations are applicable to alluvial channels of Northern India only. In Deccan (South India) where the conditions are different, Mannings' formula combined with Kennedy is in vogue. Research on this subject is being conducted in Indian Research Institutes.

Bed Slope

The proper selection of the bed slope of the canal is the guiding factor as any scouring velocity generated in the canal does not allow the canal to become a regime channel as the finer particles do not seal up the permeable bed, thereby with the increase of percolation losses eventual water logging would be the result. It can be stated that though no finality has been reached on design of earth channels for silt laden water, the practice in India based on Kennedy, Lacey and others is the nearest approach to the ideal.

Silt Ejectors & Excluders

The canals drawing water from rivers which carry high gradient load are found to deteriorate through accretion which reduces channel section and its discharging capacity. This results in the increased canal slope upsetting the regime of channel and its ultimate usefulness. This defect is overcome by means of canal ejectors constructed at the head or by suitable location of the canal off-take with a view to draw only the surface water which is free from coarse sediment. In the recently constructed barrages in our country silt excluders have been provided to prevent heavily silt laden water entering into the canal.

Alignment of Distribution Channels

The main aim of the arrangement of the layout of a distribution system should be to serve in the most economical way effective water distribution combined with adequate command of the area to be irrigated with as little interference as possible with the natural drainage of the country. An alignment along any water-shed within the irrigable area secures command of all the ground up to the next valley on either side of the alignment without any interference with drainage and at the same time drains away the excess of water used for irrigation without causing water-logging.

Drainage Channels

In very flat areas like portions of the Punjab, U.P., and West Bengal an artificial drainage channel should be constructed by the Irrigation Engineer for efficient drainage and prevention of water-logging.

Losses in Earthen Channels,
Distributaries & Village Channels.

The skill of the Irrigation Engineer is judged in his conveying irrigation water to the field in as large a proportion as possible of the supplies available at the head of a canal system, by minimising losses in the canal in the distributaries, water course and in the field itself. On this aspect little research appears to have been done to find out exactly what part of the supply let down at the head of a canal is actually applied to the crops in the field. Some ad hoc estimates of seepage and evaporation losses in canals, branches, distributaries and water courses have been made in different parts of the country and their results are varying as no uniform system was adopted. An approximate estimate would reveal that of the water let in at the head of a canal system about 16 percent is lost in the canals and branches; about 6 per cent in distributaries and about 23 percent in water courses, thus leaving only 55 percent to reach the field. If absorption losses in the canals, distributaries and water courses are reduced considerably by taking suitable precautions while designing additional areas can be provided with irrigation facilities from the water already available, and water logging and raising of water table could also be avoided.

Irrigation Outlets

Great precaution should be taken in designing Irrigation Outlets. The aim should be to allow only that quantity of water through the outlet which would mature the crops. The outlet should not draw excess water from the channels which results not only in wastage but also eventual water-logging.

Several forms of outlets have been devised to give a discharge to the village channel, irrigating cultivators fields unaffected by the level of the water in the parent channel or of the tail water. Semi module or module types of outlets are used where the supply of water is very limited and any wastage would result in serious damages, e.g., in very flat and sandy commanded areas. On the other hand in areas having copious supplies and steep topography ordinary pipes or barrel types of outlets usually serve the purpose. Standing wave type of outlets have been designed to give proportional supply to the village channels as compared to the parent channels. In times of drought people try to get more water and this creates a lot of complication in the lower reaches. A judicious selection of the type of outlet for the particular condition saves a lot of troubles, such as wastage and water-logging. In North India where the topography is very flat, module, semi-module or standing wave type of outlets are in use along with other barrel types but in South India ordinary types are mostly used as there is good steep slope available in the commanded area.

Bad Construction Methods

During the construction of canals the siting of the borrow pits play an important part. Whereever possible the borrow pits may be put in the canal bed itself if there is a good chance of the same getting filled up by the silt coming in the canal water. If sufficient berms have been provided earth may be taken from them as well after leaving suitable dividing ridges. The silt would fill up the same in due course. In case sufficient earth is not available from the bed or berms of the canal, borrow pits may be dug outside the canal banks but sufficiently far away as not to allow water to seep into them. The pits should not be very deep. One to two feet deep borrow pits usually neither spoil the land nor work as mosquito breeding pools. The borrow pits should be suitably drained if possible to avoid water logging. Deep borrow pits should be avoided.

Reservoirs

The Big Reservoirs formed by the construction of Dams across some of the rivers in our country are no doubt very good and useful in many ways but have got their disadvantage in forest areas. Mosquitoes breed on the fringe of the reservoirs. Deep borrow pits for taking out earth if sited on the downstream side of the dam instead of the usptream, bring in bad water-logging and become mosquito breeding pools.

Trees should invariably be removed from the reservoir area before the same starts filling. If the trees remain in the reservoir, the organic matters decompose for several years resulting in unhealthy atmosphere for the locality. The stumps of the big trees remain standing for 30-40 years and their presence stands in the way of the development of fishes which die after getting a shock from obstructions.

Anti-malarial measures are a necessity on fringes of the reservoirs.

Bad operational methods : As soon as a canal system is constructed it requires a lot of care to be taken regarding its maintenance and development of irrigation. The banks go on settling at places and at times the banks breach and flood certain areas with canal water. Arrangements should be made so that immediate actions are taken to make good the breaches and if drainage lines are intercepted any water-logging must be properly taken care of. Such defects should never be allowed to linger on. The proper course will be to provide drainage channels immediately at the cost of the main project.

In reaches of canals or distributaries where profuse seepage losses are detected suitable linings should be provided to check the same.

In new canals, in the beginning, temporary pipe outlets may be provided. The working of the same may be watched in due course and suitable type of permanent outlet module, semi-module or ordinary type designed and fitted in the distributary bank after the same is settled properly.

Water-logging and Drainage

One of the essential features of a successful irrigation scheme is the control of the groundwater level. The maximum allowable depth of water table depends mostly on the crop grown, but it is usually reckoned that it should be below 3 feet, though rather higher water tables are allowable for pastures. The rise of water table in irrigated lands may be due to (1) seepage of water through bed and sides of canals which are generally aligned in the highest ridges of the country; (2) impervious construction in the way of laterally flowing subsoil water; (3) soils w clay substratum underneath; (4) impermeat soil surface where the excess water cannot penetrate rapidly below the root zone of the crops with the result that it stands in poolson the field and forms marshy lands, and (5) sometimes the water level in low pocket area rises due to irrigation in the neighbouring locality where water may even pass to the ground water table through unsaturated layers.

Ground water level should never be allowed to rise higher than 3 feet, and if this level cannot be adequately controlled by careful use of water, by means of lining the canals, water courses and village channels, etc., then either a suitable system of drainage or interceptor ditches must be constructed to remove the water or the ground - water must be pumped into drainage canals by means of tube wells.

Soil Aeration

Drainage improves the soil conditions as well. It improves the aeration of the soil by removing water filled up in the pores. This allows oxygenated water to penetrate rapidly up to the subsoil. In consequence of the improved aeration and removal of stagnant unoxygenated water, crops can develop a deeper root system.

Salt Accumulation

Draining surplus water has another desirable consequence. The fundamental problem underlying all irrigation projects in arid and semi-arid regions is preventing soluble salts accumulating in the surface soil. Before the commencement of canal irrigation, salts initially present in the soil profile are evenly distributed throughout the soil crest. With the introduction of irrigation, the salts accumulate in the form of solution at some depth below the surface forming a zone of accumulation or they may be forced up in the crest zone from the lower layers due to rise of water table, unless the salts are washed away either into the subsoil below the root zone of the crop or into drainage canals and so back into the river below the area.

The soluble salts which are detrimental to the plant growth are sulphates, chlorides and carbonates of sodium. It has been found there is not much possibility of these salts accumulating in the surface, if the water table lies below 10 ft. Leaching of surface salts by drainage and growing of salt resistant crops are the usual techniques adopted for reclamation of such lands.

Dry Farming

In arid and semi-arid regions of limited rainfall where irrigation cannot be used due to water shortage, dry farming is adopted to make the best use of the available water. This is usually done in 3 ways : (1) reducing all unnecessary waste of water by runoff or weeds; (2) selecting crops which grow mostly in rainy season, and (3) by conserving moisture in the soil by means of suitable fallow.

The function of fallow is to store water and this can only be possible under certain definite conditions. Rain must fall during the fallow period, there must be sufficient rain to increase the soil moisture content below 4" to 8" deep, and there must be no weeds.

Rotations in dry farming are of only limited value in dry areas, because few crops can so be profitably grown.

Intensive work on dry farming has been done by J. H. Martin, J. S. Cole, A. L. Halsted, etc., and their works are available in literature.

Irrigation Efficiencies

Naki Üner

In most of the irrigated areas the efficient use of our limited water supply has always been of primary importance. In some areas the water is so limited that the production of crops will depend entirely upon the wise application of the basic irrigation principles.

Proper handling of irrigation water requires methods of measurement and evaluation of performance. In order to put the irrigation water to beneficial use it has been necessary to develop certain basic concepts of irrigation efficiency which are a criterion for properly evaluating the irrigation practice.

Two fundamental concepts of irrigation efficiency which have been accepted widely are water conveyance efficiency and water application efficiency. Besides these efficiencies, Dr. Vaughn E. Hansen has proposed new concepts of irrigation efficiencies which are very useful. They are water storage efficiency, consumptive use efficiency and water distribution efficiency.

We, therefore, have five different ways of expressing irrigation efficiency. They are all related to better water use but each one emphasizes a different aspect of the subject. The five irrigation efficiency terms will now be discussed in detail.

Water Conveyance Efficiency

Water conveyance efficiency is of primary concern to the engineers as it involves the creation of drainage problems on lands below a canal system and means of canal lining and treatment to prevent canal seepage.

Most of the water comes from diversions, streams or reservioris. Some water will be lost from the point of diversion to the farm. The concept of water conveyance efficiency has been developed to evaluate this loss.

$$W.C.E. = 100 \frac{\text{Delivered}}{\text{Diverted}}$$

or $$E = 100 \frac{W_f}{W_r}$$

E_c = the water conveyance and delivery efficiency, percent

W_f = the sum of the depths of water delivered to the farm under the canal

W_r = the water diverted from the river or reservoir into the irrigation canal

The distance from the diversions to the farm, canal treatments such as lined or unlined canals and the grade of canal influence the W.C.E.

Let me take a few examples from Menemen cotton farms. On Neuzat Dirhemsizoğlu farm, the diverted water was measured as 115 litres/second. After 500 meters of earth canal we measured only 65 lt./second. Then;

$$W.C.E = 100 \frac{65}{115} = 56.5\ \%$$

I would like to give another typical example on Tozak farm, Menemen. The farmer used the country road as a ditch. He diverted 150 lt./sec. from the irrigation canal and brought the water in the road 1.5 kilometers. The water delivered to the farm was only 50 lt./sec. Then:

$$W.C.E. = 100 \frac{50}{150} = 33.3\ \%$$

According to our measurements on Menemen cotton farms approximately 40 to 50 % of the water diverted from the sourse is lost before it reaches the farm land because of canal losses such as : seepage and not controlling the flow during the conveyance of water.

Water Application Efficiency

Water application efficiency is defined as the ratio of the volume of water that is stored by the irrigator in the soil root zone and ultimately consumed (transpired or evaporated, or both) to the volume of water delivered at the farm. The concept of water application efficiency was developed by Dr. Israelson to measure and focus attention upon the efficiency with which the water delivered to the farm was being stored within the root zone of the soil where it could be used by the crop. By definition :

$$E_a = 100 \frac{W_s}{W_f}$$

where :

E_a = Water application efficiency

W_f = Irrigation water delivered to the farm.

W_s = Irrigation water stored in the root zone of the soil on the farm.

According to this formula W_f includes surface runoff from the farm, R_f, and deep percolation, D_f, below the crop root zone. Then :

$$W_f = W_s + R_f + D_f$$

$$W_s = W_f - (R_f + D_f)$$

$$E_a = 100 \frac{W_f - (R_f + D_f)}{W_f}$$

It is essential to know the moisture content of root zone soil before and after irrigation to find water application efficiencies. Soil moisture content may be measured by either of 3 methods, namely : 1. gravimetric, 2. electrometric, or 3. tensiometric. These methods are good for research studies. On the other hand it is also possible to determine the moisture percentage of root zone soil by the "test ball' method, even though it is not precise. So it may be a rough determination of water application efficiency for every technician in our country.

For calculation of water application efficiency we should know the following :

1. the depth of root zone soil (cm)
2. the total moisture need of root zone soil to fill to field capacity (milimeter)
3. the rate of flow (lt./sec.)
4. Area (Decare)
5. Time of application (hour)

Let me take an actual example on the cotton farm at Menemen :

The depth of root zone : 120 cm.
The total moisture need : 130 mm.
(Readily available water)
The rate of flow : 60 lt./sec.
Area : 100 decare
Time of application : 150 hours

According to the formula :

mm. x decare = it./sec. x 3.6 x hours.

or

$$da = q^t$$

where :

mm = the depth of application of water
decare = Area
lt./sec. = the rate of flow
3.6 = constant
hours = the time of application

We calculated that the need of available water of the cotton field is only 130 mm per decare. Now we can determine how much water the farmer put on the soil :

$$mm = \frac{\text{lt./sec. x } 3.6 \text{ x hours}}{\text{Decare}}$$

$$mm = \frac{60 \times 3.6 \times 150}{100} = 324$$

So he applied 324mm of water instead of 130 mm.

W.A.E. is :

$$W.A.E. = 100 \frac{130}{324} = 40 \text{ percent}$$

Our studies in Menemen have shown that the average water application efficiency is about 30 percent.

The main causes of low water application efficiency originated from :

1. irregular land surface
2. improper irrigation method and farm irrigation system
3. high time rate of water applications
4. long irrigation runs on highly permeable soils.
5. excessive surface runoff losses because of poor attention of the irrigator
6. early irrigation without need
7. high volume of water applied in a single irrigation
8. poor control and distribution of irrigation water on the farm

High water application is especially important in areas where drainage system is inadequate such as Menemen, Söke, Nazilli Valleys of Turkey. Therefore, low efficiencies may raise the water table and create salt problem in these areas. Consequently, a good drainage system is essential and the turning point for W.A.E.

Water Storage Efficiency

Dr. Hansen proposed to go a step further, without neglecting the importance of water application efficiency and focused attention upon the efficiency of storage of water.

The growing scarity of water discourages the excessive use of water. In many cases only a fraction of the needed water is being applied. The water application efficiencies under such practices are essentially 100 % and yet the irrigation practice is poor. Consequently, Dr. Hansen has proposed the new concopt of water storage efficiency which directs attention upon how completely the needed water has been stored in the root zone during the irrigation. According to the results of research in the U.S.A. the improved water storage efficiency will triple the production in the Lower Rio Grande Valley of Texas and similar research in Western Kansas produced double the production from better storage efficiency. The high water application efficiency and low production measured in both Texas and Kansas give positive proof that for these conditions water storage efficiency is the important irrigation concept.

The previously discussed water application efficiency evaluates the application in terms of how much water was used over and above what was required. Water storage efficiency requires quantitive evaluation of the adequacy with which we fill the soil moisture reservoir during the irrigation.

Attention is focused upon the storage efficiency through the use of the following formula to evaluate the water storage efficiency.

$$W.S.E. = 100 \frac{\text{Stored water}}{\text{Needed water}}$$

Equation I :

$$E_s = 100 \frac{W_s}{W_n}$$

where :

E_s = water storage efficiency

W_s = water stored in the root zone during the irrigation

W_n = water needed in the root zone prior to the irrigation

It will be noted that the definition of water storage efficiency does not concen itself with the water not stored in the root zone. The entire attention is focused upon how completely the root zone is filled by the irrigation water. The denominator of the water storage efficiency formual is the water needed in the root zone prior to the irrigation.

Equation I above, modified into the following form, will be useful in a rapid field determination of water efficiency.

$$E_s = 100 \left(\frac{A - ae}{A} \right)$$

or

Equation II :

$$E_s = 100 \left(1 - \frac{ae}{A} \right)$$

where :

E_s = the water storage efficiency

A = the total area of the irrigation area

a = area of the field receiving a deficient irrigation

e = ratio of the moisture deficiency in the root zone of soil following the irrigation, to the moisture deficiency prior to the irrigation.

As an example, suppose six decares were to be irrigated, and the needed depth is 10 cm. of water in the root zone soil. If two decares of the six received only a 2.5 cm depth instead of the needed 10 cm., then the water efficiency would be, using equation I :

$$E_s = 100 \frac{W_s}{W_n}$$

$$= 100 \frac{10 \times 4 + 2.8}{6 \times 10} = 75 \%$$

By using equation II :

$$E_s = 100 \left(1 - \frac{ac}{A} \right)$$

$$= 100 \left(1 - \frac{2 \times 3/4}{6} \right) = 75\%$$

Dr. Hansen suggests that the following concepts be kept in mind. Of considerable practical significance, both to the field technician and often to the research worker, is the fact that the precise evaluation of irrigation efficiency usually has little regional value. A good estimate of the average efficiency in an area and an estimate of the general conditon related to this efficiency is far more valuable than a few "precise" measurements on given farms that in themselves may not be representative of the area because of operational, cultural, topographic, or soil conditions.

For instance, on most of the cotton farms in Menemen Valley we can find a common topographic situation but different soil texture. Consequently, in selecting samples we must be careful

I would like to give some examples in this area. According to our measurements we have found the farm where the farmer applied 450 mm of water per decare instead of about 100 mm. Let me explain why he did this. He irrigated his cotton field with the wild flooding irrigation method, the distance between two borders was more than 25 meters, and the ground surface was badly uneven.

When we checked the soil moisture 48 hours after irrigation we found that 25 % of the 40 decares of land had the field capacity in 60 cm. depth, namely 50 mm. of water. Seventy-five per cent of 40 decares was over-irrigated. We checked the moisture with the soil probe. So :

$$E_s = 100 \frac{W_s}{W_n}$$

$$E_s = 100 \frac{30 \times 10 + 10 \times 5}{40 \times 10} = 87.5\%$$

or

$$E_s = 100 \left(1 - \frac{ac}{A} \right)$$

$$E_s = 100 \left(1 - \frac{10 \times 0.5}{40} \right) = 87.5\%$$

As we can understand, the efficiency of water storage does not concern the amount of water such as 450 mm. in our example. It depends upon the needed water before irrigation, such as 100 mm. in the example.

The water storage efficiency concept is particularly useful in sprinkler irrigation, on lands of uneven topography or poor irrigation control or management resulting in poor surface distribution of the water, on lands being irrigated with a high water application efficiency, or on lands consistently requiring a uniform, excess application of water to keep the salt level below the toxic range.

It would be a good idea to mention the disadvantages of high water storage efficiency in those areas where there is no drainage system to release the excessive water such as : Menemen, Nazilli and Konya valleys of Turkey. In these areas soil has a tendency to become salty because of high water storage efficiency, low distribution and water conveyance efficiencies and inadequate drainage systems.

Water Distribution Efficiency

The important characteristic of irrigation is the uniformity of distribution of the irrigation water throughout the root zone. Under most conditions, the more uniformly the water is distributed, the better will be the crop response. Uneven distribtion of water has many undesirable characteristics. Draught areas appear throughout a field which is not irrigated uniformly unless excess water is applied, which in turn results in a waste of water. Whenever a tendency exists for salt accumulation, those areas receiving less than the desired amount of water will show the greatest accumulation of salt if there is an adequate drainage system.

The formula for water distribution efficiency is :

$$W.D.E. = 100 \left(1 - \frac{\text{average deviation}}{\text{mean depth applied}} \right)$$

$$E_d = 100 \left(1 - \frac{d^1}{d} \right)$$

E_d = water distribution efficiency

d^1 = average numerical deviation, in depth of water stored, from mean depth stored during the irrigation

d = Average depth of water stored during the irrigation.

This formula proposed is simple, direct and the answer has physical significance which can be visualized. It is recognized that the effect of uneven distribution is not a linear function of depth. A function such as the square root of the sum of the squares, has advantages, but when applied to a warped surface becomes complicated beyond the point of utility.

Consumptive Use Efficiency

Water stored in the soil during an irrigation may not remain in the soil for use by the crops. A wide furrow spacing and considerable exposed ground surface may result in either or both excessive surface evaporation and continual significant downward movement of moisture beyond the root zone. This condition becomes quite evident whenever potatoes are in ridges of permeable soil and irrigated by furrows. The reason for the plant not being able to fully utilize the moisture stored in the soil is due to several factors.

The rows are widely spaced which result in a variable capacity to extract the water from the soil, especially during the earlier stages of growth. Because of the greater downward movement of water beneath the furrow, the water is not distributed uniformly throughout the soil.

To further complicate the problem, the moisture does not move readily up into the ridges. With the permeable soil quite moist, and with frequent applications of water to maintain a high percentage of moisture in the soil in order to obtain maximum yields, the water particularly under the furrow will move steadly downward and beyond the root zone. The rate of downward movement is greatly accelerated whenever dry soil exists below the depth to which the irrigation water has penetrated. Also, with considerable exposed ground surface, water stored in the soil may be lost by evaporation. Recent studies in the U.S.A. indicate that with a good ground cover of vegetation, evaporation from the ground and foliage is reduced by an amount equal to the amount of moisture depleted from the soil by the plant. However, when excessive ground surface is exposed, some net loss by evaporation will occur.

This loss of water by deep procolation and by surface evaporation following an irrigation can be evaluated by the concept of consumptive use efficiency :

$$C.U.E. = 100 \frac{\text{Consumptively Used Water}}{\text{Stored Water}}$$

$$E_u = 100 \frac{W_u}{W_d}$$

where :

E_u = consumptive use efficiency

W_u = water consumptively used

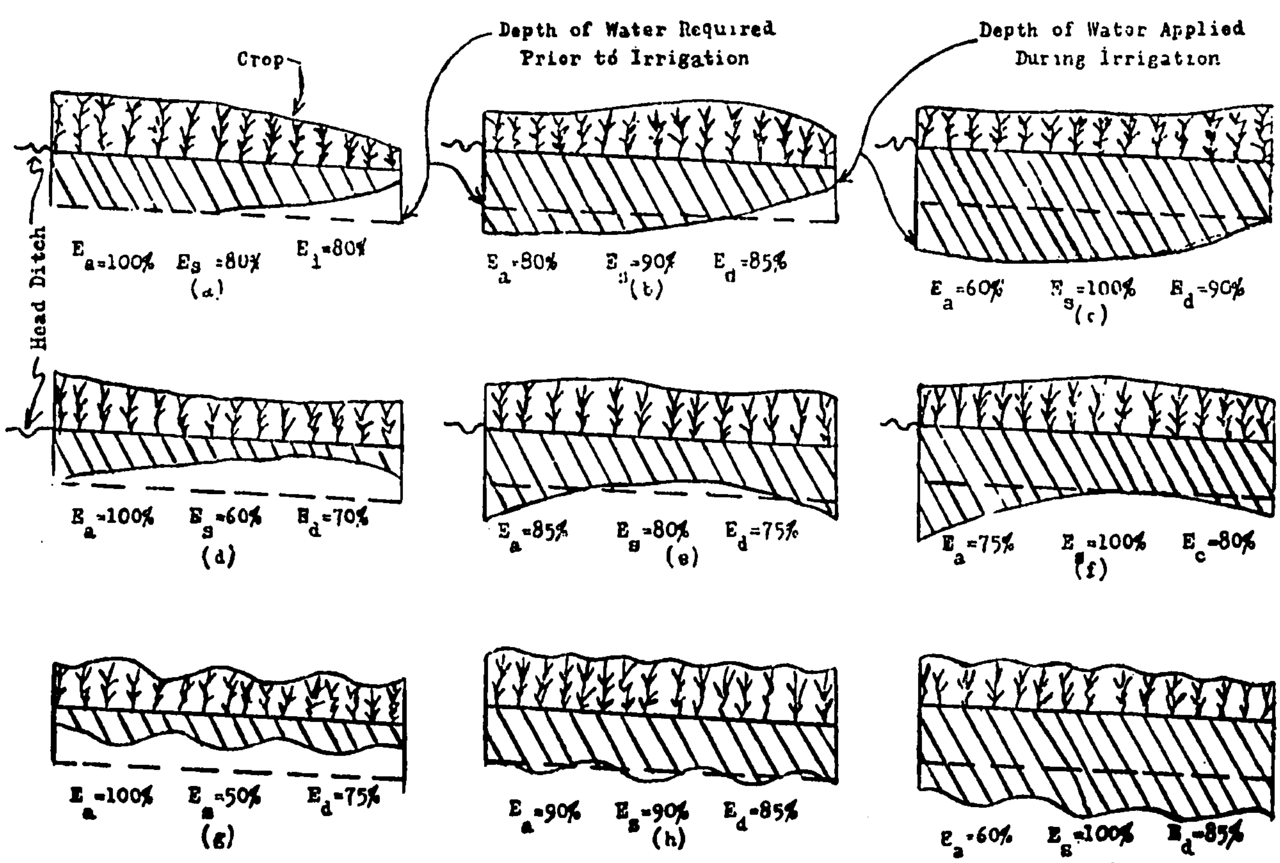
W_d = net amount of water depleted from root zone

Experiments indicate that this concept may be extremely important, particularly where high moisture, high permeability, wide spacing, and ridges are combined. The efficiency can be materially increased if the ridges are not used (observations indicate that for the sandier, better-drained soils, ridges are not necessary for good potato culture). The efficiency can also be increased if the row spacing is decreased, or if good sprinkler irrigation is used to more uniformly distribute the water. In other words, if better irrigation practice is followed the consumptive use efficiency is increased. Consumptive use efficiencies are a measure of irrigation practice involving the efficiency with which the roots are able to utilize the moisture stored in the soil during the irrigation.

Consumptive use efficiency will explain the difference in crop response from different methods of irrigation. When considering which irrigation method to use, the important aspect is which method will place the water where it can be most efficiently utilized by the roots of the plant. Consumptive use efficiency is a measure of the efficiency of placement. This concept will likely not be important on alfalfa with its well distributed root system, but may be very important when potatoes, corn, cotton or melons are grown.

Examples of Water application Efficiencu, Water Storage Efficiency and Water Distribution Efficiency.

Figure 1 contains nine illustrative profiles of rather common irrigation practices. Examples (a), (b), and (c) are cases of heavier application near the upper end of the field and illustrate how the three efficiencies vary as the amount of water



(Note : Water application efficiency estimates are made assuming no runoff). Fig. 1. — Application, Ea, storage, Es, and distribution, Ed, efficiencies and the effect upon crop production illustrated by two dimensional profiles of the soil.

applied increases. Examples (d), (e), and (f) illustrate a common case where heavier applications of water are applied near each end of the field. Examples (g), (h), and (i) illustrate the type of pattern which frequently occurs under sprinkler irrigation. Example (g) is common storage efficiency, and low water distribution efficiency showing vividly where the difficulty lies. Example (i) is also an undesirable irrigation practice and is well marked by the low water application efficiency.

The reader should not be misled into thinking that efficiencies of 100 % are always desirable. Maximum net profit can often be obtained by only making every second, third, or fourth irrigation heavy enough, depending upon the soil and crop, to obtain a water storage efficiency of 100 %. This is primarily due to the capacity of a plant to extract more water from the upper portion of the root zone than from the lower portions. Alternating the depth of application also promotes better bacterial growth in many soils.

Likewise, water application efficiencies and water distribution efficiencies of near 100 % are not always desirable nor practical. The expense necessary to secure high application and distribution efficiencies is often in excess of the economic returns. Another important reason for not always desiring water application efficiencies of near 100 % is that one or more excessve application of water per year, depending upon the salt content of the water and soil, is usually desirable to flush out accumulative salts in the root zone and thereby keeping the soil in a good productive condition.

Conclusion

The main objective of irrigation is to put the water to benefical use to get high production. In order to be successful, we should recognize waste water on the farm. The evaluaton of irrigation practices can be made by learning the losses of water and then the needed measures can be taken.

The efficiencies mentioned in this paper aid in controlling the irrigation practice. W.C.E. checks the canal losses. Water application officiency (W.A.E.) describes the tendency of excess water application. W.S.E. is useful whenever insufficient water is applied to the root zone during the irrigation. W.D.E. evaluates the uniformity with which the water is distributed throughout the root zone. C.U.E. measures the ability of the roots to utilize the moisture which has been placed in the root zone during the irrigation.

References

1. *Israelson, Orwon W.; Criddle, Wayne D., ; Fuhriman, Dean K.; Hansen, Vaughn E.*

   Water Application Efficiencies in Irrigation.

   Utah Agr. Exp. Sta. Bul. 311. Logan, Utah, March 1954.

2. *Israelson, Orson W.; Irrigation Principles and Practice.*
   John Wiley and Sons, 1950.

3. *Hansen, Vaughn E.; Water Storage Efficiency. Agricultural Engineering. Dec. 1953.*

4. *Hansen, Vaughn E.; Haddock, J. L.; and Taylor, Sterling.*

   A. Irrigation, Fertilization, and Soil Management of Crops in Rotation. 1952 Annual Progress Report. Logan, Utah. September 1953.

5. *Bishop, A.A. Waste Water. Utah Agri. Exp. Sta. Logan, Utah, June 1953.*

6. *Hansen, Vaughn E.; Irrigation Efficiencies. Utah State Agri. College. Logan, Utah. 1954.*

Water Supply And Delivery Factors As Related To Efficient Water Use

Fred Locher

Water supply and the delivery of water to irrigation projects and farms cannot be planned without due consideration to the physical conditions which effect the design of the project. Under certain circucumstances the physical limitations are of minor importance, and the system can be operated much the same as a water tap is used in the ordinary household. Such systems can be designed when the source of supply, if stored waters are used, is near the headworks, the project is not too extensive in size, when sufficient money is available to provide for automatic controls, and when the water carries little or no sediment. Some systems in Algeria and the United States have approached this idea. They are very efficient in the use of water, there is very little waste, and the farm delivery is very closely controlled. Such systems are very expensive and are economical only under special circumstances.

The rivers of Iraq, which are the source of water for irrigation, pass through large alluvial areas and at certain times of the year both the canals and the rivers carry a tremendous volume of sediment. The content of sediment varies between 150 ppm. during low river discharges to a high which sometimes reaches 20,000 ppm. The concentration at the heads of the canal taking water directly from the rivers have about the same variation. The period of heavy sediment loads occurs between February and June.

The deleterious effects of the sediment on the canal systems is apparent in most areas of Iraq where irrigation has been carried on for extensive periods of time. In some areas I have seen as many as eight parallel canals leading to the same area with only one canal serving the area with water. The other seven were abandoned one at a time as the task of removing the silt became insurmountable or uneconomical because of the high banks formed by removal of sediment from previous years. The Naharwan Canal, an ancient and famous irrigation system now out of use, had silt banks in some places 90 feet high.

You, no doubt, are wondering how the sediment content in canals effects water deliveries and the efficient use of water. This is one of the physical limitations which has a profound influence on the design, the pattern of water distribution and the times when water is available at the farm if the canal system is to be kept in operation for an extended period of time. One could say that the solution to the problem is desilting works at the head of the canals. This is true however, there are other difficulties which must be overcome before such works can be installed and put to use. The installation would require a tremendous capital investment and there would be high operating costs later on. Gravity silt extractors require a reasonable amount of head for operation. This head is not available when the sediment content of our streams is at its maximum and such works would need auxiliary power, which we do not have available. In addition to this, there is a pyschological factor which must be overcome. The farmers want the silt on their land because they feel that it serves as a fertilizer. Consequently, there is a general resistance to artificial silt extraction.

Since a program of silt extraction does not seem possible in the foreseeable future, we will have the problem with us for a long time and the canal systems must be designed an operated accordingly if they are to be kept in service for a reasonable period of years. The effects of such designs and planning on water deliveries as it is carried out in Iraq is to make the water available to the farms at certain specified times and periods and at the maximum rate set for the turnout. There are very few instances where water is delivered at fractional turnout capacities for longer than the planned rotation period. This makes it possible to operate the canals at full capacity whenever water is needed and to close them completely at other times. In this manner full use is made of the non-silting non-scouring design criterion and much of the sediment is carried through to the farms instead of being deposited in the canals. Canals carrying heavy sediment loads deteriorate rapidly if operated at partial capacity This point will be explained more fully later on, but to clarify the method of water distribution the following data is given for a gross project area of about 1,250,000 mesharas (1 meshara equals 2,500 square meters), all of which is commanded by canals but not all of which is cultivated at any one time. About 50 % of the irrigable area is cultivated during the winter season and 10 to 15 % during the summer season. This is the traditional pattern of cultivation in Iraq. It nearly coincides with the natural supply, which is useable in the Euphrates and Tigris rivers and fits the local belief that fertility is maintained or improved by leaving land fallow. It has been practiced for centuries. To supply the project with adequate water the canal operates at full capacity 55 % of the time in January, and will be closed for 45 % of the month. Other months are as follows :

	Feb.	*Mar.*	*Apr.*	*May.*	*June*	*July*	*Aug.*	*Spt.*	*Oct.*	*Nov.*	*Dec.*
% time operated at full cap.	*30*	*90*	*75*	*50*	*50*	*50*	*50*	*50*	*40*	*70*	*65*
% time closed	*70*	*10*	*25*	*50*	*50*	*50*	*50*	*50*	*60*	*30*	*35*

During the periods of flow each farm will be receiving water at a rate which will satisfy the demands of the cultivated crops until water is again made available. During the remainder of the time no water is delivered to the farm and the canal head gates are closed. In other words, the farm receives water at a fixed rate of flow regardless of the season. The amount it receives is controlled by the length of time that the water is made available. Water is not delivered -say for 15 days in June and then no water for another 15 days. It usually is delivered on the basis of five days on and five days off, or some other short period depending on conditions peculiar to the area.

Such a system of water distribution does not allow much flexibility. It assumes that all farmers will handle the water equally well and that they will all want it at the same time. It also assumes that soil preparation, the planting of crops, etc., is done by all the cultivators simultaneously. Actually, this is not the case and allowances are made in the operation of the canal during periods of soil preparation, planting and harvesting to compensate for variation in demand. This is usually accomplished by varying the periods of supply and no supply. However, it is not possible to match the requirements too closely in these periods and in some areas there will be an excess of water while others may actually be in short supply. This is more pronounced on extensive systems like the Hilla Canal, which serves some 2,500,000 mesharas.

For the benefit of those who wish to investigate further, the non-silting, non-scouring theory of Lacey and Kennedy, they are referred to page 269 and 270 of the Journal of the Institute of Civil Engineers, January, 1930, and a later explanation of the same work by G. Cardiocas, available in the Irrigation Directorate in Iraq. Briefly, Lacey assumed complete geometrical similarity in the cross section of regime channels, the scalor factor being the reciprocal of the silt factor. It is not necessary that the silt distributed around the wetted perimeter is of the same fineness throughout a particular section. All that is necessary is that the grading of the silt from section to section be identically similar with the only difference being a constant difference in silt scale between identically located points on various sections. With the aid of the above assumptions, Lacey derived the formula $Pw = KQ^{\frac{1}{2}}$, where Pw is the wetted perimeter; K is a constant, depending on the silt factor, and Q is discharge. By combining this formula with Manning's formula, the following are obtained for bed width "b" and depth "d" for trapezoidal channels having side slopes with angle "a" with the horizontal.

$$d = \frac{KQ^{\frac{1}{2}} \pm \sqrt{K^2Q - 4\left(\frac{2}{\sin a} - \frac{1}{\tan a}\right) K^{\frac{8}{5}} n^{\frac{3}{5}} Q^{0.6} S^{-0.3}}}{2\left(\frac{2}{\sin a} - \frac{2}{\tan a}\right)}$$

$$b = Pw - \frac{2b}{\sin a}$$

The derivation of the above formulas are shown in the appendix.

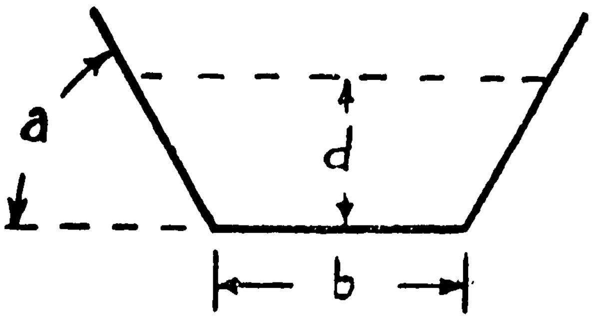
The capacity of the farm turnout has considerable influence on the efficient use of water. If it is too large, much of the water is apt to be wasted and passed through to drains. If it is too small, areas near the turnout become over-irrigated while those on the far end of the plot are under - irrigated. The ability of the farmer, type of soil, crops grown, slope of the land, type of irrigation and area all have an influence on the size of turnout for the most efficient use of water. There are probably as many opinions as to the correct size of turnout as there are people designing irrigation systems. In Iraq we have two proposals for the capacity of turn outs serving essentially the same size farm unit. One is for 20 litres per second, the other is 40 litres per second. The 20 liter per second turnouts are now being installed on a 240,000 meshara development. The farm units have a culturable area of about 60 mesharas of which it is planned that about 50 percent of the area will be cultivated in the summer season, and about 85 percent in the winter season. Water will be furnished on the rotation basis with the canals operating 50 percent of the time in the months of maximum demand.

We have another example where an individual has six mesharas of citrus trees and datepalms and a turnout with a capacity of 100 litres per second, which he operates six hours out of every 21 days. This represents a depth of about 14.4 cm. over the entire area. Normally, one would expect waste and perhaps erosion under these circumstances. Actually, there is very little waste since his irrigation system consists of a liberal lacing of deep ditches between the trees which are filled with water that is left to seep into the ground. There is no spreading or other attending given to the water during the period of irrigation. You can readily guess that the land slopes are also very gentle.

One cannot stress too strongly the installation of adequate measuring devices to insure proper and equitable distribution of water and to make people conscious of the proper use of water. There are a large number of devices which can be used for for this purpose and data for them can be found in various publications. Many of the measuring devices require special application, others require a reasonable fall, etc. On one project we have adopted a broad crested weir for each farm turnout. It will stand about 80 percent submergence without materially affecting the coefficient of discharge, therefore, the head loss through the weir and turnout is tolerable with the flat slopes prevailing on the project. These weirs are precast and have cast into the concrete a mark visible for some distance, which indicates the proper level for the designed turnout discharge. It is hoped that these marks will make both the project personnel and the farmers more water conscious. It certainly will give the farmer something to complain about if the water level is not up to the mark.

APPENDIX

Open Channels



Computation of bed width "d" and depth "d" from the Manning and Lacey formulas :

Manning's formula : $V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$ 1.1

Lacey formula : $Pw = KQ^{\frac{1}{2}}$ 1.2

Pw = Wetted perimeter ; K is constant varying between 4.14 and 7 ;

R = hydraulic radius ; S = slope of the canal ; n is a roughness coefficient varying between. 020 and. 025 for normal canals : A = area of water Prism or the cross sectional area of that part of the canal occupied by the flowing water.

$A = PwR$ 1.3 ; $Q = VPwR$ 1.4

By substitution of 1.1 and 1.2 in 1.4.

$Q^{\frac{1}{2}} = \frac{K}{n} R^{\frac{5}{3}} S^{\frac{1}{2}}$ 1.5

$R = (\frac{n}{K})^{\frac{3}{5}} Q^{0.3} S^{-0.3}$ 1.6

By substituting 1.2 and 1.6 into 1.3.

$A = K^{\frac{2}{5}} n^{\frac{3}{5}} Q^{0.8} S^{-0.3}$ 1.7

$Pw = b + \frac{2d}{\sin a}$ 1.8

$Pwd = bd + \frac{2d^2}{\sin a}$ 1.9

$A = bd + \frac{d^2}{\tan a}$ 2.0

Equation 1.8 is the wetted perimeter for any trapezoidal canal. Equation 1.9 is equation 1.8 multiplied by d. Equation 2.0 is the area of any trapezoidal water section.

By subtracting 2.0 from 1.9, $Pwd - A = d^2 (\frac{2}{\sin a} - \frac{1}{\tan a})$ or $(\frac{2}{\sin a} - \frac{1}{\tan a}) d^2 - Pwd + A = 0$ 2.1

This is solved for d and results in the following :

$$d = \frac{Pw \pm \sqrt{Pw^2 - 4 (\frac{2}{\sin a} - \frac{1}{\tan a}) A}}{2 (\frac{2}{\sin a} - \frac{1}{\tan a})} \quad 2.2$$

By substituting 1.7 for A and 1,2 for Pw

$$d = \frac{KQ^{\frac{1}{2}} \pm \sqrt{K^2Q - 4 (\frac{2}{\sin a} - \frac{1}{\tan a}) K^{\frac{2}{5}} n^{\frac{3}{5}} Q^{0.8} S^{-0.3}}}{2 (\frac{1}{\sin a} - \frac{1}{\tan a})} \quad 2.3$$

From 1.8, $b = Pw - \frac{2d}{\sin a}$ .... 2·4

Equation 1.2; 2.3; and 2.4 used in combination make it possible to compute the necessary water cross section for a non - silting non - scouring channel when K, Q, the canal side slopes, the slope of the canal, and n are known or fixed.

If the above principles are adopted for the design of a lateral system, the work is greatly facilitated if a table is prepared for values of b and d corresponding to various values of Q and S. In general K and n will be constant throughout a particular lateral system.

Values of K have been determined for a number of canals in Iraq. Some of the smaller canals have K values of 4.14. The entire Mussayib system was designed with K = 4.5. The Hilla Canal with a capacity of 150 cubic meters per second has a K value of 6.0. Attention is drawn to the point that the above formulae apply only to regime channels in alluvium.

Irrigation Methods

J. B. SMITH

Fellow technicians, Neighbors of the Near and Middle East, it was in your world that irrigation began. And it was with that beginning that problems of irrigation were introduced. Imposing ruins in your countries write the history of difficulties experienced in the early days of irrigation. Abandoned fields inform us that then, the irrigator was able to move away and leave his irrigation difficulties behind.

Today is a new day. We can no longer abandon our troubles and move to new land. Today my neighbor is the man across the ocean, and when I stand my shovel in the mud and step across the fence to share my neighbor's problem the fence is the ocean, and the problem of interest may be half way round the world. Somehow distance does not alter the nature of the problem and it may be exactly the same as that back in my field where my shovel stands in the mud. Not only are your concerns my concerns, but your technical knowledge is my technical knowledge. We find that in the exchange of knowledge we all grow. We all become more competent and better qualified to deal with the difficulties which we are no longer able to run away from.

It is with the attitude of exchange of knowledge that I have prepared this paper. It is with a feeling of neighborly friendship that I invite your questions and your comments.

It is not my intention to give you a text book discertation in this paper. The purpose is to acquaint you with my concept of the major types of irrigation methods and to lead you through interesting experiences which I have had with them.

It is my opinion that no one can describe satisfactorily or even name all of the many methods and combinations employed. There are reasons for the use of all the different methods of irrigation. There are good and sound reasons, based on experience, conditions, circumstances, and tradition.

Wild Flooding

Perhaps one of the first ways to irrigate was to obstruct a stream and thus cause a part or all of it to be diverted over the banks to spread where the natural topography determined. This primitive method is still employed throughout large areas in the United States and many other countries. The modern name given to it in the United States is wild flooding. It is also called free flooding, or uncontrolled flooding. These names not only apply to the most primitive application of this method but also are generally used to designate improved variations and modifications. One improvement to this type of irrigation is employing a diversion ditch to carry the water farther back on the banks or into a field, and there release it on one or more ridges, allowing it to make its way over the slopes into the natural depressions.

A further improvement is to set up a system of ditches across the slope laid out on very slight gradient. They progressively spread and respread the water as it flows down the slope. With good engineering this improved type of flooding can be utilized quite effectively under some conditions. The supply of water should be plentiful as the system is very inefficient. Perhaps an application efficiency of 15 % to 20 % is all that can be expected. The system can be set up to be employed with either a large flow or small flow of water. It should never be employed on extremely light erodable soils. There should be a good cover on the ground to prevent erosion.

This system is used extensively in the Rocky Mountain area of the United States. Many high mountain ranches use this method of irrigating pasture land and hay meadows. It is not unusual for the rancher to irrigate from streams or ditches of 20 to 40 cubic feed per second. The streams are divided into small ditches carrying about one to three cubic feet per second. Usually these ditches are laid out on natural ridges which have had little or no smoothing or change or work.

The small ditches lead the water wandering over meadows of 100 to 200 acres. Two or three men riding horseback, or in jeeps, or on foot travel back and forth over the field building small dams, or cutting short ditches. They tease the water along for periods of 24 to 48 hours attempting to persuade it to cover the remote high spots which they never quite reached the year before. Such are the irrigations year after year, leaching the plant nutrienis, under - irrigating the high places, over - irrigating the low places, and bringing reeds and sedges which have very little feed value.

Many of these ranches are located at quite high altitudes where the growing season is short. Usually the soils are light to medium textured and shallow to sand or gravel. Leveling may be impossible without cutting into gravel or the raw sand The land may have such small potential unit income value that it is not economical to level and haul in topsoil. Irrigation water is plentiful and any waste water will be used farther down stream.

Many ranchers and farmers are employing land preparation and good irrigation systems in the same areas. With a well engineered system of the wild flooding method an irrigator may be able to irrigate some 5 to 10 acres per day, but even at best there will be uneven irrigation and leaching of plant nutrients.

Border Method

From the modifications of the flood methods has developed one of the most widely used and highly efficient methods of modern irrigation. It is most commonly called border method, or border - check method. It is so named because the water is confined between low border levees as it spreads itself in a thin sheet from one end of the check land to the other. Row crops and crops intolerant to contact with water are unsuited to irrigation by this method. When crop rotations require row crops, rows are made within the bordered areas and the levees remain to be used when the rotation again involves crops suited to flooding.

There are two classes of border systems, temporary and permanent. The temporary system is formed by simple non - compacted dikes which the farmer can make with his plow. If the fields is steeper than about 0.15 % it may be necessary to construct a few small earth dams in the furrows alongside the dikes. The temporary levees being small of cross - section and non - compacted will not withstand the settlement resulting from more than one irrigation. It is an inexpensive means of confining water for a single irrigation. It may be preferred over furrows because it will permit a quick light application and may thus enable the farmer to get in one more crop per season.

Another good use of the temporary system is for a trial to help the farmer to examine his field under flooding conditions prior to designing a permanent system.

The size and shape of the permanent levee is designed to meet the requirements of confining the water, permitting plant growth on the dike, withstanding the trampling of hoofs and crossing of wheels when harvesting by livestock or machinery. Weeds thrive on dry levees. Cattle, horses, and especially sheep love to play and trail on dry levees, and can destroy them in a short time.

Remember that during the life of a permanent border, different crops will be grown on the field, but there will be one main crop. Keep all of the crops in mind but design especially for the main crop. For instance, for alfalfa which is to be harvested by machinery keep the levees low and with a wide base. Twenty - five feet from each end lower the levees by 20 % and widen the base by 20 %. This will make it easier to mow, rake, and haul the hay from the field. Bouncing a tractor over a high steep levee, or gouging the end of a sickle bar into it is no fun, and it costs money.

Some authorities recommend discontinuing the levees a few feet from the lower end of the field to permit waste water to flow laterally into the adjacent check. I have found that the irrigator will accomplish a better irrigation if the borders continue to the end of the field. There, have a wide shallow ditch to carry the waste water away. At times the farmer may wish to start irrigating one check while he is still harvesting a crop in the adjacent one. Any encroaching of waste water will be a nuissance. Also water standing on the lower end of a field may cause places to be over - irrigated and will encourage weed growth.

Erosion, infiltration, crops, and cropping practices determine permanent design details. The irrigator is interested in getting the water over the field and into the soil for crop use as rapidly as conditions permit. Only erosion or water supply will limit the amount of water he turns into the check when the soils have rapid intake. The width of the check will be designed to allow for spreading this head of water evenly to a depth of about 0.3 foot. The length of the run will be determined by the distance which this amount of water will flow in the time required for desired penetration.

The soils irrigated by border flooding should be of such character that they do not disperse and crust or erode badly. All other soils can be irrigated satisfactorily by designing for special conditions. For high efficiency soils with rapid intake require shorter runs with larger flows of water. Thus they require wider distances between borders.

Cropping practices have a large role in determining details of the system. For instance during the first year of an irrigated pasture the soils may have a high infiltration rate but if the cattle or sheep eat the grass down to the ground and muck around when the soil is wet, the intake rate may change considerably. This is no different in practice than to compact a reservoir dam with rollers to prevent its leaking.

In my 21 years with the United States Department of Agriculture I have learned the value of good technical knowledge as a guide to proper design. In my 12 years of operating two irrigated farms with cooperative experiments being conducted I have learned to value highly, "on the farm" experimentation. Therefore, I recommend that before changing irrigation methods, the farmer experiment on his own farm with a temporary system. He can be utilizing his various condition combinations and all of the technical knowledge available to him.

Check-Basin Method

From flood and border check irrigation has evolved a most efficient method known as check - method, basin method, or check - basin method. It falls within category 6 of the United States Department of Agriculture land preparation classification. Class 6 is the highest type recognized by the classification. Check irrigation is used all over the world where irrigation is practiced extensively. Different countries have their modifications of the basins to fit their individual sets of conditions. The paddy method, contour check, border check and such are examples of them.

Cereals, alfalfa, clovers, and orchards are adapted to basin irrigation.

If slopes are steep the basins must be small or the difference in elevation between them will make cultivation difficult.

Infiltration rate of the soil and water supply are probably the most important factors involved in design of the method. The size of the check must be designed to permit the water to cover the entire basin floor before much of it has had time to enter the ground. If the soil has rapid infiltration characteristics it will be necessary to make the basin small or have a large flow of water.

Basin irrigation can be used with any size stream. Simply turn the water into the basin and allow it to flow until a desired amount has run into it. With soils having low intake rate the water can be allowed to flow until it has built up to the necessary height on the borders as a gauge for the irrigator. Some checks are constructed to permit the water to flow over the borders into the adjacent one after a certain height has been reached. This requires a little special preparation in dike construction in order to make it erosion resistant.

The width of the basin compared to its length will be governed by the slope of the field and convenience of operating cropping equipment. Because it is more convenient to operate most equipment on a straight run than to turn the machine it is more convenient to have the basin long and relatively narrow. Since the basin floor is level it is more efficient, from the irrigational standpoint, to have the basin square. A compromise between operational convenience and irrigation effeciency seems te be wise.

Israelsen, (1), has calculated and shows in convenient tables quantities of flow, depths of coverage, and time required for applications based on the formula: quantity of flow, multiplied by time, equals volume. This gives the average amount of water applied over an area and shows a correct coverage for a unit area. As any part of the basin increases in distance from the supply, the formula becomes less applicable in proportion to the infiltration rate of the soil.

The size and shape of the levees in the basin method should be similar to those of the border method. The average height of the levees is usually confined to a maximum limit of 0.7 to 0.9 foot. The base width should be governed by the type of soil, the crop characteristics, and the operational character of the cropping equipment, or general land use.

An adaptation of the check method used extensively in the Middle East which has possibilities of being very efficient is the paddy system. Middle East paddies are extremely irregular in size, shape and design of borders. The farmers have made their systems by hand to fit their topography, their cropping methods, their water supply, and as much as possible without machinery. Many of the paddies are only 25 to 30 feet square. There may be one foot or more difference in elevation between them. The borders are not uniform in shape. It is remarkable though how practical the systems are for the type of farming done in them. The farmers use no automotive equipment in the small irregular paddies. He could not use that type of equipment there if he had it. He may have done a very minimum of leveling but until very recently no leveling equipment has been available. As more tractors, combines, mowers and other machinery is introduced land leveling will have to be done. The paddies will increase in size. The borders will be made to accommodate the operation of machinery. Border method irrigation will take the place of some of the paddy irrigation. Larger areas will be farmed by one man. Waste and drainage systems will be placed on the farms.

Contour-check method

A modification of both the border system and the check or basin method is the contour-check method. This method differs from the regular check method in that it is formed by borders laid out on the contour at regular vertical intervals. There is practically no leveling done between the borders. Since the land may not be on a smooth plane the checks are not uniform in width. Usually the checks are long and relatively narrow. There is a cross levee placed at each end of the check to impound the water

Contour checks are most widely used in orchards on relatively flat land. They are used somewhat as substitutes for border or basin irrigation in orchards, which have been established prior to the laying out of an irrigation system. In such cases the borders must vary slightly from the contour in order to miss trees and to prevent curves which are too sharp for farm equipment to follow. In such cases extra work is required on the dikes. In most instances the ridges are put in as temporary and they are removed before harvesting fruit crops.

If care is taken in the layout of the contours the system can be relatively efficient. Large heads of water can be applied in short periods of time, tending toward even distribution, but application is not as uniform as with the basin method. Usually the labor required is considerably greater than for the regular border or regular basin method. It varies greatly with the topography of the field.

The design features are contour interval, length of check, size and shape of the ridges, and water supply ditches. Factors determining design are crop, soils characteristics, topographic features of the field, and water supply. The contour interval usually averages about 0.2 foot. Since the width of the check depends on the slope of the field and contour interval, the interval will vary some in order to utilize convenient locations for the border. The check may be widened or narrowed to suit the soils requirements and water supply. The same principle of designing check width and length to fit erosion, infiltration and crop applies as for border and basin irrigation.

The borders are usually of the narrow base and rounded top design. It is not necessary to stress the operational convenience features in the ordinary contour-check layout because the system is temporary. The dikes are usually about 1.0 foot high with base width of about 4 to 5 feet. Irrigation ditches may be necessary throughout the field located to give the desired length of run to the checks. These ditches may be of temporary nature, obliterated and reconstructed each year.

While the system is temporary in nature, the design is permanent. It is quite important to design it well in order to protect a crop or valuable trees. If the topography is not uniform the design of a system which functions well may be quite difficult. For this reason it may be necessary to spend much time in the first layout of this nature in the orchard and after using it for a season it is likely that the irrigator can improve on the system. After a good layout is determined it is possible to do the cultivational operations in such a manner as to improve the functioning of the system.

Furrow Method

The furrow method in some form or modification is perhaps employed in more localities and with a greater range of crops than is any other method. The principle involved in furrow irrigation is to furnish moisture for the crop by conveying the water along side the plants in small ditches called furrows or corrugations. The moisture seeps from the sides and bottom of the furrows never flooding over the ground surface. Its chief application is for row crops.

Furrow method is employed quite successfully on slopes of one to three percent with a small amount of care and precaution. The size and shape of the furrows depend on the crop, the slope of the field, the erodability and infiltration characteristics of the soil, the amount of water supply, sediment in the water, crops and cropping practices.

This method is employed on slopes as great as 15 % or more. Even on these extremely steep slopes the furrows are run down the steepest slopes of the field. These furrows must carry extremely small flows of water, (perhaps as small as 0.005 cfs.) in order not to create excessive erosion. In order for these very small flows to furnish moisture to the surface for seed germination it is necessary to have furrows not deeper than about 0.2 foot deep. This is particularly true if the soils are highly permeable. The small volume of water will not flow far before all of it has penetrated into the soil, therefore the length of run is extremely limited. Many problems arise from the irrigation of such steep slopes and if conditions permit another method of irrigation is recommended.

Usually such steep slopes are in regions of high altitude where the method is employed to irrigate small grain, pasture, and vegetables. Some orchards are irrigated in this manner.

Hay crops which are to be harvested by machinery require furrows or corrugations of small or medium size. It is very difficult to mow, rake, and haul hay over deep, wide furrows. Pasture crops permit a wider range of furrow size. The size is more likely governed by the water supply or soils intake rate. Small vegetables which are cultivated by tractor equipment require small or medium furrows. Orchards permit the largest furrows.

Roe, (2), states that the essential primary feature of a furrow system is the head ditch. Its important function is to deliver and control the desired flow at all times. The design for the furrow supply ditch differs from that of other methods by distributing into many different divisions. One may accomplish better control and distribution into the furrows if there is a small spreader ditch parallel to the head ditch from which a series of about 6 to 8 furrows may be regulated. Many different commercial structures are available to assist in furrow distribution.

The waste ditch is a very important part of the furrow system. It should be a shallow wide ditch crossable by cropping equipment, designed large enough to carry about one third of the irrigation supply.

One of the more common variations of the furrow method is the practice of using extremely large furrows or ditches. These ditches may range in size from about 2 to 6 or more square feet in cross section. They are laid out in a similar manner to the regular furrow method, taking off from a head ditch, running parallel and alongside the plants to be irrigated from them. These ditches may either terminate in a waste ditch or may end abruptly at the end of the plant row. Some of these ditches are made by the use of a plow or lister throwing a ridge up between the ditches. Because of the ridge the method is sometimes called the ridge method of irrigation. This system is most widely applicable on extremely flat slopes where the gradient for flow is built up in the ditch itself. The deep ditches are sometimes used to facilitate infiltration where there is considerable sediment in the water. The sediment will settle to the bottom of the ditch and the infiltration takes place through the sides. Generally the efficiency is low. Sometimes the ditches are designed to contain a given volume of water, which volume is turned into the ditches and left to seep away. These systems are used in orchards and for vegetable crops where all of the work may be done by hand or with horses. It is extremely difficult to operate machinery in a field with this type of system.

One other modification of the furrow method which has been praised by many conservationists and damned by many irrigators needs some mention. It answers to the names of either contour or gradient furrow method.

Its chief application is with plants permitting deep furrows in highly erodable soils on moderate slopes. Its chief mis-use has been on steep slopes and uneven topography. For the method to be successful the surveyor must stake rows across the slope at fairly close intervals. The rows must be laid out on the steepest non-erodable gradient but not steep enough to alternately erode and deposit.

The farmer will follow the stakes closely with his furrows. Any change in the slope of the field will cause the furrows to become closer together or farther apart. If the slope is steep or uneven, any failure to follow the stakes closely will result in some of the rows irrigating well while others will fail causing much more erosion than if the system were never employed.

There are special application practices which will minimize the difficulties. One must always start irrigating the field from the upper end. Alternate rows should be irrigated during a set.

The trial on my farm resulted in the following: The conservationist who staked the field was bubbling over with enthusiasm.

The farmer making the furrows voiced considerable difficulty in following the stakes.

The neighbors claimed that the system would never work. The hired man refused to irrigate the field, not knowing which way the water should run.

My wife threatened to fire the irrigator, do the irrigating herself, or move to the city. She now lives in the city.

Seven technicians struggled through the first irrigation to prove that the method would work.

The water ran well after the battle of the beginning.

The trees were well irrigated except in a small portion of the field where the slope changed severely.

The system was used on the field for 5 years.

The same method was later employed on another portion of the farm.

No united conclusion was ever reached regarding the success or failure of the method.

(NOTE) : Incidently, the irrigator moved to the city.

Subirrigation

Two general types of subirrigation are recognized by most authorities. They are referred to as natural and artificial subirrigation.

The natural method of subirrigation operates by the application of sufficient water by means of ditches to build up ground water to such a height that capillarity will furnish sufficient moisture for the plant roots. The roots tend to follow the water as it recedes to a lower depth.

The artificial type is so called because of the use of tile or perforated pipe to transport the water which raises the ground water sufficiently for plant use.

For successful operation of the method three conditions, rare in combination, must exist. There must be a surface soil of character suitable to rapid capillary water movement. There must be a relatively impervious layer some 6 to 10 feet deep to prevent rapid loss of water supply. There must exist means of drainage. The drainage may be accomplished by artificial means but in some instances the cost may be prohibitive. The natural slope of the land must not be steep enough to cause an extra high water table down slope. The topography must be relatively uniform for good results.

I am quite familiar with an area in San Louis Valley, Colorado, U.S.A. where a new combination of layout is being installed to operate for both irrigation supply and drainage. I am fortunate in having had a part in the application of the system. A series of cross ditches aggregating several miles in length supply water for hundreds of acres of good farm land which has begun to deteriorate because of salt accumulation. The ditches average about six feet in depth. Control gates can hold the water level in the ditches to within about two feet of the ground surface, then release it after the irrigation season is over, effecting drainage six feet deep.

Natural precipitation along with limited surface irrigation is expected to carry excessive salts away by use of the open drains. The subsoils in this locality are such that moisture moves laterally several hundred feet in only a few days. This condition permits a ready supply of irrigation water over the entire area.

Sprinkler Irrigation

About 10 to 15 years ago sprinkler irrigation had reached a peak in causing curiosity among the irrigators. Farm crops were valuable: some farmers were beginning to get free of debt for the first time in their lives and they were investigating ways of getting ahead of their neighbors. Many companies were concentrating on the sale of sprinkler systems. New improvements were being added to make the systems more convenient and serviceable. More and more farmers were testing the method and asking many technical questions. In general, the companies had difficulty in giving satisfactory answers to the many practical inquiries.

Irrigation technicians busied themselves to find the answers. They did a commendable amount of research. Comprehensive publications by Molenaar, (3), Christiansen (4), McCulloch (5), and others were made available. Good irrigation texts such as by Israelsen (1), Houk (6), Roe (2), and others treat on the subject.

I conducted some work with a rotary head, portable system on the germinating of pasture mixture on soils which were very heavy and salty, and which had a tendency to puddle and crust. The soils were so impervious that it was practically impossible to get a spray fine enough to eliminate some runoff. It was found necessary to sprinkle every three days in order to curtail extreme crusting which would prevent emergence of the plants.

The labor of moving the pipe over the slick heavy soil was tremendous, but the plants were germinated well by the system and it would have been impossible to have accomplished the job by surface irrigation over the same area with the same amount of water. Adjacent furrow irrigation failed. The rate of intake was too slow.

The method of applying water above the ground allowing it to fall in spray or small drops like rain is practical under several conditions.

Soils which are quite difficult to irrigate because of extremely high infiltration rate can be irrigated practicably by sprinkling. Highly erodable soils and irregular topography can be irrigated by the method. Almost all plants are adapted to sprinkling. Grapes appear to be an exception in some localities.

The costs of the systems vary with the completeness as to permanent installation over the whole farm versus portable system to be transported and used at many different locations. The initial cost of the permanent system is relatively great. Portable systems can be purchased in the Rocky Mountain Region for the cost of a good average land leveling job.

Many varying claims have been made regarding the efficiency of the method. Christensen, (4), has done some good work on evaporation of water applied by sprinkling. McCulloch, (5), says to use 70 % as an efficiency base figure. Then he sets up increase or decrease figures to be applied as conditions vary.

Wind, temperature, and especially direct sun light, seem to be factors causing much difference in the irrigation efficiency of the method.

Portable systems or inadequately engineered permanent systems require as much labor or more than that required for ordinary furrow irrigation. Highly engineered and equipped systems compare well with the highly efficient surface irrigation methods.

In the low pressure class of system the pumping head necessary for operation only, (disregarding friction and other additions), is equivalent to raising the water a height of about 34 feet. For the more common high pressure systems the pressure equivalent is about 100 feet height. This shows that if all of the other normal pressure head losses in a system be added that the pumping cost alone might be a significant figure. Because of the costs involved and inadequacies of poorly designed systems many farmers have sold their sprinkler systems and returned to surface irrigation after the high returns for farm produce no longer prevailed.

Summary

In summary, progress in irrigation methods appears to be a product of time and hard earned experience. It follows the sweat of the farmer, the technician and the educator. It stays abreast of social and political progress. It cannot trail far behind economic progress. It is a part of all progress, and such an important part it is!

Its greatest improvements come from the locations of the greatest problems. When the problems become acute the solutions will follow. When the demands require, the supply must find a way. Some crude methods may suffice now. Tomorrow they must be replaced. How do we meet this challenge? By more intensive study and research by the technicians, by more determined teaching in our agricultural colleges, by better extention between our colleges, experiment stations, and the farmers; by more technical association, by more intensive training, by eagerness of the farmer to press for better methods can we meet the challenge.

APPENDIX

WATER AND LAND MEASUREMENTS

Approximate equivalents

1.	*1 foot*	=	*0.3048 meter*
2.	*1 mile*	=	*1609.3 meters*
3.	*1 acre*	=	*1 jereeb*
4.	,,	=	*1.6 Iraqi donum*
5.	,,	=	*0.96 feddan*
6.	,,	=	*0.40 hectare*
7.	,,	=	*1.6 meshara*
8.	,,	=	*4,000 square meters.*
9.	*1 cubic foot*	=	*0.0283 cubic meters*
10.	*1 acre foot*	=	*43560 cubic feet*
11.	*1 cfs*	=	*1 cubic foot per second*
12.	*1 cfs*	=	*0.0283 cubic meters per second*
13.	*1 cfs. flowing for 12 hours*	=	*1 acre foot = 1223 cubic meters.*

Selection of Method, Table I

Method	Advantages	Disadvantages & Limitations
Wild Flooding	Initial preparation costs low. Very little equipment is needed for preparation Cropping equipment can operate with little interference. Grazing by livestock damages the system very little. Can be used with either large or small water delivery head. Can be employed where soil is shallow not permitting leveling.	Loss of water by deep percolation is excessive. Loss of waste or runoff water is great. Plants are often over-irrigated or under-irrigated. Requires more labor for accomplishments. May cause excessive erosion. Contributes to loss of fertility. Contributes to increase of undesirable plants of little feed value.
Border	Amount of waste water is little. Very uniform irrigation may be attained. Labor requirements are relatively small. Maintenance is moderate. Rapid irrigation is possible. Cropping equipment is hindered little. Land values are increased by a good system.	Initial cost may be greater than for other methods. Requires fairly large supply of water. May require deep cutting for leveling. Suitable chiefly to close growing crops & orchards under certain conditions. Large earth moving equipment may be required for land preparation. Not suitable for use on soils which tend to disperse, compact or seal when flooded.
Check-Basin	Practically no runoff waste. Very little waste water. Rapid irrigation possible. Varying water supply may be used. High efficiency is possible.	Initial cost may be excessive if constructed large enough to use with machinery. Suitable chiefly to close growing crops. Not suitable to be used on soils which tend to disperse, compact or seal when flooded.
Contour-Check	Little original land preparation necessary. Fairly efficient. System interferes with cropping operations.	Must be replaced each year. Requires fairly regular topography. Requires flow of about 1.0 cfs. Or more. Can be used on slopes less than about 2 ½ %.
Furrow	Fairly high irrigation efficiency possible. Water not in contact with plants. Applicable to large variation of crops. Relatively simple to install. Inexpensive to maintain under normal conditions. Versatile in design. Can use any size head of water supply. Can be used on rather steep slopes.	Requires skill to operate efficiently. Can cause serious erosion if misused. Can be a nuissance to cropping machinery operations. Labor requirements are fairly high. If poorly designed can be very inefficient from irrigation standpoint. Requires frequent maintenance if the water contains much sediment.

Selection of Methods, Table I
(continued)

Method	Advantages	Disadvantages & Limitations
Deep Furrow	A desired amount of water can be placed in the furrows and left to seep away without contact on the plants. Allows a deep ditch for silt laden water. Permits a space above plants located on the sides of the ridge for salt to rise. Furnishes a gradient for water to flow in furrows when the natural slope is verr small.	Amount of labor required to make the ditches is extremely great. Croppin" operations are difficult. Limits greatly the type of machinery which can be operated. Weakens root system of trees. Has tendency to give very poor distribution of mo:sture. Encourages undesirable weed growth.
Sub-Irrigation	Labor costs are low. Crops receive uniform irrigation. Irrigation equipment requirements are small. Cropping machinery can operate at all times. No surface furrows or ridges are present to hinder cropping operations.	Unique natural conditions must exist. Skilled labor of high caliber is required. A reliable steady irrigation water supply is required. Large scale crop damage can result from dilatory manegement. Land deterioration has resulted in most areas where the method has operated. Buildings and structures over large sections must be protected from high ground water. Expensive land smoothing may be necessary. The farmer is limited in individual irrigation practices without affecting his neighbor.
Sprinkler	Fairly high efficiency of method. Usable on highly erodable soils. Usable on very porous soil. Efficient in emergency irrigation where water is scarce and one wishes to apply a very small head of water. Usable on undulating topography. Usable on steep slopes. Relatively easy to apply any desired amount of water per irrigation. Highly skilled labor not necessary. Prevents necessity of having furrows and ridges in the fields.	Original cost relatively great. Operational cost including pump, relatively great. Maintenance great if used where irrigation water carries sediment and detritus in suspension. Difficult and unpleasant to move pipe in mucky soils. Operates poorly with a variable water supply.

Method	Conditions Favoring the Method
Wild Flooding	Variable head of water. Pasture, meadow or other closegrowing crops. Low erodibility of soils. Good soil permeability. Irregular topography. Shallow soils. Very large flow of water. Little equipment available for preparation. Low land values. Low labor costs.
Border	Large supply of irrigation water. Most soil textures. Deep soils. High value forage. High value cereals. Fairly smooth topography. High land values. High labor costs. High value water. Available heavy earthmoving equipment.
Check — Basin	Variable sized water supply. Most soil textures. Deep soils. High value forage. High value cereals. Fairly smooth topography. Variable land values. Variable labor values. High water values. Variable equipment.
Contour — Check	Established orchards where no irrigation system was planned prior to its establishment. Smooth topography. Slope of field less than 2 percent. Trees which will not be damaged by flooding. Irrigation water supply of 1.0 cfs. or greater.
Furrow	Greatly variable irrigation supply. Irregular topographic conditions. Fairly steep slopes, up to 6 % or greater if precaution is used. Plants which may be damaged by contact with irrigation water. Only farm equipment available for installation. Skilled furrow irrigation labor available.
Deep Furrow	Much silt or sediment in irrigation water. Extremely flat land. Extreme salt conditions in soil. Where machinery is not available for cultivation. Where labor is plentiful.
Sub-Irrigation	Smooth topography. Natural slope 0.1 % to 0.5 %. Impervious stratum 6 feet to 10 feet deep. Soil above the imprevious layer which permits rapid ground water movement. Reliable steady irrigation water supply. Cooperative neighbors. Highly specialized farming. Drainage possibilities. Large earth-moving equipment available for land smoothing.
Sprinkler	Large areas of crops to germinate in a limited period. Land which is so rough and shallow that it is impracticable to prepare it for surface irrigation. Steep land which will produce high agricultural returns under irrigation. Pasture and other cover crops. Most crops. Soils of exceptionally high infiltration rate. Crops of high income value. Where skilled surface irrigators are not available.

References

(1) *Israelsen, Orson W., "Irrigation Principles and Practices"*

(2) *Roe, Harry Burgess, "Moisture Requirements in Agriculture"*

(3) *Molenaar, Aldert, "Design of Sprinkle Irrigation Systems"*

(4) *Christiansen, J.E., "Irrigation by Sprinkling" University of California.*

(5) *McCulloch, A.W., "Design Procedure for Portable Sprinkler Irrigation"*

(6) *Houk, Ivan E., "Irrigation Engineering"*

(7) *Wood, Ivan D., "Irrigation in Subhumid Regions" (and other papers)*

(8) *"Sprinkler Irrigation", U.S. Department of The Interior, Bureau of Reclamation.*

(9) *Thorne, D.W., and H.B. Peterson, "Irrigated Soils"*

(10) *Criddle, Wayne D., Research reports on Furrow Irrigation.*

(11) *Marr, James C., "The Border Method of Irrigation" University of California.*

(12) *Brown, J.B. & J.C. Marr, "The Contour-Check Method of Orchard Irrigation", University of California.*

(13) *Middleton, James E., "Water Management", University of Arizona.*

(14) *Veihmeyer, F.J., and A.J. Hendrickson. "Essentials of Irrigation and Cultivation of Orchards" University of California.*

(15) *Hazen, Arlon G., "Irrigation Trials in Western North Dakota", North Dakota Agricultural College.*

(16) *"Farmer's Irrigation Guide" U.S. Department of The Interior, Bureau of Reclamation.*

Relationship of Drainage to Irrigation and Drainage Investigations

James S. Reger

The story of man could be written very easily in terms of his need for water and the thousand and one problems which he encounters in his varied concerns with this resource. The problem of drainage in irrigated agriculture could very well occupy an entire chapter in a moving account of man's progress. In the early days of irrigated agriculture, man's first concern was that of obtaining a water supply. He was not greatly concerned with the soils underlying his land, the chemical characteristics of his irrigation water or with the seasonal and annual variations of water supply. His chief concern was to water his land and crops, for in the beginning — this was man's knowledge of irrigation. Later, when his lands became waterlogged and his crops could no longer tolerate the heavy accumulations of salt, he merely moved to a new location. Such a simple method of solving this problem could be utilized only so long as new lands were available. Eventually, however, man was forced to seek a solution to the problem rather than escape it through abandon-one of the most serious problems encountered in agriculture — that of Drainage.

Drainage in agriculture is the process of removal of excess water from the soil. Excess water discharged by flow over the soil surface is referred to as surface drainage, and flow through the soil is referred to as internal or sub-surface drainage. Although surface drainage is extremely important and must be considered, the chief concern of the engineer in draining irrigated lands is usually that of sub-surface drainage to affect a general lowering of shallow water tables.

The accurate prediction of the scope and extent of drainage problems before they actually occur in a new project area is a challenging phase of drainage engineering and one of extreme importance. Failure to anticipate the ultimate total drainage requirement may result in the development of an irrigation project which will be burdened with ever-increasing drainage problems and costs. It is, therefore, highly desirable that the drainage program for irrigated lands be initiated and continuously integrated with the planning and development of the irrigation project in order to attain an efficient over-all water and salinity control program. Unfortunately, the practice of initiating detailed drainage investigations during the early stages of project development has not been widespread. The presence of large areas of irrigated lands seriously effected by poor drainage is not peculiar to any one country. Such has been the histroy of irrigation wherever practiced throughout the world. Fortunately, much progress has been made in recent years. More attention is being given to detailed drainage studies in the development stages; the Land Classifiers and Drainage Engineers are coordinating their studies; new techniques for field and laboratory determinations are being developed; improved methods in construction have reduced seepage losses from canals, laterals and other irrigation works, and finally, improved irrigation practices are likewise aiding in the struggle to alleviate drainage problems.

The major sources of excess water that must be removed by artificial drainage are deep percolation losses on irrigated lands and seepage losses from reservoirs, canals and laterals. On most project areas, deep percolation losses on the lands probably constitute the chief contributing factor, and for this reason there is a tendency for many engineers to place all the blame on the farmer by accusing him of over-irrigating. While this is true in many cases, the fact remains that a high water table may develop even under the best of irrigation practices. The lateral movement of unconfined or free ground water and the upward flow of confined water from an artesian aquifer are oftentimes major sources of excess water. In either or both cases, the origin of this water may be seepage losses from canals, laterals, etc., or deep percolation losses from irrigated lands. Efficient water application on the higher lands will often reduce the need for drainage on the lower lands. In fact, good irrigation practices throughout a project area are essential if drainage problems are to be maintained at a minimum. No one can doubt the fact that irrigation and drainage go hand in hand.

Fortunately, most drainage problems can be overcome provided they receive the proper study. The design of drainage systems is influenced by many factors and there are no simple rules or formulas by which all factors can be taken into consideration. The principal factors may be grouped under 1) drainage requirements, 2) water transmission properties of soils, and 3) boundary conditions.

With these in mind, the basic types of information required for any drainage investigation may be summarized as follows :

a. Topography
b. Soils
c. Ground water hydrology

These are not mentioned in order of their importance, nor should they necessarily be investigated in the order given when the specific problem and its cause becomes evident, as for example, in the case of a rising water table resulting from canal seepage, then attention should be focused primarily upon the source-of-water factor. The more complex problems require an orderly procedure of investigation and analysis for their solution. In general, the following answers must be provided :

a. What is the source of the water?

b. Can the water table be maintained at a satisfactory depth below the root zone of the soil?

c. What will be the drainage requirement or how much water will have to be removed?

d. What type of drainage system will be the most effective?

It is evident that with the exception of topography a detailed drainage investigation becomes primarily a study of ground water hydrology as related to irrigation. This must be closely correlated with land classification and, if possible, the two studies should go hand-in-hand. The primary requisite in obtaining ground water hydrologic data is a properly designed grid of observation wells, properly located - installed - logged - read - and finally interpreted.

A common mistake often-times made by engineers in constructing a grid of observation wells, is to assume that any well, regardless of depth or type of construction, reflects water table conditions. In this regard it might be stated that the satic water level in a well may reflect artesian conditions, in which event the level will be above the water table, or, it may reflect a waterbody under sub-normal head in which event the level will be below the true water table. If, however, the well is completed in a free ground water body, the measured static water level will reflect true water table conditions regardless of depth. The importance of a careful evaluation of such data is illustrated by an incident which occurred on an irrigation project in the southwestern part of the United States. During 1945, a one mile east and west-north and south grid of observation wells was installed for drainage investigation purposes. Each well was drilled by a modern hydraulic-rotary rig to a depth of approximately one hundred feet; cased with transite pipe (a cement-asbestos product designed to withstand the toxic effects of saline ground waters); gravel packed and the lower ten feet of the casing perforated with one-eighth inch openings drilled through the casing. This was an expensive grid of wells to say the least. Static water levels in these wells ranged from about 30 to 100 feet below the surface. Normal seasonal and annual fluctuations were recorded. Apparently, this project was destined to escape drainage difficulties for many years to come. In 1950, "suspicion" led to a further check of ground water conditions throughout the project area. This was accomplished quickly and inexpensively by means of jetted piezometers installed at close proximity to the existing wells. The majority of the wells were found to be reflecting true water table conditions. Others were far from correct. In the final analysis, it was found that the water table underlying one part of the project area was 12 feet below the ground surface rather than 40 feet. In several other areas, the depth to water was closer to 20 feet below the surface rather than 40 feet as indicated by original wells. In still another area, the water table was 45 feet below the surface rather than 30 feet as indicated by the existing well.

The following essential data can be obtained from observation wells installed for investigation :

a. Stratigraphy (location of key lithologic horizons with respect to depth and spacing of drains).

b. Lithology.

c. Type of ground water body present.

d. Presence of vertical hydraulic gradients.

e. Depth to water table.

f. Stratigraphic cross sections (with water table profiles plotted thereon).

g. Water table contour maps.

h. Depth to water table maps.

l. Quality of ground water.

Water table contour maps will clearly show the direction of ground water movement and to some extent, the lithologic characteristics of the aquifer materials. It should be emphasized that a determination of the direction of ground water movement is an essential factor to consider in the design of open and closed drainage systems. Depth-to-water-table maps will provide data relative to the annual and seasonal fluctuation of the water table and to the necessity of drainage. Stratigraphic profiles, with water profiles, plotted thereon, will indicate the proper depth of drains and to some extent will aid in determining the spacing of drains. By means of a study of the rate of change of the water table and the application of irrigation water, a comparatively accurate determination can be made of the natural drainage.

Data obtained from such studies will provide useful information in regard to the amount of water which may eventually have to be removed by means of artificial drainage. This amount of water is termed the "drainage requirement" and this important factor is usually the governing one in determining the performance and capacity specifications for a drainage system. It may be defined as the quantity of water that a drainage system must convey, both surface and sub-surface, as related to the permissible depth and mode of variation of the water table with respect to the soil surface. The climate, quality of the irrigation water, soil characteristics, type of crops grown, and the cropping system must all be considered in determining the drainage requirement for any given locality. In areas from which reliable data are available, the drainage requirement has has been found to range between 15 and 50 percent of the diversion duty, and with very little reduction as related to the farm delivery of irrigation water.

The relation between salinity and drainage must be clearly understood. In irrigated regions, the very adequacy of drainage is closely related to salinity. Salts in the irrigation water, in the soil, or in shallow ground waters, increase the drainage requirement. In addition to aeration effects and soil moisture requirements for tillage, a minimum allowable water table depth that will permit adequate leaching and yet prevent concentrations of salts in the root zone by upward flow must be established. In other words, the depth to the water table must be such that the upward flow of saline ground water into the root zone is either reduced or eliminated. Thus, irrigation, leaching and soil management practices that are involved in the control of salinity are most important in establishing the drainage requirement for the area under investigation.

By a comprison of the initial water table contours with those made later after significant changes have occurred, it may be possible to determine which irrigated lands are contributing most heavily to the ground water. The same may be determined for canals, laterals and other structures which likewise often contribute to, or aggravate drainage problems.

After sufficient basic data have been obtained, a small experimental reclamation project should be installed on each major project area investigated. These projects will not only provide useful data relative to drain spacing, type of drains most effective, salt removal methods, etc., but will also serve as educational centers as well. This is a most important factor to consider in the East. In this regard, however, it must not be assumed that the information obtained from one small experimental plot will apply in detail to all lands throughout a project area.

Throughout the course of such investigations, both field and office determinations must be made. Field work will consist primarily of surveys necessary for properly locating wells and obtaining elevations of reference points required for ground water observations; the proper installation and logging of observation wells; reading of wells; obtaining samples of ground water for chemical analyses; obtaining samples of earth materials at strategic locations for certain laboratory determinations to supplement those made during the land classification survey; and certain other work required for the generalized investigations as well as obtaining certain data relative to experimental projects. The interpretation of these data and the final design of farm drainage works becomes an office procedure. It is, therefore, necessary that these data be properly obtained and correctly interpreted.

Generally speaking, there are three types of drainage methods most commonly employed These include drainage by open drains, closed drains and pumping from wells. Mole drains and French drains have been used to a limited extent in many areas, atlhough they have not proved to be entirely successful. The drainage of swamps or depression areas is often accomplished by means of inverted wells, provided geological conditions are such as to permit the downward flow of water into a non-saturated aquifer. The selection of the method must first await the results of the investigation. For example, a mere topographic survey may reveal a lack of natural outlets for drainage waters or that the terrain is unsuited for the construction of open drains except at costs which might appear economically unsound. Quite often, especially in desert areas, the basin type of topography lends itself well to pumping from wells for drainage. Topography alone, however, is often misleading and it may or may not reflect the geological conditions which actually control the rise and fall of the water table, whether influenced by local precipitation or by irigation. Disregarding other factors, flat slopes lend themselves well to tiling, whereas swales and benches often-times suggest the use of interceptor drains - either open or closed. The sequence of permeable strata and the ability of the separate layers to transmit water determine to a large extent both the type of system that sholud be installed and certain elements regarding its design. Lack of drainable strata below one and one-half meters from the surface may make drainage by tiling infeasible. Thus, the proper location, size, depth and spacing of the tile lines or open drains and the depth, size, location and capacity of drainage wells or other types of drainage installations - all depend on the results of a detailed investigation and a proper diagnosis of the problem.

There is no reason to believe that the reclamation problems in the East are any more insurmountable than in other irrigated parts of the globe. The first step is to provide artificial drainage - where necessary - and where possible. This will provide a ready permanent means for maintaining a satisfactory water table elevation and for leaching salts from the soil, thereby constituting the first essential step in land reclamation.

With drainage, the skills of the agronomist, the soils scientist and land classifier, the plant pathologist, the agricultural and irigation engineers, and the farmer can be utilized successfully in forging a sustained irrigated agriculture.

Economic And Farm Management Factors Of On-The-Farm Irrigation

Dr. Warren E. Adams

Economics is concerned with the allocation of scarce resources between alternative uses so as to maximize satisfaction derived from these resources. We usually group resources into three types: land or natural resources, labor or human resources, and capital or accumulated resources. Farm management is a specialized part of economics which has to do with the farm organization of these resources in the most efficient manner but one which is flexible to adjust to future changes in prices. Resources utilized in the farming enterprise we refer to as factors of production. The choices which the farmer must make with respect to which of the possible factors of production to use and how to combine them is the economic side of on-the-farm irigation.

Farm irrigation is an important producer and consumer of goods and services. Primarily, irrigation increases yields and prevents the loss of crops by drought. This, in turn, improves and stabilizes farm production and income, provides new opportunities for more people on farms and surrounding villages, bolsters the economy of surrounding dryfarming areas, and increases national production. However, despite these virtues, irrigation does not always bring unmitigated benefits to all concerned. The irrigated farm enterprise must be judged on economic principles, which may apply with even greater strength than for the dry-farming enterprise.

Essentially economics expects three things of any operation : a favorable relationship between cost of input factors to the price of the resulting output; good conservation of natural resources; and efficient utilization of human resources. In addition, both the economics and society demand that the social relationship be a healthy and stable one. Analysis of the cost-price or input-output relationship is done for each factor of production as well as for the total combinaltion of factors. The analysis is done in terms of money which allows comparison of dissimilar objects. Thus, the merits of growing vegetables can be compared with those of grains in terms of money costs and prices. Analysis of the other two considerations, natural and human rescurces is not so easily done. Economics assumes that through a free working of supply and demand these resources will be allocated the most efficient and best possible manner. Nonetheless, social values such as political stability are involved which cannot be measured by money. These values are important and we are rightly concerned with them. I will touch upon them, but the main subject which I will discuss involves the importance of considering the measurable cost items.

Obviously, the answers given today to the foregcing relationships will not hold true for years to come. Prices and costs change in an absolute sense and relative to each other. Input-output relations change as new techniques are developed. What is impossible today may well be highly feasible in a few years. Our present ideas of good conservation may change as new techniques and resources are developed. What is presently considered acceptable utilization of labor may be intolerable by some future standards. An economist cannot forecast the future, but he can help in the making of intelligent decisions based on current conditions and likely developments. These decision like those of the farmer must be held flexible and ready to change as conditions change.

Costs of producing farm products are made up of two classes of items; variable or operating costs and fixed or overhead costs. The variable costs include out-pocket or cash outlays for water, seed, repairs, hired labor, fuel, and maintenance items. Fixed costs include sums which are or should be set aside annually to cover depreciation of equipment, and structures; interest charges; and management charges. As the titles imply, variable costs increase as production increases while fixed costs are present with or without production. Fixed and variable costs combine to make total costs of operation. These total costs may be stated in terms of the farm, an individual crop, a unit of land, or a unit of production. Good farm managers understand these cost items for their farms and utilize them to make a profitable farming operation.

Before proceeding further, we should note two significantly different situations which might face an on-the-farm irrigation program. In some localities we are concerned with a program irrigating new lands, either not cultivated or dry-farmed previously. The program in other localities may involve only extension or improvement of current irrigation facilities. There are similarities, but there are also differences in these programs which we should note.

Newly irrigated lands can be handled in any one of many ways. In the planning stage everything is variable. The size and shape of farms as well as the distribution pattern are flexible. Often the farmer has never had experience with an irrigated agriculture. The change to irrigation farming is no less difficult than bringing new land into production. It involves not only learning to apply water, but also changing some of the crops and farming practices traditionally used by the farmer. Farmers soon find that they cannot handle as large an area under irrigation and that efficient operation of a small unit provides a greater net income than doing a half-way job on a large area. The change to irrigation increases yields and soil fertility, which may be quickly lowered unless legumes are grown and manure and other fertilizers applied. It is usually advisable for the farmer to introduce some new cash crops such as sugar beets to increase the income and absorb increased costs due to irrigation. Small grain growing, on the other hand, may well be decreased as production of other crops is increased. These adjustments are not always easy ones for the farmer.

Programs for extension and improvement of existing irrigation face a different set of conditions. The size and shape of the farm unit is already set, distribution systems are located and installed, and possibly soil erosion, salinity or other problems have set-in. However, in working with this program it is possible to benefit from the experience and records of the farmer concerned and to turn to local experiences as well. Nonetheless, the range of improvement which is possible is substantially limited by custom, conditions as they are, and the accumulation of past errors.

To an increasing extent agriculture in the Middle East is moving from the subsistence type to a market type. As this shift continues there will be added incentive for the farmer to evaluate the cost of his factors and to utilize them in the most efficient manner possible. This shift should be encouraged because it will improve the position of the farmer financially and aid in conservation of human and natural resources. Let us then look at some of the factor choices and adjustments which face the farmer on the farm when practicing irrigated agriculture. The choices are often technical ones, but they have economic considerations of affects. They include choice of the land which is suitable for irrigation, land preparation, choice of distribution system, drainage, cropping pattern, and supplements.

FACTORS OF PRODUCTION

The labor of the farm family is one of the major resource items on any farm. It is of great importance to the farmer himself, to the society he lives in, and to the nature of the farming practice. Despite its great importance, farm labor is often ignored in evaluating farm and irrigation practices. In part this is because of the subsistence nature of the agriculture. When so few of the crops reach the market place, it is difficult to place a definite value on the work of the family which is largely repaid through its share of the production. As more of agriculture is devoted to market sale, the task of measuring this cost and other factors of production will be simplified.

In addition to being a source of income or a business, farming is a way of life for most to the people engaged in it. The employment and livelihood features of farming are mixed with the living pattern of the family. It is this fact which accounts for cases where the "Costs of production" are obviously not met by the returns; the family is in effect absorbing the "deficit" in its standard of living. Frankly, this factor is not an easy one to handle in traditional economic terms, yet it is a significant factor in the agricultural economics of this area.

Tradition is a strong factor in farming practices in the Middle East. Much of farming is learned solely by word of mouth handed from one generation to another. Economically, we must continually bear this fact in mind when talking of labor costs and comparing them with alternative ways of farming, for example by machines. It is impossible to turn in the "old style" farmer on a new one readily adapted to new methods. The traditions and inefficiencies of the old must be dealt with by an investment of time and education. The greater efficiency of a row crop cultivation over a paddy cultivation in terms of labor usage seems apparent, but there must be a time lag and educational effort by someone to accomplish the shift. This is not to say that it can't or shouldn't be done. However, the total costs of making the change should be considered and the variation in the final results accounted for in bringing experiences from other countries to bear on local problems.

It is possible to visualize some particular size of farm which with the existing physical conditions will utilize the labor of the family to the extent desired. However, taking conditions as they are, the actual amount of labor required for each crop can be computed. This is one of the principle studies of farm management. Comparison of the methods employed by different farmers will undoubtedly reveal certain methods which are more efficient than others, ie, the same amount of labor can produce greater output or the same output can be produced by less labor, thus freeing labor for other crops. Each operation of farming under a variety of conditions must be studied before we are in a good position to advise the farmer on this important problem. At present, the farmer does allocate his time between existing operations but this allocation is usually a highly traditional one and is done without much awareness of alternative methods.

To combine labor considerations with other factors of productions, it is necessary to arrive at some cost for labor. Hired labor is merely valued at its actual cost. We can value the family farm labor at the cost which would be incurred if the labor were hired. By imputing this cost to family labor, we are assuming that family labor would bring this return if employed off the farm, or that the farmer saves that cost by reducing his need to hire labor. For this reason, it is justifiable to impute cost to family labor. It is essential to good farming practice for the farmer to be aware of this item of his cost so as to make his operation more efficient with respect to this important resource factor.

Water is basic to life in arid areas. For some countries the supply of water is critically low relative to the area or the size of population. Even countries like Iraq, with currently adequate water supplies, are faced with a rapidly growing population and growing demands on their water. Due to the combination of scarcity and usefulness, water is an economic good. As an economic good, water should have some readily established value. This value is usually determined by the price. However, tradition and strength often replace the function of price in the allocation of this valuable commodity in the Middle East. The absence of an established price for water discourages economic utilization and encourages waste and mis-use. This waste is bad not only for the economy of the country but for the farmers as well. Treated as a free good water is often used in excess. This reduces crop yields and wastes water. Excess water also contributes to salinity and other soil problems. Wasteful use limits the amount of land which can be irrigated with a given supply of water.

Farmers who obtain their water by pumping or other systems developed by themselves are more likely to realize the value of the water. Where government activity is responsible for delivery of water, some charge should be made to place a value on the water in the eyes of the consumer. Such a charge should not be too high relative to current returns and it should be adjustable for price level changes and periods of failure. The amounts of water needed for different areas can be arrived at roughly by applying some formula like the Blaney-Criddle formula for water duty of crops. Combining use of the formula with good water measurement, the farmer will be able to make more economical use of his water. Water charges will encourage him to do this. Distribution and application efficiency is even more important than consumptive use in many cases. For some areas, authorities have estimated that less than one-fourth of the diverted water supply actually becomes available for use by the plants. Skill in the handling of the water by the irrigator, proper land preparation, and adequate farm irrigation structures may greatly increase the efficiency with a corresponding decrease in the total amount of water that must be delivered to the land for crop production. Water and other costs will be lower.

Probably the factor having the greatest effect on irrigation efficiency, aside from the irrigator himself, is the soil on the farm and that through which the canals and ditches run. Therefore, the choice of lands which will receive irrigation is an important one. Not all land possessed by a farmer is necessarily justified in receiving water. Marginal lands may not be physically suitable for an irrigated agriculture. The benefits to be gained from such lands will not repay the expenditure which is necessary for irrigation. These conditions may result from a variety of difficulties: poor soils, poor drainage, poor location, and many others.

One of the first actions to be taken by an irrigator is to have his farm land classified. From this classification, a map of the farm showing the major physical characteristics can be made. This map is then available for subsequent planning of irrigation structures as well as a general plan of work and cropping for the farm. Location of the structures will be largely a function of the farm layout, but it will also fit in closely with the work and crop plans which reflect the cropping pattern appropriate to the labor and water which are available. The overall aim of a farm plan is to produce the most income, to distribute labor and water requirements as evenly as possible over the season, and to maintain the fertility of the soil. Without a plan it is possible that the farmer will accomplish tolerable results, but a plan of action should be encouraged for it makes it possible for the farmer or anyone helping him to see the situation easily.

Leveling operations are considered essential to most good irrigation practices. Leveling can be expected to improve tillage, spreading of water, uniformity of fertilization, plowing, and drainage. It will lead to more uniform stands and easier harvesting also. However, there are localities which can not avail themselves of substantial leveling. The top-soil may be so thin that extensive leveling will remove it and result in lowered productivity. In such localities, when the benefits to be gained are sufficiently large, it may pay to level and then restore good topsoil.

Leveling may involve substantial earthmoving operations or it may involve simple land smoothing operations. Local topography and the desires of the farmer will determine the type of operation. It is common to do the major earthmoving operation once, but to repeat the smoothing operation annually to prevent the land from returning to its original shape. Earthmoving of grading work, terracing, and ditch construction is the expensive portion of land preparation. Smoothing is cheaper and easier. In Texas, it was found that smoothing varied from 50 cent to $ 3.00 an acre. Major leveling for cotton growing cost over $ 14 an acre, which compares favorably with estimates of costs in Iraq. This investment brought an increase in gross returns which more than doubled the amount of cost within two years.

Farmers should make estimates of the cost of leveling operations in order to arrive at an intelligent decision whether it is desirable to level or not. The fixed costs of the machine and the interest charges on capital borrowed can be estimated easily. It is more difficult to know what period of depreciation should be applied to the machinery under local operating conditions. Presumably the life of any machine will be considerably shorter than in America. Whatever the charge may be it will be smaller per unit of production if the size of the operation is increased. Variable costs for fuel, repairs, and technical labor are directly related to size of operation; as size of operation increases variable costs increase also. Topography, distance from places of maintenance, and availability of technical assistance will strongly influence variable costs. Service and maintenance will be competing for the services of technicians who are already in short supply. This means that for some time to come costs of maintenance will be high. Machinery may will be idle for periods in excess of experience elsewhere.

Total costs of leveling equipment and operation are likely to be high. Returns on some farms will not be sufficiently high to cover these costs. In other cases, the costs of leveling will require capital beyond the abilities of many farmers. One method of reducing the costs to the farmer would be for the farmers in a given area to pool their operations. Under this system the costs of major leveling equipment would be spread over the operations of many farmers. Another alternative is the action of the government in providing the necessary equipment to the farmers on a custom basis. However, even when they are spread, the total costs of leveling relative to the returns will probably not be as favorable as it has been in Western experience.

There are two alternatives to leveling the land for irrigation. One of them, which is finding increasing use in America, is the use of sprinklers for water distribution. The other system presently used in much of the Middle East is the utilization of small paddies which can be prepared by simple hand tools and labor. Sprinklers can be installed on land which has not been leveled. Reportedly, their use economizes on the amount of water required and the costs compare favorably with other methods. The original sprinkler costs are influenced by a number of factors, some of which are fixed and others which are a matter of design. Compact square areas require less pipe than irregular or long, narrow areas. Permanent mains equipped with valves in risers will increase the first cost, but will save on water and labor costs. High rates of application will require larger pipe but may reduce the number of sprinkler lines needed. Light applications, such as might be given grains, permit more area to be covered by the same equipment. Pumping units will vary in cost according to their characteristics. Operation and maintenance costs vary according to the types of water, treatment of the equipment, and fuel costs.

The labor costs of a paddy system of irrigation would make it more uneconomical in the mechanized countries. However, where labor is relatively much cheaper than imported machines, where machine repair and maintenance costs are correspondingly high, and where depreciation is more rapid, use of heavy equipment in land leveling loses some of its appeal. Nonetheless, the negative effects of the paddy system are also considerable. It uses water wastefully, it makes control of the water for different crops difficult, and over longer peridos of time gives rise to or accentuates problems with soil compacting and salinity. Drainage to remedy these problems is more difficult when paddy irrigation is present. Also mechanization or improved utilization of farm labor through row cropping is made more difficult under the paddy system.

The distributional system for irrigation offers the farmer another opportunity to exercise choice. Variations in the source of water whether from storage, well or river will be a major cost determinant and will influence the type of distributional system. The layout of the farm will also influence the choice between flow or border, paddy, or sprinkler distribution of the water.

Whenever pumping is involved in irrigation there are a variety of economic decisions which face the farmer. Pumped water costs is a combination of operating outlays and overhead costs made up of: interest on the investment; depreciation; maintenance including repairs; taxes; insurance; and outlays for fuel, oil, greases, and supervision. Since a pumping plant is made up of four units, the rates of which may vary, the calculating should be figured for each of the a) well, b) motor or engine, c) pump and connections, and d) housing. In order to calculate the cost of the water it will be necessary to find the first cost of the total installation, its capacity, the total annual use, operating costs, and the overhead costs. The pump and motor requirements are fairly closely related to the particular conditions on the farm, but fuel costs will depend on the market conditons and the type of engine used. In Iraq most of the engines used are diesel, which is natural in view of the local supplies of cheap fuel. Based on American experience natural gas, butane and electricity are all cheaper. There are current plans to make rural electricity more readily available. Thus Iraqi farmers putting in new pumps would do well to examine the relative costs for their particular farm and to plan a fexible system which could be converted later. The possibility of natural gas or butane should also be considered. Experience in some parts of Texas with somewhat similar pumping show a reduction from $ 470 to $ 170 in monthly pumping costs due to a shift from butane to natural gas. Choice of power units is another important variable to be considered. Many farmers use power units which are in excess of the true needs of their system. On some farms tractor power is used in situations where a more permanent power source is justified and is more suitable. Pump efficiency also affects costs. Pumps with low yields supply high cost water. Irrigation by pumping involves a rather complex balancing of these and other technical and related cost considerations.

If water for irrigation is puchased by the acre-foot or some other measure, then the problem of determining supply costs is relatively simple. In planning new settlement areas, the choice of the proper distributional system involves economic considerations. Some of these have been discussed when considering sprinklers. Planners find that the size and shape of units effects the costs of distribution. Larger units reduce both construction and operating costs. Contour laterals are cheaper to construct usually, but the irregular shapes which result will lead to farm management losses in actual operations. However, a grid layout may appear to benefit management efficiency only to lead to "ponding" of water with loss in production and cumulative bad soil effects.

Economy of irrigation by any of the surface methods is a function of the correct balance of area or cross-section, soil types, length of run, and the water supply rate. Too long a run may cause too much infiltration at the start of the distribution system (either border or furrows) by the time the water reaches the bottom; too small a supply can do the same thing relatively for any of the systems. Poor economy of irrigation water by surface methods of application is largely the by-product of poor balance of these facts. Irrigation systems can never be 100% efficient and seeking too great efficiency may actually become uneconomical. However, the best possible balance should be sought.

Proper maintenance of ditches and structures is an item which is often sacrificied in an attempt to cut costs. The nature of the distributional system will undoubtedly affect the costs of maintaining that system. The availability of labor or other means of maintenance should be a consideration in the original design of the system. If we view the cost of construction of the distributional system as the fixed cost, the maintenance costs will be partially fixed costs and partially variable. Certain maintenances charges will be incurred without regard to the amount of use and other charges will reflect the amount of use directly. Both charges should be added to original cost estimates, and income should be sufficient to cover these maintenance costs.

Many newly irrigated areas have entered production without the cultivators understanding the need for drainage. Fortunately, some areas have good natural drainage. However, in other areas where darinage has been ignored, production has suffered. Sometimes the damage progresses rapidly and drives farmers off the land. Even when drainage is subsequently installed, the net cost is greater than it would have been earlier in such cases. Construction of drainage structures after settlement and cultivation has begun is difficult and expensive.

Drainage costs should be included in every estimate for farm irrigation. The nature of drainage costs will vary with the physical conditions and the amount and type of installations required. They range from fairly simple and cheap drains to lined and tiled drains, and even to drains requiring pumping to a major cutfall. In cost and financing drain pumping is similar to irrigation pumping. Construction of drainage structures in some areas of Iraq is roughly equal to the cost of the irrigation structures. Operation and maintenance costs can be presumed to be about the same also. To try to save these costs is a false economy which will not only lead to salination and erosion problems but will also involve even larger costs at a later date. If a given farm's income will not justify the double expense of irrigation and drainage, it is better not to irrigate.

Irrigated farming will intensify the need for soil supplements. In some cases, this will require better planning of crop rotations so as to replenish the humus in the soil. Rotation will have the additional advantage of producing significant amounts of alfalfa or other forage crops which will help to establish mixed crop-livestock farming. Livestock can help to produce on-the-farm fertilizer. However, the need for commercial fertilizers is very likely to be an added cost of farming when irrigation is introduced. Fertilizer costs are considered one of the essential variable costs which will vary with the scale of operation. The added annual expense of irrigated soils will presumably be more than repaid by the additional productivity. This feature of added cost, however, is important in increasing the need for annual financing. In situations where financing is difficult or expensive, farmers are likely to omit the necessary use of fertilizers. This ommission will ultimately affect the income of the farmer adversely.

CONCLUSIONS

What can economics contribute to on-the-farm irrigation? It can help the farmer to make the decisions about what lands to irrigate and the proper system of irrigation and drainage. It can help to focus the attention of the farmer on th importance of evaluating labor needs of the different crops and methods of cultivation. It will als help him to consider the water duty of each crop with relation to the amount of water available and the cost of the water. Economic considerations should also be employed in planning governmen policies which might be engaged to fulfill the need of irrigated farming and to encourage further improvements.

Farmers should be encouraged to plan a cropping pattern which will conserve natural resources and make the most efficient use of available labor land, and water. Research and study are required to ascertain local conditions. With the generalizations which can be made after study, it will be possible to advise and assist farmers with problem peculiar to the individual farm. Knowledge of the water and labor requirements of each crop will make farm planning possible. Not only will labor and water be used more efficiently, but other indirect costs of structures will be spread over a larger operation which means lower cost per unit.

Governments can influence irrigation practices through institutional encouragements. Charges for irrigation water would be a significant government policy which would help in resource conservation and better farm management. The charges need not be large, but almost any charge will encourage the farmer to economize his water use. Government tax policy can also be written so as to encourage good conservation practices. In Iraq favorable tax policy has encouraged development of river pump irrigation.

Agricultural credit with moderate charges and supervision is needed by all of agriculture. However, because of higher investment needs, irrigated farming will be even more dependent on credit facilities. If the institutions set up to administer farm credit require farm planning and conservation practices, the farmer would not only have his credit needs met but also would be induced to improve his practices. Supervision is an accepted adjunct to a farm credit program and it would fulfill a useful purpose in the case of irrigation.

Irrigation and drainage districts or associations are another institution which has been used to enable groups of farmers to finance and manage irrigation and drainage works. These associations may be either private or government-initiated. In either case, the government can do a great deal to encourage formation of such groups and to influence their activities. These associations can help farmers to plan and carry out necessary activities which they could not do individually. For example, individual farm drains must be coordinated. Water allocation and administration can also be handled by farmer groups.

Cooperative efforts are commonly used in these associations. Cooperation also finds an important role in operation of heavy machinery or in handling - marketing of specialized products. Machinery cooperatives could help with the vexing problem of financing expensive leveling or ditching machinery by spreading both the cost and the utilization over a larger number of farmers. The cost to the individual farmer is lowered thereby. For the economy as a whole machines will be used with greater efficiency.

Cooperative marketing associations will be especially useful in helping farmers to dispose of specialized crops efficiently and at a better price then they could individually. Many of the specialized and high income yielding crops are highly perishable. Thse crops require rapid marketing or good storage if they are to bring good prices. Farmer cooperatives having the income-yield in mind will enable the farmer to realize his best potential income. Cooperation gi[illegible] the farmer a way of improving and enlarging his market.

The alternative method to cooperative handling of the heavy investment in machinery, administrative controls of water, and marketing is to utilize the government. Examples of all degrees of government participation and encouragement in these problems can be cited. Undoubtedly, benefits accrue from these efforts. However, it may be more desirable to utilize the efforts of farmers wherever possible. Any real improvement in irrigated farming practices ultimately depends on the ability and willingness of the farmers to seek improvement. Therefore, every chance to encourage and increase self-reliance should be taken.

These remarks have been intended to indicate the range of economic and farm management problems related to on-the-farm irrigation. Each locality will have its own particular combination of problems and its own special solution. It is important, however, to realize that economics becomes of increasing concern if more and better irrigation is to be practiced. It is not sufficient merely to increase production and efficiency which irrigation can do. The manner of irrigation practices can and should lead to better living for the farmer and better utilization and conservation of the nation's land and water resources.

The outlook for an improved irrigated agriculture is a good one. We can expect increased production and higher incomes to flow from the improved practices. Agriculture will become more intensive in the utilization of land, labor and capital. New crops will be grown, although it is important that this expansion not exceed the growth of the expanding demand and the abilities of the marketing system to handle the supply. Less irrigation will be devoted crops like rice which are heavy water users in proportion to the returns which they can bring to the farmer. Farm mechanization may or may not develop to the extent that it has in irrigated parts of America; California which is largely irrigated farming is also one of the most heavily mechanized agricultural areas in America. The extent of mechanization will depend on the relation of labor and machines on the cost side and the relative incomes of crops suitable for mechanization on the price side. We should not forget that some Eastern countries have a highly intensive farming under irrigation without the accompanying machinery. Evenso, the pressures for capital accumulation as a basis for success in irrigagated farming will undoubtedly grow. This and other characteristics will cause social adjustment which may be fully as important as the changes which agricultural methods will undergo. These social adjustments can be the result of intelligent planning toward the desired type of irrigated farms or merely the result of adopting any and all "improvements" used in other countries. Government policies which support tendencies toward large-scale commercial operations as opposed to small-scale family operations will be highly important in determining how and in what way the benefits of irrigated farming are to be distributed.

Increased thinking about economic considerations and consequences is essential if the farmer and the nation are to improve irrigation practices. In Iraq, man long ago abandoned food gathering for a rainfed cultivation and finally for an irrigated cultivation. This "neolithic revolution" in agriculture constituted a major step forward for mankind. Today the Middle East is about to take the next step of developing a more specialized and productive agriculture through farm management. This step will be especially important in the case of irrigated farming. With proper encouragement and support, this improved irrigation will accompany and support the more general economic development and progress of the Middle East.

Farm Needs And Farmer Interest Surveys

Muzaffer Alap

The art of irrigation is developed from the combination of several sciences, and this modern art must be improved to increase agricultural production. Therefore, its is necessary to become interested in the farmers who are using water and guide them correctly. Irrigation farmers, in order to maintain the productivity of their land, must learn the characteristics of their soils and the irrigation rules in connection with the climate-plant-water relation, and be able to apply them economically.

As we all know very well, the farmer is conservative. It is difficult for him to change the methods which he has been using on his land and adopt new practices. It is always easier to adapt new methods in areas where there has been no irrigation. Under such conditions a thorough training is required. It is easier to work in regions where water is used every year, and cooperate with those who are favorable toward irrigation. On the other hand, it is hard to work with the farmers who are afraid of water because of the bad results obtained by poor agricultural practices, and on land where the soil is not suitable for irrigation and needs engineering assistance. For this reason, to irrigate an area properly we have to provide leaders who will guide the farmers before and after the irrigation application. That means, there is a need for study and research to improve the technique of irrigation in both phases.

In order to improve irrigation management, and prepare application guides we have to determine the subjects in which the farmer needs assistance. The farm requirements and the studies that interests the farmer are important because of indicated reasons.

The actual needs vary from area to area and from farm to farm, but they must be recognized. Farmers are generally interested in raising better crops and reducing labor costs. Often they do both by improving irrigation practices, and in order to reach this goal it is necessary to understand the science of irrigation and work accordingly.

Let us now consider the fundamental factors, both natural and human, which must be evaluated for successful irrigation farming.

I. IS THE SOIL SUITABLE FOR IRRIGATION?

The most important factor which effects every irrigation project, large or small, is the determination of the suitability of the soils for irrigation. In classifying land we study the characteristics which determine the suitability for continued cultivation under irrigation. Determination is made regarding special treatment needed for erosion control, drainage or leaching. We can discuss soils in three groups according to their suitability and useage.

1. Soils with favorable conditions: This includes soils other than those with vary heavy or very light texture, slopes steeper than 1%, saline or alkaline conditions, high water table, or erosion hazards.

2. Soils with unfavorable conditions but capable of being improved. This includes lands which can be improved economically by special treatment. After treatment the same practices are applied as for the soils in Group 1.

3. Soils not capable of being improved: This group generally includes extremely shallow soils, those where leveling or drainage is not feasible, and with high erosion hazards.

Two important characteristics of the land in regard to good irrigation practices are slope and soil texture. In a particular slope group we can use the 5 textural separations of clay, clay loam, sandy loam and sand; or very fine, fine, medium, moderately course, and course textures. Irrigation practices are related to such physical properties of the soil such as; permeability, depth, and total available moisture capacity of the topsoil and subsoil.

Let us now refe. to an exapmle. If we study the soil classifica. of the lands owned by 37 farmers on the Number 3, 6, and 10 Laterals of the A-VII Main canal of the Right Bank Seyhan River Project in the, Cukurova Region we will see that all of these lands are not suitable for irrigation and there are problems which must be solved. We can briefly state here that a farmer who does not know his soil cannot successfully apply irrigation farming.

II. WHAT DOES IRRIGATION MEAN TO THE FARMER ?

We must know what the farmers' attitude and thinking are in regard to such points as : irrigation prevents the hazard of drought, irrigation increases yields, irrigated crops should be fertilized, and crop rotations are necessary. In a survey we made among the 37 farmers located in the particular district of the irrigation project previously cited, we obtained the following answers :

a. 6 farmers say that their land is fertile enough, produces good yield, and needs no irrigation.

b. 6 farmers state that they irrigate only some years to prevent the drouth, or when there is insufficient rainfall in Spring for germination.

c. 3 farmers declare that they know irrigation increases yields.

d. 24 farmers attribute their dry farming to other irrigation troubles such as : not being able to water, fear from pests and frost, causing the land to become saline, inconviences and expenses of irrigation.

e. 1 farmer is benefited by irrigation, and he says that he irrigated every crop other than cotton. It was observed also that none of these 37 farmers were interested in the fertilizer and crop rotation.

III. HOW DOES THE FARMER OBTAIN HIS WATER, AND IS HIS SUPPLY SUFFICIENT ?

As we all know well, the farmer gets his irrigation water either from his own supply, or from sources owned by a group or a village, or from Government canals. Successful operation of any type of irrigation system is dependent upon the maintenance that is carried out to supply water system.

Three methods of water delivery to irrigated lands are commonly recognized:

a. Delivery of water to the land at the time of demand.

b. Rotation.

c. Continuous flow.

1. Demand method :

Water is delivered to the farms at times and in quantities requested by the water user. This method is ideal from the point of view of the water user, as it enables him to irrigated his crop at such times as in his judgment irrigation is needed, and to use the amount of water he finds to be most economical and efficient.

In the demand method of water delivery 40, 80, or 160 liters/second of water is delivered to each farm unit. These amounts are estimated for small, medium, and large operations. Since with three persons 40 donums of land can be irrigated and about 0.8 or 1 liter/second of water can be delivered to each furrow, for example, with 80 liters of water we can work in two sections.

Because of soil, crop and topographic differences more water is needed in some farm units than on others. The amount of water that will be delivered to each unit must be determined according to crop, soil, topography, and water holding capacity of the soil. Generally about 650 m3/decar minimum and 1100m3/decar maximum per season allowances are made. These allowances must be controlled every year to determine the proper amount.

In this method the water users make their request 48 hours in advance of the time they want water for irrigation and the canal operator regulates the gate and records the amount of water delivered. As the farmer goes on with his irrigation, he is notified periodically how much water he has left on his allowance.

2. Rotation method :

The "rotation" method of water delivery is probably the most flexible, as it can be varied greatly. Rotation may be made between two water users, two or more groups of water users under a single lateral or under two or more laterals, or between definite divisions of the project. Local conditions usually determine which of these kinds of rotation delivery is most applicable on a project.

Under the rotation method, water is delivered to each user in sufficient quantity for a fixed period of time. Time of actual delivery is called the time "on," and the time of non-delivery is called the time "off," the two together form the rotation period or cycle. A period of rotation usually covers from four days on and four days off to eight days on and eight days off, although this may be varied, to suit local conditions. For row crops in locations where the land is steep, large flows cause trouble under this method. On lands properly prepared large flows give more economic results for such crops as clover, grains and pasture. A water measuring device adjusts the time and rate according to the amount of water that the water user is entitled to.

3. Continuous Flow :

This method is wasteful of both water and time. Because the farmer can get water any time he wants, and if his irrigation practices are weak, this method tends to reduce yields from over irrigation. This method should only be used when extreme conditions render other delivery methods impractical.

Let us again discuss some examples of our water supply and delivery problems.

The Seyhan project is designed according to the needs of the main crop, cotton, and 2 x 3 = 6 rotation is used in the canal system. When vegetable growing, which requires more water and more frequent irrigation, was started the rotation was disrupted and the water supply became insufficient. Also, the water supply designed for a single plant variety became an encouragement for mono-culture.

In the example, the soil characteristics differ under Lateral 3, Lateral 5, and Lateral 10, and because the water holding capactiies of those soils are different the water requirements of the same culture plant is different. Especially in the salty areas the amount of water to be given is one-third greater than the same soils in normal condition.

Because the Seyhan Irrigation System (155,000 decares) is not completed yet, and organized only to irrigate 60,000 decares, the water that can be carried by the present canals are kept in the maximum capacity. For this reason and since very few are inclined to irrigate, the administration gives the demanded amount to any farmer upon request.

Water users are requested to notify the intended area of irrigation by a written notice before each cropping season in order to get water. During the irrigation season they notify the canal operator 24 hours in advance to turn water into their lateral. The water delivered to the farmer is measured only at the Headgate. Three farmers may use the water in the lateral as well as one farmer. The same amount of water is delivered to 30 dönüms as for 180 dönüms. When passing into modern irrigation, delivering water by measuring is as important as to teach the farmer the art of irrigation.

I would like to repeat that the soil, topography, water holding capacity of the soil, water using characteristics and minimum water requirement of crops, and gaging the irrigation time according to the soil moisture and plant condition must all be considered in determining the water supply. Therefore, it is required that the farmer learn and apply good techniques in the operation and management of irrigation farming.

The number 3 tertiary irrigation canal, which delivers water to the farmers fields, when first made 12 years ago had a 342 liters/second capacity. There are 1140 dönüms of land under that canal. The flow in June 1956 was 199 litres per second at the upper end of the canal. Four hours and 20 minutes were required for the water to reach the lower end, a distance of 2480 meters. A measurement at the lower end of the canal registered a flow of 106 liters/second. No water was delivered to farmers in this period. The loss of 93 liters/second is attributed to seepage, grass and weed growth, silt accumulation, leakage at field turnouts, and snake and rodent holes.

Water delivery methods to the farmers must be adjusted in Turkey. There are places where the irrigation right is given in the Spring for grain irrigation, and then delivered to the succeeding farmers in summer. In some areas the water supplies are owned by individuals and are only delivered to a limited amount of land, and in some places water delivery is made according to the phases of the moon.

An important factor for the solution of the irrigation problems, and increasing the crop varieties and yields is the presence of adequate quantity of water at the head of the field according to the soil and crop varieties. This water, in moderate amounts, must reach all parts of the field.

IV. DOES HIS LAND NEED LEVELING ?

To establish a better irrigation system on the farm, to apply the irrigation methods efficiently, to distribute the water uniformly to the surface, to reduce irrigation costs and labor, and prevent soil loss it is necessary to study the leveling requirements of the land. Leveling needs in a field are either natural or caused by faulty tillage. Before starting irrigation at any place one must know whether the field surface is suitable to irrigate. The type of leveling is determined by soil conditions, slope, irrigation method and economic factors. Generally, leveling recommendations are questionable in places where the soil is highly permeable and has a depth less than 25 cm., topography is rough, slopes steep, high water table present or where land is settling.

In the application of irrigation, the furrow method is preferred where the slope is steeper, and check method is preferable where the slope is flatter. In an irrigation region it is necessary to determine the leveling standards according to those factors. In terms of cut and fill for the leveling in Çukurova, 0-45m3/decare for light leveling, 45 - 90m3/decare for medium leveling, and 90 - 165m3/decare for heavy type of leveling is accepted. For cut depths; 0 - 7.5 cm for light, 7.5 - 15 cm for medium, 15 - 25 cm for heavy type of leveling are accepted basically.

The 37 farms of our example in Seyhan project, except for one farm suitable for heavy leveling, and one suitable for medium leveling, all others were involved in the light leveling class. Generally, this work should be done with land-leveler. Since good home-made leveling equipment was not available the irrigation has not been uniform.

To solve the leveling problem of the farmer it is necessary to improve the field operations (tillage and tillage techniques) and modernize the present primitive home-made leveler. The farmer is using and recognizes the benefit of the primitive home-made leveler (tapan). If cheap, home-made leveling equipment is made available to them, they will easily become adapted to it. Then roughness from tillage will be eliminated, natural high points removed and water distribution improved.

V. ARE THE FARM IRRIGATION DITCHES AND STRUCTURES SUFFICIENT ?

The arrangement of measurement, control and outlet structures in the field ditches that will provide uniform water distribution efficiently and without danger are included in this subject. The farm ditches are classified as :

The ditches in which water is delivered to the field are called "head ditches". The distribution and diversion structures are also included. These ditches can either be permanent or temporary, but in the first trials it is sometimes better to make them temporary.

"Field ditches" carry water from the main canal to the head ditches. The locations and types of these are generally permanent.

1. *Purposes :* To evaluate an irrigation system we will consider its purposes :
   a. A farm irrigation system must provide,
      1. Delivery of water that is required for an efficient irrigation.
      2. Delivery of water with a minimum loss.
      3. Delivery of water without causing erosion.
      4. A suitable condition for measurement and flow control.
      5. Permit the outflow of excess water and convert it into a useable form. (Drainage and outlet of the deep infiltration water is involved in in this them.)
      6. A system suitable for a practical and efficient conservation system must be developed.
2. What are the factors that may effect the the system layout ?
   a. Land :

1. *Soil :* Course textured soils require a relatively shorter length of run than fine textured soils. The rate of application is related to the erodability of the soil.

2. *Topography :* Steep slopes require a relatively shorter length of run than flat lands. Canal type, width, and construction must be designed to fit the topographic conditions.

b. *Crop rotation and irrigation methods :* The fields must be arranged so that the farmer can easily change from one crop, and method of irrigation to another. The length of run, amount of water flowing and the system of distribution must be suitable for various crops, irrigation methods, and rotations.

c. *The amount of water available :* Irrigation water available for any period of time, or for the whole irrigation season will effect the length of run, distance between the furrows, and irrigation method :

d. *Methods of water delivery :* This refers to the method used to deliver water such as : demand, rotation, etc.

e. *Permanent farm structures :* Buildings, roads, canals, reservoirs, etc. are included in permanent farm structures. Fences (wood, brush, wire) must be adapted to the layout without hindering the irrigation system.

3. *Design considerations :*

a. *Capacities :*

1. In places where the water delivery is not sufficient for water application, storage of water must be considered.

The volume of the reservoir is determined by the amount of water available for storage.

2. All canals and other facilities must be able to carry water without overflowing. At least 15 cm air-head must be provided.

b. *Seepage :*

There must be adequate colloids present to prevent seepage in canals which deliver water to more than one farm unit. If the canal passes through a soil of high permeability, pipe or other lining must be used.

c. *Erosion control :* All canals must operate on a slope that is not subject to erosion. If the control of the flow is needed, drops or chutes may be constructed.

d. *Water control :* Measuring devices at every inlet point to a field are desirable. Portable measuring equipment suitable to meet the irrigation and crop changes, expenses and maintenance of the canal system are recommended. In order to deliver water in a satisfactory manner, the canals must be kept clean. This may be done with a ditcher.

e. *Discharge of the excess water :* When preparing a design for leveling, delivery of the excess water from one field to another must be included. Erosion and silt accumulation in canals must be prevented.

f. *Maintenance :* All systems must be maintained by practical and efficient methods. Canal slopes where weeds have to be cut must not be steeper than 1 : 1 ½. There must be no obstacles along the canals which will prevent the operation of equipment.

In the study made in the fields of the mentioned 37 farmers no field irrigation system was observed. There were no outlet ditches, except for a tertiary which was not maintained properly. Therefore, after most irrigations, excess water remains in the field or in low spots.

VI. IS CROP ROTATION AND CROPPING PROPERLY DONE ?

Rotation is defined as the following of agricultural plants in a known order in an agricultural operation. In order to maintain soil condition and fertility, to control epidemic diseases and insects and make the weed control possible, rotation is necessary for both dry farming and irrigation conditions.

The crops can be classified into three groups according to their place and function in the rotation :

1. Legumes and forage crops
2. Small grains and other plants of this type
3. Row crops

Legumes and forage crops, as well as adding to the fertility of the soil, maintain the development and guarantee the future of the animal raising.

Small grains and flax remove a normal amount of nutrients from the soil. Generally, it is recommended that crops and small grains be followed with legumes, and legumes followed with row crops. Row crops such as cotton and corn should follow legumes in the rotation. Another factor that has to be considered in the arrangement of the rotation is to select the resistant species for saline soils.

Under dry farming conditions perhaps only a limited variety of crops can be grown, but under irrigation conditions possibilities for additional varieties increase. Where the climate is suitable as Çukurova, it is possible to raise 3 crops in 2 years. From that point of view, in places where there is a change from dry farming to irrigation, it is necessary to teach the agricultural techniques of the new adaptable crops to the farmer.

Though it is possible to plant the same crops to the same field for several years, some crops will not respond to continuous cropping. Plants can be grouped into 3 according to their degree of toleration of continuous cropping :

a. *Plants not tolerant to continuous cropping* : Clover, some legumes, sugar beets, cabbage varieties.
b. *Plants moderately tolerant to continuous cropping : Wheat, barley, beans.*
c. *Plants suitable for continuous cropping :* Cotton, rye, potatoes, tobacco, broad bean.

When a farmer observes that a plant will grow year after year, it is difficult to persuade him to adopt new crops. Since it is beneficial to select the most suitable crops for a rotation and which are adapted to the water supply, this problem must be solved.

In an area of the Seyhan Irrigation Project we observed that 26 farms out of 42 were planted with cotton continually since the system was established. Because of that mono-cultural system, the farmers are accustomed to a definite agricultural pattern. Usually some other person cultivates his land and consequently care given to the land has decreased. Also, disease and insect control and irrigation are given less and less attention.

Following are cropping and irrigation records of 42 farms in the Seyhan Project Area.

THE CROP VARIETIES AND IRRIGATION YEARS ON LATERALS NUMBER 3, 6, 10 IN SEYHAN SYSTEM

Lateral 3 :

Field No.	*1947*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*
3	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C (x)*
4	*C (x)*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*W*
5	*V (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*Mp (x)*	*Mp (x)*
6	*W*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*
7	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*
8	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*
9	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*
10	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C*
11	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C*
12	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C (x)*
13	*C (x)*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C*

Lateral 6 :

Field No.	*1947*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*
1	*B*	*O*	*C (x)*	*C (x)*	*C (x)*	*C (x)*	*W*	*C (x)*	*C (x)*	*W*
2	*C (x)*	*C*	*C (x)*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C (x)*
3	*F*	*C*	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C (x)*
4	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*W*
5	*C*	*O*	*C (x)*	*C*	*C*	*C*	*W*	*C*	*C (x)*	*W*
6	*C*	*C*	*C (x)*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*W*
7	*C*	*W*	*C*	*C*	*C*	*C*	*C*	*C*	*C (x)*	*C*
8	*W*	*C*	*C (x)*	*C*	*C (x)*	*C*	*C*	*C*	*C (x)*	*C (x)*
9	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C*	*C*	*C (x)*	*C*
10	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C*	*C (x)*	*W*
11	*C*	*C*	*C (x)*	*C*	*C*	*C*	*C*	*C*	*C (x)*	*C*

Lateral 10 :

Field No.	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
1	C (x)	C	C (x)	C	C (x)	C	C (x)	C (x)	C (x)	C (x)
2	C	C	C	C	C (x)	C	R (x)	C (x)	C (x)	C (x)
3	C (x)	C	C	C	C (x)	C	C	C	C	W
4	C	C	C	C	S	C	C	C	C	C
5	C (x)	C	C	C	C (x)	C	C	C	C	C
6	C (x)	C	C	C	C (x)	C	C	C	C	C
7	C (x)	C	C	C	C (x)	C	C	C	C	C
8	C (x)	C	C	C	C (x)	C	C	C	C	C
9	C (x)	C	C	C	C (x)	C	C	C	C	W
10	C (x)	C	C	C	C	C	C	C	C	C
11	C (x)	C	C	C	C	C	C	C	C	C
12	C (x)	C	C	C	C	C	C	C	C	C
13	C (x)	C	C	C	C	C	C	C	C	C
14	C (x)	C	C	C	C	C	C	C	C	C
15	C (x)	C	C	C	C	C	C	C	C	C
16	C (x)	C	C	C	C	C	C	C	C	C
17	C (x)	C	C	C	C	C	C	C	C	C
18	C (x)	C	C	C						

EXPLANATION : C = cotton; W = wheat; V = vegetable; Mp = market plants B = barley; F = flax; R = rice; S = sesame (x) years when fields were irrigated.

VII. IS THE IRRIGATION METHOD PROPER ?

The physical arrangement for applying water to the land in a practical and efficient way is called the irrigation method. Irrigation methods vary from field to field as well as for the crop variety.

An irrigation method to be recommended :

a. Must fit to the management program of the farm.
b. Must provide a uniform application, especially to the root zone of the plants.
c. Must prevent erosion.
d. Must confine loss either from surface runoff or by deep percolation to a minimum.
e. Must lower the cost of labor, system, construction, and maintenance.

Factors that effect the selection of the method :

a. Crop, climate, economic and social conditions.
b. Soil :
   Depth, texture, drainability.
c. Soil condition :
   Salinity, alkalinity, rocks, etc.
d. Slope, topography
e. Economical leveling type.
f. Water :
   Water available during the season, quality of the water and type of delivery.

Generally, the methods of irrigation can be divided into types as flooding, furrow, sub-irrigation and sprinkler methods. These again, can be divided into more specific types.

For example :

Flooding method :
A. Free flooding — a. Wild flooding
  b. Controlled flooding
B. Border method
C. Check method — a. Rectangular
  b. Contour
D. Basin method

The furrow method can be divided into deep furrow and corrugation methods. And these, again are divided into contour and zigzag furrows.

All of these methods are specified for each field according to their :

1. Suitability to the soil texture
2. Degree of effect to soil condition
3. Suitability to the crop
4. Amount of irrigation water in units
5. Efficiency
6. Difference from other methods in evaporation, infiltration, and amount of water that will go to the outlet.

The limiting factors of these methods are,

a. Slope of the field
b. Slope of the main canal
c. Delivery points to the field
d. Length of run
e. Amount of water flowing

Necessary control conditions are :

1. Control of the flowing water
2. Control of the excess water

And finally, the initial and maintenance costs. labor, and time are determined.

Unfortunately in all irrigated areas of Turkey, and especially in Çukurova, where cultivated and row crops are planted the wild flooding metho is used. Some vegetables plots and orchards are irrigated by proper methods, but even here the controls are poor. From the 37 farmers of our example, only one irrigates his land by the furrow method and his control operations are inadequate

The present condition of the irrigation practices must be observed by a team of specialists and a wide training program carried out.

VIII. WHAT IS THE IRRIGATION EQUIPMENT OF THE FARMER, AND IS THERE NEED FOR ANY SPECIAL EQUIPMENT ?

The farmer uses irrigation equipment in accordance with his knowledge of irrigation and his income. There is a development period when passing from the home-made wooden plow (Karasaban) to metal plow, and from seed broadcasting to the drill, The first irrigation equipment he used were a shovel, spade and hoe. He uses brush and turf dikes to divert water from a stream; home-made wooden plow, metal plows and (Çekçek) to construct supply ditches; and home-made leveling equipment (Sürgü or Tapan) to level his fields. In order to pass into modern irrigation all farmers should utilize suitable irrigation equipment and devices. These can be summarized as follows :

Leveling equipment :

Land-leveler, land-plane, scraper, horse shovels, (sürgü), and other home-made leveling equipment

Equipment for border lines and checks :

Ditcher, home-made ridger

Ditch and canal equipment :

Various types of ditcher, various types of drainage equipment, sub-soiler, chisel and mole drain equipment, home-made ditcher.

Furrow makers :

Lister, corrugators.

Cultivation and tillage equipment :

Hydraulic plows, soil surgeon, graham type plows, cultipacker, Drills equipped with fertilizer distributer, equipment for row crop tillage.

Irrigation and control equipment :

Spiles, syphons, flashboards, head gates, diversions, chutes, dikes, moisture probes and augers, and measuring flumes.

Out of this equipment and devices which we mention here, it is necessary to select the ones that can be bought or manufactured by farmers, then instruction in their use is necessary. Only one farmer out of the 37 farmers of our example has a ditcher and lister. The others have only home-made wooden leveler (tapan) and shovel as irrigation equipment

IX. IS THERE NEED FOR FINANCIAL HELP ?

For the advancement and improvement of the farmer credit must be given. These funds must be made on the basis of farm layout, design and statement of accounts. Credits given to bring the soil to a suitable condition for irrigation, construct irrigation systems, and purchase equipment must be in long-term accounts and be paid from a part of each year's income.

X. HOW DOES THE FARMER APPLY WATER ?

To successfully apply irrigation farming with reduced labor costs, and conserve the soil and the crop there are some points that a farmer must know. It is certain that the soil moisture must be kept in proper capacity during the growing period so that the plants benefit from irrigation.

a. How does he prepare the field for irrigation and what kind of seeding method does he use for making the irrigation easier ?

b. When does he irrigate ? Is he able to determine the irrigation time by the moisture and plant condition, or does he do it by other traditions or indications ?

c. How much water does he apply ?

d. Does he control the water ?

e. Is his water supply sufficient ?

In our talks with the farmers of our example we observed that none of them were acquainted with these questions. It is absolutely necessary to teach these one by one to the farmers.

XI. IN THE STUDY OF THE IRRIGATION WORKS IT IS NECESSARY TO INVESTIGATE NOT ONLY THE SUBJECTS RELATED TO IRRIGATION BUT ALSO THE OTHER PROBLEMS THAT ARE INDIRECTLY RELATED.

This subject may be discussed in 3 parts:

a. Selection of the problems from the information collected from the farmer and field, and carry out experimental and trial work where necessary.

b. Assignment of the applicable problems to the technical training groups and work toward elimination of the faulty practices by demonstrations.

c. Cooperation with other related groups to eliminate the factors and problems that effect the irrigation indirectly, such as :

1. Disease and insect control.

2. In order to pass into the construction of the farm drainage and improvement of salty land, the main drainage system must first be completed. Irrigation canal seepage must be prevented by lining the canals and by grass control.

3. Correction of some legal aspects by giving canal construction rights to those whose farms are far to the water source. Charging for the area that can be irrigated, and not for the entire farm unit.

4. Avoiding some false farm operations, and preventing the usage of the barnyard manure as fuel by urging them to plant trees for fuel. Establish a law for crop rotation if necessary.

5. Training qualified irrigation workers to use and manufacture irrigation equipment and devices, and encourage these professions.

6. Training as many irrigation engineers as possible. In the improvement and management of irrigated soils, establish cooperatives and contractors to do the work that can not be done by individual farmers.

We have attached an example on the irrigation culture to our report. This is a table of cultural conditions in the work region of Tarsus Irrigation Research Institute.

Appendix

TABLE 1 — CULTURE CONDITION IN THE WORK REGION OF TARSUS IRRIGATION RESEARCH INSTITUTE

Provinces of the Region	*Location*	*Water Supply*	*Desire for Irriga-tion (x)*	*Fear from irrigation (x2)*	*Irrigation system & equip-ment (x3)*	*Prepara-tion for Irrigation (x4)*	*Applica-tion of Water (x5)*
Içel	*Anamur Crops : peanut, Banana, Vegetable*	*plenty*	+	—	*poor*	*medium*	*medium*

Improvements to be made :

Water controlling structures, water conservation and the organization of the Anamur irrigation system constructed by the Goverenment for drainage and arid land improvement. Application of fertilizer in peanut and banana growing and the arrangement of rotation. Improvement of the small water works. Obtaining planting and harvesting machinery, and peanut drying installations to improve the peanut growing. Application of soil and water conservation.

Içel	*Silifke peanut, banana, vegetable, animal breeding, sesame, and other field crops.*	*plenty*	+	—	*poor*	*medium*	*poor*

Improvements to be made : Same as it is in Anamur.

Provinces of the Region	*Location*	*Water Supply*	*Desire for Irriga-tion (x)*	*Fear from Irrigation (x2)*	*Irrigation system & equip-ment (x3)*	*Prepara-tion for irrigation (x4)*	*Applica-tion of Water (x5)*
Içel	*Mut orchards, grains, vegetable*	*plenty*	+	—	*poor*	*poor*	*poor*

Improvements to be made :Application of soil and water conservation, improvement of pasture land.

Içel	*Gülnar vineyards, animal feed, orchards,*	*insufficient*	+	—	*poor*	*poor*	*poor*

Improvements to be made :

Application of soil and water conservation, reservoirs for snow and rain water, improvement of the pasture land.

İçel	Mersin	plenty		+	— (present for cotton)	good	citrus medium, vegetable : good, cotton : poor, orchards : medium	medium

Improvements to be made :

Erosion control and improvement of all the small water sources from Alata streamlet to Deliçay. Improvement of the Berdan irrigation system to cover a much wider area. Drainage construction. Supporting the rice and cotton planters with the equipment and devices of irrigated agriculture, and teaching the irrigation technique. Construction of the irrigation systems for the dunes along the seashore for development of vegetable gardens. Preparation of a work program for the upland areas for soil and water conservation. Speed up of the cotton fertilizing, rotation, and farm layouts.

İçel	Erdemli early vegetable, banana, citrus.	medium		+	—	medium	medium	good

Improvements to be made :

Water supply, application of soil and water conservation.

İçel	Tarsus cotton, peanut, rice, vegetable citrus, fruit, sesame, market plants.	plenty	vegetable, citrus, market pl., rice, peanut	+	vegetable, citrus	good	good	good
			cotton, sesame	—	cotton, rice, sesame, peanut	poor	medium	medium

Improvements to be made :

Prevention of seepage in the main canals of the Seyhan and Berdan irrigation system by lining the canals. Weed control of the mentioned systems, discharge canals, revision of the lateral head ditches, and construction of the head gates. Study of the saline areas caused either by irrigation or natural rainfall, and design and construction of the secondary drainage canals, training the farmers on the construction of the surface drainage canals to discharge the winter rainfall, improvement of the salty areas, and methods of irrigation construction, management and equipment. Extension of peanut growing in the region, adaptation of animal breeding, vegetable and fruit growing. Handling the diseases and insects of the main economic crop, cotton, and teaching them to the farmer. Making tillage and irrigation equipment available to the farmer.

Seyhan	Adana cotton, vegetable, citrus, sesame, peanut, rice.	plenty	citrus, vegetable, rice	+	+	medium	good	medium
			cotton, sesame	—	—	poor	poor	poor

Improvements to be made :

After the completion of soil and drainage study of Yüreğir plain, establish the Seyhan irrigation system, and teach the farmers the techniques of the irrigated agriculture before they start to irrigate. Handle the disease and insect control before irrigation is introduced.

Seyhan	Ceyhan cotton, rice, sesame, peanut.	plenty	cotton, sesame	—	—	poor	poor	poor
			rice, peanut	+	+	medium	medium	medium

Improvements tcr be made :

Training the farmers the tecniques of irrigated agriculture before the irrigation is introduced. Handling of the disease and insect control. Develop means of benefiting from Ceyhan river.

Seyhan	*Kozan* *citrus* *vegetable*	*medium*	*cotton* *sesame*	—	—	*poor*	*poor*	*poor*
	cotton *sesame* *orchards*		*citrus* *vegetable*	+	+	*poor*	*poor*	*poor*

Improvements to be made :

Initiate a study of ground water and means of benefiting from streams, application of the soil and water conservation, teaching irrigation culture to the farmers.

Seyhan	*Kadirli* *peanut,*	*plenty*	*rice* *peanut*	+	+	*medium*	*medium*	*medium*
	cotton, *rice,* *sesame.*		*cotton* *sesame*	—	—	*poor*	*poor*	*poor*

Improvements to be made :

Initiate a study of ground water, improvement of small irrigation works, teaching irrigation culture to the farmers.

Seyhan	*Osmaniye* *peanut*	*plenty*	*rice* *peanut*	+	+	*medium*	*good*	*medium*
	peanut, *rice,* *citrus,*		*cotton* *sesame*	—	+	*poor*	*poor*	*poor*
	cotton, *sesame,* *orchards,*		*citrus* *orchard*	+	—	*medium*	*medium*	*medium*

Improvements to be made :

Application of soil and water conservation, improvement of the small water sources, teaching irrigation culture to the farmer, control of the peanut, citrus, cotton disease and insect.

Hatay	*Kirikhan* *Hassa,* *Reyhanli,* *S.Dağ* *cotton,* *rice,* *tobacco, vegetable,* *millet, orchard,* *citrus, olive.*		*Plenty*	+	—	*medium*	*medium*	*medium*

Improvements to be made :

Reorganization of the irrigation systems. Teaching field drainage and irrigation technique to the farmers. Handling the rotation, fertilizer, and pest control and problems.

Hatay	*Dörtyol,* *Iskenderun.*	*medium*	*citrus* *vegetable* *orchard*	+	+	*medium*	*medium*	*poor*
	citrus, *vegetable,* *orchard,* *cotton,* *sesame,* *tobacco.*		*cotton* *sesame*	—	—	*poor*	*poor*	*poor*

Improvements to be made :

Improvement of the small water sources. Teaching the technique of irrigation, fertilizer, rotation, spraying and dusting to the farmer.

Maras	*Maras, Göksun, Pazarcik, Elbistan. rice, grains, legumes, pepper, cotton, orchard, viticulture, vegetable.*	*medium*	+	+	*medium*	*medium*	*medium*
Improvements to be made : Reorganization and improvement of the cultivation and irrigation of all crops. Selection of the most suitable rice variety for the region. Application of soil and water conservation, improved irrigation culture.*							
G.Antep	*Central town and others. rice, cotton, orchard, vinculture, grains, pistacio, vegetable, olive.*	*medium*	+	+	*medium*	*good*	*good*
Improvements to be made : Development of water sources. Application of soil and water conservation. Teaching rotation systems to farmers.*							

EXPLANATIONS :

(x1) — (if +) Eager to irrigate. Recognizes effects of irrigation.

(x2) — Has a fear for irrigation, because of salinity, disease, insects, expenses and making his field disagreeable, and poor.

(x3) — Water supply systems, Water control devices, irrigation devices and equipment; discharge and drainage systems for the field.

(x4) — Leveling, temporary field irrigation ditches, seeding and maintenance techniques according to the best irrigation method.

(x5) — Determination of the time of irrigati on, water supply and irrigation method.

Extension Or Service Organization To work with The Farmers In Irrigation

Aziz Mamarbashi

I. Introduction :

It is very well understood among agriculture authorities and agriculture scientists, that an extension service is the best way and means to get first hand knowledge and techniques to the far. mers. This is specially true in the Middle - East Countries, where agriculture and irrigation practices are still in the first stage of improvement. Irrigation agriculture science and research mean nothing unless it is taught to the farmer in a way that he can understand and practice successfully.

A vast area of Iran including other areas in the Middle East are now out of production. Poor irrigation practices, and land preparation, the lack of adequate and well designed canal and drainage systems along with other problems have contributed to these difficulties, so that large areas have been left uncultivated.

Investigation and studies are made throughout the world in the field of irrigation and drainage.

The result of these studies can be used with a certain degree of success, considering the soil and water problems of each individual country.

Modern practices in the field of irrigation and drainage should be taught to the farmers through the extension services.

Different extension methods and principles may be used.

II. Irrigation Extension and Farm Services :

In order to carry out a program for improvement of irrigation practices in a large scale on the farm, agents and irrigation extension specialists must use various audio-visual teaching methods including films, demonstration and field trips, together with speeches, small pamphlets, short courses, and finally on the farm services.

A. Demonstration

Setting up demonstration farms in localities where the farmers can be brought in easily to help to get to the goal.

Advantages and disadvantages of different methods of irrigation, land preparation, land levelling, canal lining, irrigation structures, etc., can be shown quite succesfully, and farmers get a chance to observe and understand for themselves.

B. Meetings

In rural areas agents and specialists can hold meetings, and short courses for the farmers in periods during which the farmers may have time.

Problems can be discussed and solutions can be developed. Farmers would have a chance to express their own ideas and experience so that they actually teach others as well in such sessions.

C. Pictures :

Using pictures, both movies and slides are one of the best methods in teaching and analyzing problems for farmers.

Pictures teach while they please the audience.

By this means agents and specialists can do much in training the farmers. They can show the problems, solutions, new ways and new methods very easily to them in localities where demonstration farms have not been developed.

D. Small pamphlets and brochures

Writing pamphlets and booklets in the farmers language would help a great deal in improving irrigation agriculture and crop-production (where there is high percentage of literacy.)

Problems should be discussed in a very simple language and avoiding technical terms as much as possible, so that the farmers can understand and enjoy it.

In the United States of America this method of education has worked out quite successfully in improvement of irrigation, and also has encouraged the farmers toward application of new and well designed methods of irrigation, land preparation, improvement of saline-alkali soil, etc.

E. Farm Services

There are often problems on the farm that even though the farmers are aware of them they are unable to solve as they are properly problems for an agricultural engineer.

These may involve the physical measurement of soil, water, and plant growth and the design of proper irrigation system and water disposal system based upon engineering principles. In design of irrigation and drainage systems varying degrees of engineering skill are required, from those required in the simple process of handling the water and planting crops on the contour. These often call for designing involved drainage system, constructing water conservation systems and erosion preventing structures, some of the more simple jobs can be carried out by the individual farmer who are well trained in this field but for the country wide project an organization with qualified engineers are needed to carry out this program.

The Soil Conservation Service in the U.S. is a very good example of an organization which gives service to the farmers. An organization should be set up to render similar services to the farmers in the Middle East countries, and could include the following :

1. Designing an Irrigation System

2. Land levelling
3. Designing drainage system for the farmer
4. Land classification evaluation and recommending the best usage of the soil on the farm.
5. Water analyses
6. Improvement of saline and alkali soils by leaching
7. Water distribution system, and any other techniques and service which should be brought in by the engineers.

III. Irrigation Extension Services in Iran.

Iran is essentially an agricultural country with about 80 % of the population engaged in agricultural production. Notwithstanding the numbers of people engaged in tilling the soil the standard of living of the Iranian farmer is very low. There is not enough production from the land to ensure him and his family food for an adequate diet. Since most of the country is arid, crop production is dependent on irrigation to supply the needed water for plant growth. In most areas the cultural practices used by the Iranian farmers are considered archaic. Land preparation generally leaves the ground cloddy and rough, making it difficult to irrigate.

The irrigation practice is usually confined to one method, the kart system. This method is used irrespective of topography, soil conditions, head of available water, or the crop being grown. Much of the available water supply is being wasted through improper use and bad practices. Studies carried out in the southern part of the country show that the water application efficiencies are very low, ranging from 15 to 60%. Vast areas of former agriculture lands in the Khuzestan are left uncultivated due to waterlogging and related salt problems. Water distribution systems for the farms are very poor and crop production is descreasing year after year.

In the year of 1951 when the United States Operation Mission came to Iran, it was felt that the establishment of an extension service was quite necessary for the country. Although the Ministry of Agriculture of Iran had such a service branch in its organizational patterns, it was inoparative because they had no personnel and no funds to carry that project out. So actually the effective extension program originated in the year 1951.

A special mission consisting of 6 American extension specialists came to Iran and started a training program to train agents and specialists, for provinces of Iran. Since then, a series of classes and short courses have been held for that purpose and quite a number of Iranian technicians have been sent to the States to study and observe the extension program.

Due to the lack of trained personnel in the field of irrigation and drainage this phase of activity was left untouched. So in the year of 1954 the first irrigation and farm machinery training course was established and 29 young engineers were trained.

At the present we have one irrigation and drainage specialist in each province of Iran, so actually the irrgiation extension and services came to the picture in the year of 1954-55. The main work and duties of these specialists in each Ostan is to help the farmers to improve irrigation efficiencies in the following ways :

1. Improve cultural practices and irrigation methods.
2. Efficient control and conveyance of water.
3. Improved land preparation, cultivation and tillage.
4. Revised irrigation schedules.
5. Measurement of water and soil mositure determinations.
6. Balance cropping system.
7. Effective use of flood water.
8. Uniform distribution of water over the land.
9. Combination of small streams with large ones (Reduction of main canal leading to the farms.)
10. Reduction of Erosion.
11. Drainage.

The work of these specialists is coordinated by the extension organization at headquarters, in Tehran, so each would have special programs considering the problems existing in the regions.

Progress in this has been quite encouraging. They have been able to train agents as well as farmers in the region through demonstration farms, speeches, movies and publication of booklets.

IV. Technical Service to the Farms in Iran.

This is a service organization established in the year 1955 in the Ministry of Agriculture. This organization gives service to the farmers in the following ways :

1. Surveying.
2. Land levelling.
3. Design of water distribution system.
4. Farmlayout.
5. Drainage work.
6. Improvement of saline and alkali soil.
7. Design of canal, lateral, etc.

These services are given to the farmers on recommondation of agents and irrigation specialists in the region and are free of charge. Heavy duty farm machinery are available which can be rented to the farmers for the above mentioned purposes. We have four groups of service engineers at present time, one in Tehran, one each at Shiraz, in the southern region, Kermanshah in the West and Ahwas in the southwestern part of the country.

We hope to expand this activitity throughout the country.

Training Needs And Courses

Manoutchehr Ayazi

History of Irrigation in Iran :

Iran like the rest of the Middle East is an old country : its people have been acquainted with irrigation for a long time. The ruins of old irrigation structures existing in the different parts of Iran indicate the importance of irrigation in the past. Traces can be seen of the following reservoirs and diversion dams :

Shadorwan Dam on the Shotate River (Khuzistan).

Shah Abbas Dam on Gharasou River (Saveh).

Estakhr Dam near Persepolis (Fars).

Band Amir Dam near Persepolis (Fars).

Khorasan Dams.

These dams show that a large area was under irrigation in ancient Iran, and that water was an important factor in agriculture. In ancient Iran, the people not only used surface water, but also benefitted from underground water by establishing kanat systems.

A kanat is an underground channel dug by man to lead water from a mother well deep underground out to the surface a considerable distance away, the distance depending on the slope of the land. There are today about 20,000 kanats in use in Iran. Besides these many thousands have been abandoned. Kanats can be dug and maintained by local labor. They have the disadvantages of being slow and expensive to construct, unless cheap labor is available and of failing to reach the deeper underground water reservoirs; there is also no way in which the water can be conserved for periods when it is needed; it must flow constantly so long as there is any.

Climate and Regions of Iran :

The area of Iran is about 1,658,000 square, kilometers and has three different climates, as follows :

1. Provinces in the Caspian shore are subtropic, and the precipitation is around one meter per year. In this region are the most important forests of Iran and the land is rich and productive. Subtropic crops are raised.

2. In the plateau region, which includes the Northeast, Northwest, West, and part of the southern Provinces, the climate is cold in the winter and hot in the summer. Precipitation ranges between 25 cm. and 50 cm. varying in different parts of the area, but most of it falling in the the winter. Important dry-climate forests are in this region; the trees are far apart, and the land is sparsly convered by brush and shrubs. The larger part of the area, however, is desert-like and much of it is mountainous. Dry farming is practiced in the valleys and on the hills, and on these parts of the mountains where the soil is suitable. Whereever water is available, a variety of crops are produced by irrigation.

3. The tropical area starts in the West where the plateau flattens toward the Iraqi plains and continues to the East, covering Khuzistan and the Persian Gulf shore, toward the vast lands bordering on the Oman sea and the Indian Ocean. Included are; Baluchistan, Sitan and all southern and southeastern plains. This region is hot, and precipitation ranges between 25 cm. and 30 cm. Dry farming is carried on, beginning in the Fall with harvesting in the middle of Spring. In other seasons, irrigation farming is practiced where water is available. Tropical crops such as dates and citrus fruits are raised in this area.

In the mountains of the first and second climatic zones, snow precipitation occurs generally above 1,500 meters with snow cover lasting about two weeks on the lower ground, and for about six months at altitudes above 2,000 meters. The rivers arising from the melting of this snow, the run-off of rains, and the water that has seeped into the subsoil from the water supply of the plains. Because the southern slopes of the mountains are steep and are almost bare of vegetation, an occasional substantial rainfall in the summer may cause damaging floods in the valleys and plains.

Agriculture :

The welfare of Iran is intimately connected with its agricultural enterprises. In general, food and housing for farm families are meager, and their standard of living is low as a result of using primitive production methods on small land areas. The total potential area for cultivation and irrigation is large, but the cultivated land per agricultural worker is restricted by farming and irrigation practices. Fortunately, much additional water is available for development.

Land :

Fortunately, there is an abundant supply of fertile land in Iran which is not farmed. Much of this needs water to make it productive, but there are large areas where dry farming will be profitable with modern machinery. The available statistics indicate 4,600,000 hectares of land in crops, and 1,200,000 hectares of crop land fallow. Another 33,000,000 hectares are described as usable if water and or machinery were available. Of the 4,600,000 hectares cultivated land, about 1/3 is under irrigation and 2/3 is dry-farmed.

Approximately 12,000,000 or 78 percent of the total population are engaged in agricultural production, living in 41,273 villages.

Surface of cultivation in wheat and barley is increasing year by year. The following figures show how the vield has increased in the past 9 years :

Year		*Cultivated Area (hectares)*	*Total Yield (tons)*
1946	*1325*	*1,954,725*	*1,925,209*
1950	*1329*	*2,155,784*	*2,287,947*
1955	*1334*	*2,911,199*	*2,741,089*

Crop yields are low in part because of the lack of information about soils. The science of geology is involed, as well as those phases of science known as soil physics, soil chemistry and soil microbiology. Tillage, fertilization and irrigation practices are all related to or influenced by basic facts which can be revealed only by a scientific study of those subjects.

Traditional farming practices contain a considerable degree of folk-wisdom gained through experience, but much improvement could be made through the application of modern agricultural science. Many farm owners and some operators are aware that improvements could be made, but individuals with the necessary training are scarce, and the educational level of the general farm population is low. A start has been made, as will be described persently, toward increasing the number of agricultural technicians, and making their services available to farm owners and operators.

Water Utilization Problems :

The supply of water available for irigation is a limiting factor in crop production. Yet the supply of available water is being wasted extensively by primitive methods of distribution, and application.

Some of the causes of the waste of irrigation water are :

Poorly leveled land.

Inadequate control of water.

Improper methods of culture.

Unwise irrigation schedules.

Poorly balanced cropping systems.

Methods of applying water not adapted to soil type.

Inadequate tillage equipment.

Waste of much of the winter flood water.

Lack of knowledge of how to apply water efficiently.

In order to use irrigation water efficiently and effectively, there must be a skillful combining of the science of soil, water and plant relationships with the arts of irrigation farming. The lack of tillage machinery detracts seriously from irrigation art as practiced by the peasant farmers. But lack of knowledge and information on the science of farming is also a hindrance.

Recently more effective measures have been taken for utilizing the waters of the rivers by constructing medium-sized dams and storage reservoirs, such as the Karkheh Dam, the Sistan Diversion Dams, the Kouhrang Diversion Dam and Tunnel, the Shabankareh Diversion Dam, the Golpavegan Reservoir Dam, and many others. Larger reservoir dams are under construction at Karaj and Sefid Roud and other places. Other locations for large dams are being studied, or are in the planning stage.

But if we cannot use our water with a reasonable amount of efficiency, and prevent its loss, we cannot profit from the investments we have made. Several of the larger modern irrigation projects and some of the older projects, are also confronted with problems of soil waterlogging and resulting salinity and alkalinity and sterility of the root-zone soils. Very few, if any, of the managers of projects have thus far given serious attention to the control of the sources of excess water from canal seepage losses, or from over-irrigation of the root-zone soils.

It is only in recent years that Iran has begun to take advantage of modern techniques in the efficient use of soil and water. During the fall of 1954, the Ministry of Agriculture had reacted favorably to the formation of a department of agricultural Engineering. Early in January, action was taken and the Department was created. Out of the need for trained personnel who could go out into the field and give aid in solving practical farming problems grew the idea of holding a training course: using a farm as the training ground. Study and consultation brought out the fact that the Ministry of Agriculture was very short of the type of personnel who could be trained to carry on specialized activities either in irrigation or in farm machinery. Thus it was decided to combine specialties and train agricultural engineers in both farm machinery and irrigation. Later, when trained manpower became more plentiful, then the two could be separated.

We had a few tecnnicians who had been in training both inside and outside Iran in the field of irrigation and drainage, and some in farm machinery operation and maintenance. The trained technicians, with advice and assistance from Point. IV and FAO, have put on a very succesful one-year training course in agricultural engineering.

Students were selected from recent graduates of Karaj Agricultural College, and an attempt was made to choose students from various sections of the country who expressed a willingness to work with farmers in the Provinces.

After comparing course outlines for several countries, and considering the special problems of Iran, and the qualifications of the students we expected to have, and the time available for teaching them, we decided on the following course outline :

Agriculture Engineering Training Course
General Plan
List of Activities

Activity	Duration	Reference
1. Orientation	3 days	
2. Lectures	Appr. 500 hrs	Appendix No. 1
3. Use of all F.M.	2 weeks / group	,, ,, 2
3. Driving	6 hours / person	,, ,, 3
5. Land levelling	1 week / group	,, ,, 4
6. Drainage work	1 week / group	,, ,, 5
7. Farming :		,, ,, 6
a. Demonstration		
b. Group		
8. Conferences	2 hours / perso.	,, ,, 7
9. Audiovisual	Appr. 30	
10. Field trips	South and North	

No.	Course	Theory hrs.	Field work hrs.
1.	English	50	
2.	Slide rule	10	
3.	General Geology & Kanat systems General geology Water table and Artisan aquifers Investigation for Kanat Design & operation of Kanat systems	10	11
4.	Quality of water Collection of water samples Analysis of irrigation waters Electrical conductivity Classification of irrigation waters Use of irrigation waters		
5.	Statistics & Agriculture economics Agricultural resources Land use and production Livestock Real estate investment, equipment, tools and farm supplies, family composition. Receipts, expenses and income living expenses. Planning the land-use program Economic principles and the farm planning approach. Types of farming The use of economic information	10	

No.	Course	Theory hrs.	Field work hrs.
6.	Water rights & laws		
	Available supplies of water		
	The doctrine of appropriation		
	The doctrine of riparian rights		
	Definition of water rights		
	Local water rights		
	International water agreements		
7.	Organization of irrigation & drainange districts	5	
	Purpose		
	Organization		
	Source of district revenue		
	Operation and maintenance		
8.	Water and snow measurement	20	23
	Units of water measurement		
	Formulas for rates of flow		
	Orifices		
	Weirs		
	Parshall flum		
	Current meters		
	Dividers		
	Snow surveys, establishing snow courses		
	Forecasts of snow runoff		
	Methods of forecasting		
9.	Hydrology	10	11
	Definition		
	The hydrologic cycle		
	Classificatiion of streams		
	Hydrograph analysis		
	The unit hydrograph		
	Drainage basin-precipitation		
	Water losses		
	Ground water		
10.	Soil & water relation - soil & water conservation	30	33
	Soil moisture		
	Water movement		
	Erosion control		
	Terracing		
11.	Use of water in irrigation and irrigation methods	10	10
	Water losses		
	Efficiency of water use		
	Quantity of water to apply		
	Time of application		
	Method of application :		
	1. Surface irrigation		
	(a) Flooding		
	(b) Furrow		
	2. Subsurface irrigation		
	3. Sprinkler irrigation		
	Selection of irrigation method		
12.	Land classification and mapping	10	10
	Basic principles		
	Classes of lands		
	Types of land classification		

No.	Course	Theory hrs.	Field work hrs.
	Land classification specifications Soil map Field operation Interpretation and use of results		
13.	Surveying Purposes of surveys Measurement of Horizontal distances Differential levelling Measurement with compass and transit Topography Field books	40	30
14.	Land levelling Benefits Correlation of land leveling and soils Correlation of land leveling and irrigation methods. Levelling surveys Staking for levelling Computation of yardage for levelling Levelling equipment	22	30
15.	Irrigation structure and works for the farm Farm distribution system Low dams - dikes Canal & related structures Headgates - check gates Division boxes and weirs Farm ponds-ditches Flumes pipes culverts - siphons	40	40
16.	Motors & tractors Construction Repair Operation and maintenance	40	40
17.	Farm machinery Tillage implement Planters Seeders Cultivators Harvesters Animal drawn equipment	60	40
18.	Drainage Soils in relation to drainage Rainfall and runoff Drainage investigation Major types of drains Open channels Tile drain Pumping drain Drainage of irrigated lands	42	30
19.	Reclamation of saline & alkali soils Saline soils Alkali soils-types of alkali salts Illustration of reclamation procedures Leaching - chemical treatment for soil improvement Design of drainage for the removal of alkali	16	10
20.	Pumping for irrigation Centrifugal pumps Turbine pumps	5	5

No.	Course	Theory hrs.	Field work hrs.
	Deep - well pump Sewage and sludge pumps What is head on pump ? Economical pipe size for pumps Pump selection, installation, and operation		
21.	Correlation of all aspects	5	
22.	Cropping and fertilizers Maintaining of organic matter in soil Fertilizer elements and fertilizer materials Using fertilizers	10	
23.	Irrigation research Evaporation Infiltration Permeability Basic intake rate Length of run Length of furrow Consumptive use	20	15
24.	Operation & Maintenance of irrigation systems. Inspection of structures and facilities in operation Irrigation operations personnel Operation of canal and laterals Delivery of water - water use and measurement Control of weeds, rodents and silt Estimates of annual irrigation operation and maintenance costs.	20	20
	Conferences :		
1.	Short courses	Impl ɩents dealers	10
2.	Motion picture films		8
3.	Slides		10
4.	Use of planimeter		2

Appendix No. 2

Use of all Farm Machinery

Trainees should get familiar and obtain enough knowledge to be able to operate, repair and maintain Farm Machinery.

Each group will have to spend two weeks with related instructors for the following activities :

1 — Disassembling
2 — Assembling
3 — Ajustments
4 — Minor repair
5 — Care of prerequisits
6 — Put into operation
7 — Complete use in small scale
8 — Maintenance & storing

This includes hand, animal and tractor drawn equipment.

Appendix No. 3

Driving Progr...

Fridays 8 : 00 — 12 : 00

6 Fridays would be for 4 persons who will go together each hour :

1 st. 15 minutes for 1 st. person
2 nd. „ „ „ 2 nd. „
3 rd. „ „ „ 3 rd. „
4 th. „ „ „ 4 th. „

each person would have 4 times chances of 15 minutes to drive and would then be 1 hour.

Repeated with the same group in 6 weeks, each person will have 6 x 4 times of 15 minutes = 6 hours times for driving and that seems :

1 — not tiresome
2 — not too far apart to forget previous instruction
3 — adequate to get knowledge enough for driving

Appendix No. 4

Land levelling

Trainees would get opportunity to have a piece of unlevelled land.

They will have to expedite the following activities :

1. *Surveying as needed for land levelling*
2. *Computation of cut & fill*
3. *Design of the area*

and all details concerned.

Each group will have two weeks time for the entire activities for the area allocated.

Appendix No. 5

Drainage

Students should get practical information on drainage problems.

Each group will spend one week in Ghezel Hessar to perform the following activities :

1 — Permeability measurement
2 — Use of piezometer tubes
3 — Measuring depth of water table
4 — Lab work
5 — Computation of spacing in a given field
6 — Land reclamation
7 — Soil survey

And all details related to drainage

Appendix No. 6

Farming

Students are to assume responsibility related to actual farming. For a growing season they would be actual farmers and practice every-thing by themselves from the very begining points of land preparation to the end of harvesting.

Each group will have an area about 2 hectares to farm. All of students in a group have a mutual responsibility. Each group will have special schedule for cropping and their farming would exactly be as a demonstration farm.

Appendix No. 7

Individual Conferences.

There will be 30 pamphlets, books and brochures provided to be in disposal of students. Each student has to read his pamphlet through, translate it to Persian, make it ready, prepare a summary of it and in his turn has to give a conference which will last 1 hour.

On this conference all related instructors will audit it and everybody can criticise and bring questions. Considering these criticisms and questions the student has to review the translated pamphlet and arrange it such that to be helpful and of benefit to Iranian farmers. Elaborate formulas and techniques should be avoided and everything should be put into easy and comprehensive way to be ready to publish.

Students are allowed to work together and cooperate with each other. This is their home work.

In the training course the students are encouraged to do the work themselves, and to learn by doing. Their time is roughly divided about 1/3 to class instruction and 2/3 to field works. Classroom work predominates in the winter, and field work in the spring.

A great-satisfaction in this work for all concerned was the change in the attitude of the students towards work. Throughout the course, the nobility of an honest day's work was stressed, and the need of farmer for help in solving his problems. Most of the students actually rolled up their sleeves and worked hard. The land on the training farm was not level, and without considerable effort on the proper end of a shovel, the irrigation would not have taken place. When the temperature was 105 degrees Fahrenheit, the perspiration glistened on their faces. With the greatest of pride, a student came one day to show the instructor the blister he had worn on his hand.

The first class of 29 trainees began to work in the Fall of 1954, and completed their course in the Fall of 1955. They are now working in different parts of the country on studies of consumptive use of water, on drainage investigations, irrigation research, land levelling, surveying, techinical services to farmers, farm machinery operation and maintenance and extension. Their work has been valuable, and we feel we have had good results from this first year's course.

The second year of the training course began in the Fall of 1955. By this time, more scientific equipment was on hand, and it was arranged to house the students near the training farm. The new class includes five foreign students, four from Afghanistan and one from Libia.

Facilities for the training course are as follows :

Farm machinery

Field and laboratory equipment

12 hectares of training ground

100 hectares of demonstration farm

600 hectares located in an area where drainage is a chronic problem; here students apply in the field the techniques of drainage investigation and operation which they are being taught in the classroom.

2 irrigation research stations, one for sugar beets and one for cotton.

Since still more technicians in soil and water conservation and farm machinery are needed in Iran, we hope to continue the training course for five more years. It would not be difficult to enlarge the number of students taking training. This would however, necessitate an increase in the number of pieces of scientific and field equipment, in housing and other facilities, and in technical help.

Point IV has given some help for the past four or five years, but we still need technical help and equipment to improve irrigation farming and increase the income of the farmers and of the country as a whole.

Iran is developing rapidly, and we need more technicians to serve the Block Development and to advice and guide the farmers.

The agricultural phases of irrigation are assentially concerned with the uses of irrigation water on the farm. Many more people are directly concerned with the agricultural than with the engineering phases. Every irrigation farmer must decide important questions concerning his irrigation practice, and some of these questions have to be decided each - . year they cannot be decided once for all time. There are no specific rules applicable to all arid-region climates, to all soils, and for all crops, as to when irrigation water should be applied to the soil. The seasonal depths of irrigation water required to produce crops economically under different climatic and soil conditions perplex many irrigation farmers.

Agricultural aspects of irrigation include the determination of the proper depths of water necessary in single applications, how to distribute the water uniformly, the capacites of different soils for irrigation water, and the flow of water in soils.

In order to make the most efficient use of water, the methods and practices in irrigation must be based on the climatic and soil conditions provided by nature in the localities concerned. The crops grown are selected to some extent according to the climatic conditions under which the farmer works. Agricultural engineers and agronomists have the opportunity and the responsibilitu of finding the necessary facts with which to aid the irrigator and answer correctly the many perplexing questions in the agricultural aspects of irrigation.

The scientific aspects of irrigation farming are far too complicated for most of our farmers for they have very little education. However, most of them are willing to try new methods if approched in friendly fashion and given an opportunity to see for themselves that some different practice will bring better results.

The farmers are willing to work hard to improve their crops. Around Isfahan, Yazd, and Tehran, where water is available and the lands is some what suitable, the farmers work very hard and produce good crops, although in places they have to be careful about salinity.

Irrigation practices in these areas are better than in much of the rest of the country, and the farmers have a better standard of living. Great improvements could be made in many areas if the right personnel were available to assist and advise the farmers.

Our task and our opportunity, therefore, is to make the best possible use of the few technicians that we have who have adequate training, whether they be Iranian or foreign, to give the best possible training to young men who will be capable of making their new skills and information helpful to farmers, through the Extension Service and in the various development programs.

Other Middle Eastern countries have problems somewhat similar to ours, and we will be interested to learn how they are approaching their tasks. Perhaps we can join our ideas together, and each learn from the other.

Chapter III

Field Workshops

Field Workshops

Any study program concerning irrigation is enhanced by visits to the countryside where actual field operations are taking place. The Seminar Program was so arranged that the participants would have the opportunity to see the work for themselves, ask questions of local technicians and farmers, and learn something of conditions and practices in Turkey. A summary of the field workshop program follows.

First Day :

The first day was spent in the Menemen Area, which is in the lower end of the Gediz River Valley, and lies about twelve miles north of Izmir. The Gediz Valley is one of the most important agricultural areas of Turkey, where cotton, grapes, mellons, vegetables, small grains and livestock are raised. The Valley and its development for irrigation and flood control were explained by the Regional Director of the State Hydraulic Works. A brief review of the Menemen Irrigation Station was given by the Station Director.

In order to bring about improved farm irrigation practices the following factors must be known or available :

1. A knowledge of sound and efficient water use practices. These may not be used or known in any one country, or research data may not be available for basic background. However, experience from years of practical operation and technical study in other countries is available and may be used to initiate work in any other country. This does mean that practices can be directly imported from one country to another, but they can and must be adapted to fit the local conditions and customs.

2. Trained technicians to work with farmers. Farm irrigation is a field where trained technicians must be available to work with farmers. There are may technical jobs which the average farmer cannot be expected to do himself, nor is he inclined to hire such work done if services are available privately. Neither can a farmer do many of the jobs by merely looking at a picture or having someone tell him how. If a corps of technicians is not available training activities must be initiated.

3. Farm irrigation equipment.

Hand labor may be effectively used for land preparation where the plots of land are small and the quantity of water available is small. Where the fields are larger than a few decars and larger flows are used the scope of the work to be done is too large for hand labor and gross inefficiency results unless equipment is available. Satisfactory operations can be carried out with either simple, locally made implements or imported, commercially made equipment.

4. An interest on the part of the farmers to improve their practices.

Farmers are naturally inclined to resist changes and follow the ways of their forefathers. However, there are always progressive individuals who are interested in improving their methods, raising better crops and consequently, improving their way of life. By working with these leaders demonstrations can be established, and if practices are sound they will be adopted by neighoboring farmers.

One part of the field workshop was organized to bring these four factors out into the open in such a way that interest and discussion would be stimulated.

The use of simple, animal-drawn farm irrigation equipment was demonstrated in actual operation on a farmer's field. Horses in teams of two, three and four animals and oxen in teams of two and four animals were used to pull the exuipment. The equipment consisted of : level (for checking elevations and grades), fresno, buck scraper, float, V-drag, A-type ridger, plow, furrow opener, and hitches for all equipment. All of this equipment was made in Turkey and is well adapted for use on small farms and with animal power. It is thereby available to a wide range of farmers, requires no foreign exchange or special power units.

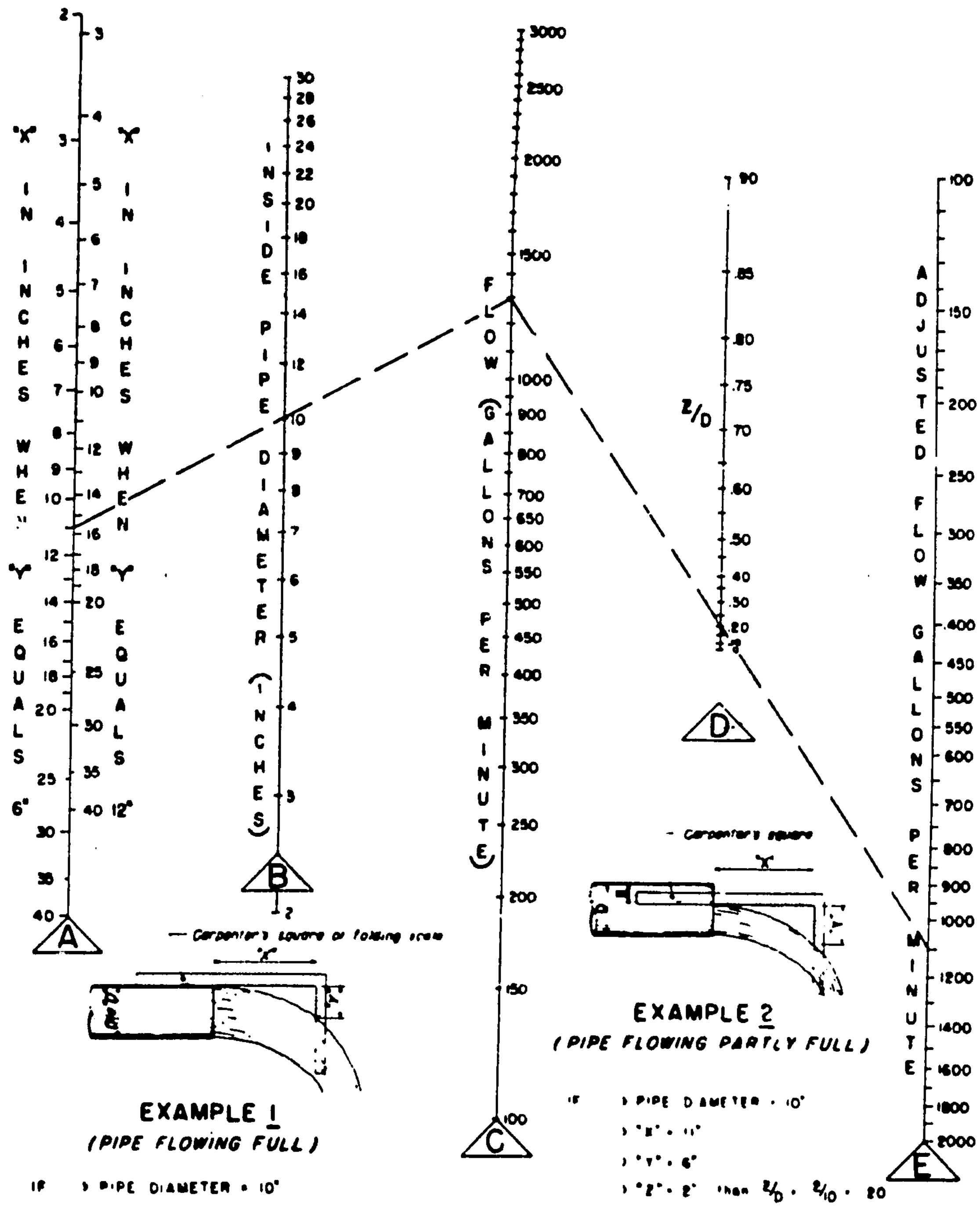
During the past ten years many types of farm irrigation equipment have been developed, especially in the United States. This equipment is almost exclusively for use with tractors and much of it has hydraulic controls. In countries where farming is becoming mechanized and there are no problems with import restrictions or foreign exchange such equipment is well adapted to larger size farms and for use by commercial operators or cooperatives.

Some of this equipment, which included a carry-all type scraper drawn by a crawler tractor John Deere and Eversman levelers and Chattin ditchers drawn by rubber tire wheel tractors, was demonstrated on another farmer's field in the Menemen area.

Since the Seminar was held at the end of the irrigation season irrigation practice and technique demonstrations were held on a field at the Menemen Irrigation Experiment Station. Fields had been prepared for the border and furrow irrigation methods by use of the animal drawn equipment previously described.

ESTIMATED FLOWS FROM PIPES

PIPE MUST BE HORIZONTAL FOR BEST RESULTS
ALL QUANTITIES OBTAINED ARE APPROXIMATE



EXAMPLE 1
(PIPE FLOWING FULL)

IF > PIPE DIAMETER = 10"
> "X" = 11"
> "Y" = 6"

WITH A STRAIGHT EDGE CONNECT 11" ON SCALE A ("Y" = 6") WITH 10" ON SCALE B AND READ 1300 GALLONS PER MINUTE ON SCALE C

EXAMPLE 2
(PIPE FLOWING PARTLY FULL)

IF > PIPE DIAMETER = 10"
> "X" = 11"
> "Y" = 6"
> "Z" = 2" then Z/D = 2/10 = 20

ASSUME PIPE IS FLOWING FULL AND PROCEED AS IN EXMPLE 1 THEN WITH A STRAIGHT EDGE CONNECT 300 GALLONS PER MINUTE ON SCALE C WITH 20 ON SCALE D AND READ 1100 GALLONS PER MINUTE ON SCALE E

U.S.D.A.
FARMERS HOME ADMINISTRATION
3 2 53 ENGINEERING HANDBOOK

Water was obtained by pumping from a canal with a small centrifugal pump. Measuring the flow of water at the pump by the trajectory method and by use of a small Parshall flume installed in the field supply ditch were demonstrated. The available moisture in the soil of the fields to be irrigated was determined by the ball test method. Since the amount of water to be added to the soil, the area of the field and the rate of flow had been determined, the time required to irrigate the fields was calculated by the use of the formula : mm. x decars = lt./sec x hours x 3.6 (Refer to paper on Irrigation Efficiencies).

Second Day.

The actual proof to a farmer as to whether or not improved irrigation practices are desirable must be determined by increased yields and reduced operation costs. Therefore, during the second day of field workshop the Seminar group visited the farm of İbrahim Kulahtaş, located in the Gediz Valley north of the city of Manisa. Mr. Kulahtaş, owns and operates a cotton farm and in 1953 became interested in improved irrigation practices as his land was very uneven and he had great difficulty in getting water to his crops, which he irrigated by flooding. Irrigation technicians from the Ministry of Agriculture made a survey and prepared plans on a 75 decare field. The plans called for land grading, field distribution system and irrigation of the cotton by the furrow method. Mr. Kulahtaş, agreed to carry out the recommended plan and the Ministry agreed to provide equipment for land grading at cost and furnish technical guidance on proper irrigation techniques during the first year. Land grading operations, which required the moving of 1,866 cubic meters of soil to establish a satisfactory grade for irrigation, were completed in January 1954. Cost records showed that 1,050.75 TL had been spent, which included engineering surveys and plans, depreciation and interest on equipment, operator's wages, fuel and oil. This represents a cost of 14 TL per decare.

Mr. Kulahtaş, records show that before 1954 his yield averaged 240 kg. of seed and lint cotton per decare and the 1954 and 1955 crops averaged 336 kg. per decare. After the improvements were carried out the field was irrigated in half the time required before, and 3 laborers were used to irrigate where 12 had been required under the old system. This sums up to a 40 % increase in crop yield, a 50 % saving in water used, and a 75 % saving in labor. Since water is obtained by pumping from a shallow well, there was also a 50% saving in pumping costs. Mr. Kulahtaş, appeared before the group and spoke very enthusiastically for the benefits of improved irrigation practices and the technical assistance received from the Irrigation Section of the Ministry of Agriculture.

As a comparison, the adjoining field on the south of the Kulahtaş, farm was visited. The cotton was very spotted, being drowned out in the low areas and stunted from drought in the high areas. The owner is very desirous of grading his land but had not been able to obtain the equipment. Land grading is a relatively new practice in Turkey and a sufficient number of implements are not available to take care of the demand for work. The manufacture of horse-drawn equipment is being speeded up to take care of this demand.

Another field, that of Hakki Oral, farther up the Gediz Valley near Salihli was also visited. This field of 58 decares was graded in the fall of 1955. 3,017 cubic meters of soil was moved at a cost of 1,589 TL, or an average cost of 27 TL per decare. 1956 was the first year in irrigated cotton and agricultural officials estimate that the yield will be between 200 and 250 kg. per decare. In contrast, an adjoining field which has not been graded and is irrigated by wild flooding was estimated to yield 50 to 75 kg. per decare.

It should be pointed out here that the increase in yield on the Kulahtaş, farm was obtained only through the application of good irrigation practices, with cotton being grown each year. A good crop rotation and fertilization would bring about an estimated additional increase in yield of 40 to 50 %.

Completing the field workshops, was a trip up the Gediz Valley to the Demirkopru Dam which is now under construction. This trip provided the participants with a view of the scope of the job confronting the State Hydraulic Works Department in completing the dam and constructing the irrigation distribution system and the Ministry of Agriculture in securing sound and efficient use of the water on the farm land.

Soil is checked with auger to determine amount of available moisture within the root zone. Determination is made by "ball test" or "feel" method. Accuracy within practical limits may be attained in a short time.

The third crop of cotton after application of impro ved irrigation practices on the farm owned and operated by Ibrahim Kulahtaş. Yield was increased 40% with reductions of 50% in water used and 75% in labor.

A field irrigated by old methods. Note the poorstand caused by uneven water distribution. This field adioins the one shoun above

GENERAL INFORMATION ON GEDİZ BASINPROJECT AND RELATED ECONOMIC DATA

The basic facilities of the Gediz River Basin Project which includes irrigation, flood control and hydroelectric power features, are the Demirkopru Dam, Reservoir and Power Plant. Other parts of, the Gediz River Basin Project are Lake Marmara Works, Adala Weir, Emiralem Weir, Ahmetli Weir, main canals, distribution canals, flood channels, levees and high tension power distribution lines, Some of these features were constructed years ago, others more recently; while some are now being constructed and others have not yet been started. All of these subsidiary parts of the Gediz River Basin Project are planned for completion about the time the Demirkopru Dam, Reservoir and Power Plant are completed. The total cost of the Dam, Reservoir, Power Plant land purchasing, highway relocation, consulting services, permanent and construction equipment, is approximately 145,000,000 TL. The final figure can be expected to differ some what from these when the project is completed.

The total project benefits and costs pertaining to irrigation, flood control and power have been computed. On the basis of benefits received by the farmers, businessmen and Turkish Government, the ratio of annual irrigation benefits to annual costs of the irrigation features of the projcet were estimated in 1954 as 6,8:1. Similarly, the ratio of the annual power benefits to the annual costs of the power features is 2,5:1, and the ratio of the annual flood control benefits to annual costs of flood control features is 2,7:1.

IRRIGATION :

There are 77,900 hectares of land which will be irrigated in the Gediz project. This land lies in the valley of the Gediz from the village of Adala to and including the Menemen plain at the sea.

POWER :

The estimated annual power production of 193,000,000 kilowatt hours will be distributed through power lines to be built by the Eti-Bank to the following cities : İzmir, Kemal Pasha, Manisa, Menemen, Tire, Turgutlu, Salihli, Ahmetli, Alaşehir, Kula and villages. The Gediz Project power network will be part of the Ege power pool and will be connected to systems to the north and to the south.

FLOOD CONTROL :

The area in which floods will either be entirely eliminated or reduced in severity is 66,400 hectares. This area is situated along the river, especially in its middle and lower reaches.

BASIC DATA ON DEMİRKOPRU DAM, RESERVOIR AND POWER PLANT

Watershed area above reservoir	*6,590 sq. km.*
Mean annual runoff into reservoir	*708,000,000 m3*
Volume of the Reservoir (to spillway crest)	*1,320,000,000 m3*
Area of the water surface (at spillway crest)	*4,900 hectares*

Type of Dam	*Compacted Earth*
Height of Dam	*77 m*
Volume of earth and rock in Dam	*4,000,000 m3*
Lengths of tunnels	*2,700 m*
Length of Steel Aqueduct	*556 m*
Diameter of tunnels	*4.8 m*

Number of Power Turbines and Generators	*3*
Type of Turbine	*Francais*
Average operating head on turbines	*105,7 m*
Turbine capacity at 300 r.p.m.	*31,800 hp*
Nominal Generator Rating at, 80 factor	*23,000 kw*
Generator Voltage	*10,600 v*
Annual Power Production	*193,000,000 KwH*

Chapter IV Reports Of Panel Groups

A simple level made from a carpenter's level is useful for checking elevations and grades. Care in use and short shots give reasonable accuracy.

REPORT OF PANEL GROUP I

Land Preparation Factors, and Farm Irrigation Equipment

After the customary period of discussion in which the panel members orient themselves and as a group arrive at the angle of attack to be used, this committee settled on presenting suggestions and recommendations to the seminar for the preparation of a bulletin covering the use of light homemade equipment. We feel that this should list the needed equipment; have plans; bill of materials, and operational directions. And also such a publication should contain directions for proper and correct hitching. It is recommended that generous use of clear cut illustrations be made, especially of actual photographs.

The committee feels that at this stage of irrigation development the Middle East has a place for the employment of light homemade equipment. It is thought that this will benefit more farmers and do much to accelerate efficient and profitable irrigation. We realize that this type of light equipment may not be useable on some heavy soils. This kind of equipment may be limited to areas having moderately heavy, medium, and light soils.

The committee recognized that there is a definite need for large equipment in preparing land for irrigation. However, the committee felt that due to the high cost of such equipment that at this time any educational publication should be limited to light equipment. We do feel that perhaps such bulletins might well discuss briefly this heavy equipment and its uses. Everyone is agreed that where finances or credit is available that large machinary can be used more economically than small equipment. Heavy equipment can be used where the farmer has large land holdings and his finances make it possible for him to own such equipment. This equipment can also be owned by contractors who can prepare land on a hire basis. A third possibility is the purchase and operation of large machines by cooperatives. These may be farmer cooperatives or a group of investors who may form a company to prepare land on a hire basis.

The panel suggests that the above mentioned cooperatives and associations be encouraged to train technicians and operators in the correct operation and maintenance of this equipment. It is also suggested that this be done as rapidly as possible.

One of the problems encountered in the use of heavy machinery in the preparation of land for irrigation is the securing of good efficient operators. The panel feels that an attempt should be made to work out a means of paying the operators an adequate wage. Perhaps the I.C.A. might assist in working out a way of improving the wage scale.

The panel feels that since most of our farmers have very small holdings and are very poor that faster progress will be attained by educating them in the use of light equipment. Equipment that can be made available easily and cheaply. The committee recommends the use of the following four pieces of equipment in addition to the ordinary farm plow on the small irrigated farm :

1. Fresno or scraper
2. Buck scraper
3. Crowder (sometimes known as a V-ditcher)
4. Float - with adjustable blade

Along with the above land preparation equipment the panel felt that the farmer needs: (1) a two-way plow, and (2) a single row cultivator. Any bulletin that is prepared should have a brief discussion on the need and use of such tillage equipment.

The committee resommends that this conference encourage the Ministry of Agriculture in each participating country to assume the responsibility of preparing such a bulletin. It is also suggested that the Republic of Turkey supply other nations with copies of any applicable publications which are now available or will be published in the future. These can be used as patterns by the others. Each country can then adapt the material to their respective conditions.

Smith, J. B. — Iraq
Çekel, Ziya — Turkey
Bakkaloğlu, Nami — Turkey
Vindinlioğlu, Sedat — Turkey
Metzger, James D. — Turkey
Steele, John — Turkey
Shamma, W. S. — Iraq

The group inspects a small fresno and 2 - horse team in a land grading operation.

REPORT OF PANEL GROUP II

Irrigation Research Related to Efficient Irrigation Practices

Irrigation research is the scientific method of investigating and making observation of facts which will lead to the improvement of irrigation practices

Irrigation research may be classified under two categories :

1. the engineering phase of irrigation
2. the agricultural phase of irrigation

Engineering phase of irrigation research should provide the information regarding water supply for the proper design of canals, prevention of seepage and efficient distribution of water and proper drainage, etc.

Agricultural phase of irrigation research should provide the information for climate-soil-moisture, and soil-moisture-plant, and soil-moisture-plant-social relations. These should cover soil classification, soil tillage practices, fertilizing, crop rotation, consumptive use or water duty, irrigation methods and practices, and weed control.

Social relations may include economic relationships and cultural systems and social goals, and irrigation enterprises.

Irrigation research can be done by government agencies, universities, and private groups for the benefit of the country.

Cooperation between research agencies in the country and between the countries should be encouraged by the exchange of research publications and seminars.

All the steps should be taken to see that the information obtained from research work is passed on to the farmer through extension services and publication in local languages.

Uner, Naki — Turkey
Mathrani, M. P. — India
Güman, Selâhattin — Turkey
Koroglu, Cemal — Turkey
Alap, Muzaffer — Turkey
Çolpan, Faik — Turkey
Adams, Warren E. — Iraq
Said, V. Fathalla — Iraq

REPORT OF PANEL GROUP III

Land Classification, Water Requipments, and Drainage

This panel felt that more time was needed to cover the three subjects listed in the title.

It was agreed that a great deal of work yet remains to be done in the field and laboratory, to give the technician the needed information in many countries, so that he can make a more realistic appraisal of his problems in these fields.

The following conclusions were reached :

Land Classificication.

1. That a basic set of land classification standars be established for use within the Middle East countries.

This basic set of standards could be and should be modified to fit the conditions of each country. Then the technicians working in the field of land classification would be using similar types of standards in each country, which could and may lead to a better understanding of ideas, problems and answers, if and when the technician from other areas meet and talk together.

2. A reconnaissance land classification survey should be completed, before too much project planning is completed.

A detail or very intensive land classification survey should be carried out or completed before the project reaches the construction stage.

3. It was also agreed that a central office of highly qualified specialists in the field of irrigation and a complete laboratory should be maintained. This central office would be used for a clearing center for the technical questions and problems that confront the technicians of the Middle East countries. Also, these specialists could be used as consultants by those countries upon request from each country.

Water Requirements.

Many factors influence the amount of water required for irrigation. The more important natural influences are : climate, soils and topography, water supply, ditch or canal seepage and deep percolation.

With a more complete knowledge of water requirements, a better water supply and distribution system and drainage system could be planned. Better farm irrigation systems, irrigation practices and farm darinage systems can be made.

In the past various methods have been used in estimating the water requirements for new and existing irrigation projects in each country; some of these methods are good, others are not so useful.

We suggest that either one or both of the following two methods of computing water requirements be adopted for the basic use. Additions and modifications can be made if a sound method is available as a basis.

The following methods are suggested for a reliable starting point :

1. Lowry Johnson method
2. Blaney and Criddle method

Each country should also carry out actual research work for various crops and different periods of irrigation for various parts of each country and all types of irrigation efficiencies. Any other problems that may be necessary to obtain a better crop, water and drainage relationship should be included in these studies.

Drainage.

The group felt that a large part of Mr. James S. Reger's paper, presented at the Seminar, entitled : "Relationship of Drainage to Irrigation and Drainage Investigations." could be used as a basis to start drainage investigation studies within most of the countries.

Other factors that should receive early attention on proposed projects and old projects are : (1) Present water table conditions; (2) Possibility and probability of draining the land; (3) Establishing observation wells; (4) Using the land classification maps and laboratory results for the bases of making any drainage system layout. (5) water analysis of: a.) River water; b.) Ground water; c) Return flow from drains; d.) All other types of water that might be used for irrigation.

Hristof, Boris — Turkey
Kemahlioğlu, Suha — Turkey
Ozgul, Şeref — Türkey
Chaya, Elie — Lebanon
Ayazi, Manoutchehr — Iran
Resnick, Sol — India
Mookerjea, D. — India
Davis, Keith E. — Turkey
Shansab, Saifuddin — Afghanistan
Tolley, Hugh — Pakistan

The group watches a buck scraper being used tocomplete a border dike.

REPORT OF PANEL GROUP IV

Extension Service Operations Programs and Technician Training

Our topic consists of two distinct, but very closely related subjects. After discussion, we decided to prepare our report in the form of recommendations to the participating countries. The recommendations are as follows :

Extension Service Operations Programs

1. That each country establish as soon as possible appropriate organization within the Ministry of Agriculture for dealing primarily with matters of irrigation, drainage and soils.

2. That the organization referred to in No. 1 be set up on a national, provincial, county and village level in such a way that it can provide technical assistance to farmers in irrigation, drainage, soils, and soil conservation.

3. That each country provide an irrigation specialist on the national level as a part of an extension service, and that each province or region have at least one experienced irrigation technician.

4. That each country establish farms to demonstrate improved irrigation practices so that other farmers can observe the benefits and be given encouragement to establish improved practices on their land.

5. That county agents and village agricultural teachers be provided with appropriate irrigation equipment, both locally made and imported, in order to encourage and assist farmers in establishing improved irrigation practices.

6. That each country examine the possibilities of financial assistance to farmers for improved irrigation practices and small irrigation and drainage projects through incentive payments and loans.

7. That individual countries establish irrigation and conservation districts or associations when practical.

Technician Training

1. That agricultural colleges in each country provide education and carry out research in the fields of extension, soils, farm irrigation and drainage, and soil conservation.

2. That secondary and other agricultural schools provide practical training to students in extension, soils, farm irrigation and drainage, and soil conservation.

3. That each county agent and village agricultural teacher be given practical training and refresher courses on improved irrigation techniques and benefits therefrom to insure that irrigation practices will receive appropriate attention.

4. That each country take immediate steps to provide specialized training in all phases of irrigation, soils, and drainage for work on national, regional and local levels. I.C.A. should assist in this matter by providing training programs in the United States for qualified persons who have at least a B.S. degree. The training programs in the United States should be of long enough duration to permit the trainees to receive adequate training in their fields.

5. That I.C.A. personnel assist technicians of each country in securing fellowships for advanced study in American universities and colleges in the fields of irrigation, drainage, and soils.

Cansikmaz, Mehmet - Turkey
Madran, Nurettin - Turkey
Tamaddoni, GH - Iran
Kilgore, Russel - Egypt (observer)
Memarrbashi, Aziz - Iran
Karaelmas, Adem - Turkey
Arer, Servet - Turkey

REPORT OF PANEL GROUP V

Farm Water Delivery and Irrigation System Operations

1. Farm conditions are radically different among the seven countries represented here. Only a very generalized statement of problems and solutions can be given for farm water delivery and irrigation system operations.

2. These differences are due to political and economic factors, rather than to natural ones. These factors are so important that they seriously effect the adequacy of engineering and planning of future irrigation distribution systems.

3. Recommendations

a. In view of the difficulties encountered by engineers in some of the countries, it is believed that their work should be devoted to small projects which will have the effect of demonstration to both the farmer and the government.

b. Needed in most countries is the development of farmer interest in improvement of irrigation systems through the Extension Service now existing at selected locations by :

(1) Consolidation of farmers main canals for conservation of water.

(2) Proper permanent checks, turnouts and measuring weirs.

(3) Sub-governmental organization for management of water and assessment of operation costs, or collective improvement of the system.

(4) The land holdings should be properly surveyed for apportionment of water and costs.

(5) And where feasible permanent weir dams should be installed for controlled diversion, equitable distribution and efficient use of water under governmental management.

c. In initiating any project development the proper end use of the water must be made in order that the project will be economically feasible and will result in a project that will not deteriorate because of increasing salinity and water logging. Project management engineers are required for this purpose.

Vessal, Hooshang - Iran
Wheeler, W. E. - Iran
Malak, Bashir Ahmad - Pakistan
Walters, Wm. T. - Lebanon

Chapter V

Country Followup Statements

Country Follow-Up Statement

AFGHANISTAN

Saifuddin Shansab

Mr. Chairman and Gentlemen : I am very happy to have had the opportunity to attend this seminar. I received a lot of information from you fellow delegates. I wish to thank the Turkish Government for providing the facilities which made this meeting possible and also appreciate the help from the members of I.C.A.

I hope this kind of seminar may continue in the future. With the exchange of ideas we can gain knowledge about the activities going on in Middle East countries in connection with irrigation and drainage problems.

Following is a summary of the irrigation problems which we must overcome in Afghanistan :

AFGHANISTAN'S IRRIGATION PROBLEMS

The agricultural production of Afghanistan depends almost entirely on its irrigated land. To increase its agricultural production it is therefore necessary that new sources of irrigation water be developed and better methods of water application be used.

The topography of the nation lends itself to water storage behind dams in streams that have a heavy flow during flood seasons. The water supply in many of these same streams is extremely limited during the season when irrigation water is most needed. In my opinion, the agricultural production could be materially increased, in many of the areas that have been farmed for generations, if more irrigation water was available and if it was applied more effectively to the particular crop being produced.

It is probably impossible or at least impractical to try to change or improve the irrigation methods of Afghanistan until other farming practices, customs, etc., are materially changed. For instance, cultural methods, crop rotation and soil tillage will have to be materially changed before new methods of water application can be effectively applied.

Mold board plows will have to be introduced so that green manure crops and animal manure can be plowed under and the soil humus increased. The water holding capacity of many soils could be increased by improving soil tillage. Tractor-powered machinery is not necessary for this operation but animal drawn machinery must be improved. Improved cultivation and weed control are vitally necessary. Weeds must be eradicated and eliminated rather than cut off at the surface of the land so a regrowth can immediately start. Good irrigation methods will not show effective results if weeds are permitted to grow abundantly so that land is supporting a crop of weeds as well as the field crop being produced.

Systems of crop rotation must be introduced and followed if improved irrigation methods are to show maximum results. At the present time, not enough leguminous crops such as alfalfa, clover, etc., are being produced. The land at the Central Research Station at Kabul, in many places, shows a definite phosphorus or nitrogen deficiency.

Row crops such as corn, beans, sugar beets, potatoes, etc., should be planted in rows and cultivated so that soil tilth would be improved. When row crops are planted in rows they can be ditched and irrigated without the land being submerged with water. The common practice of broadcast planting and basin irrigating most all crops does not lend itself to good soil tilth or improved tillage practices.

At the Central Experiment Station at Kabul and at the recently established Sub-Station at Lashkar Gah two irrigation experiments are being conducted. One experiment, started last year at the Kabul station, was the "furrow method compared with the basin method of irrigating corn." Another experiment, started this year at Kabul and Lashkar Gah, was "length of run-depth of penetration for corn." The crop in both of these experiments was planted in rows. In the experiment comparing the furrow with the basin method of irrigating corn yield data will be compiled. In the length of row-depth of penetration experiment soil probe tests are made at each end of the length of run involved when the water has penetrated to the root zone depth at the lower end of the length of run being tested. Crop yields will be determined on this experiment. Several factors have had a deleterious effect on this experiment but lack of an adequate water supply has been the most serious.

In addition to these experiments, the irrigation system has been reorganized. Three four-inch Ministry pumps and one four-inch I.C.A. pump has been installed at wells already located on the Ali-abad research land.

The lack of adequate irrigation water can be materially improved by constructing two more irrigation wells on the Ali-abad research plots. Each of these wells should be large enough to supply a continuous water supply for at least a three-inch pump.

In the future we expect to continue to improve the irrigation system at Ali-abad and reorganize the plots accordingly.

We also plan to conduct irrigation experiments at Bene Hissar. The new wells being constructed there will insure an adequate water supply for part of the crop land. How much more water will be required, only time will tell, after the pumps have been installed.

Country Follow-Up Statement

INDIA

D. Mookerjea

Mr. Chairman, Ladies and Brother Delegates : I am grateful to you for giving me an opportunity to speak before such a distinguished and learned galaxy of Engineers and Scientists.

You have already heard some details of the progress made in the field of Irrigation Engineering in our country during the last few years. I feel that we have yet to cover a larger field in the matter of the latest principles of design and research particularly in regard to the improved irrigation practices with special emphasis on the water utilization, management, land classification and on the measures to be adopted to increase the yield of various crops from the same field by changing, if necessary, the crop pattern or crop rotation. This Seminar has given us an opportunity to hear the views and opinions expressed by the delegates from the participating countries and the practices followed therein. Even outside the Seminar Hall we had exchanged ideas with our brother engineers and have made every endeavor to solve our common problems.

It is needless for me to emphasize the need of holding such Seminars as frequently as possible, which I am sure, would help the cause of improvement and advancement of Irrigation and Agriculture throughout the world.

I would, however, place before you the following suggestions for your consideration :

(1) The title of the Seminar may be changed to Regional Irrigation and Agricultural Practices Leadership Seminar.

(2) Such Seminar should be held by rotation in the other countries year after year so that the participants may get the benefit of seeing actual field practices adopted and developments made in the Irrigation and Agricultural operations in different countries.

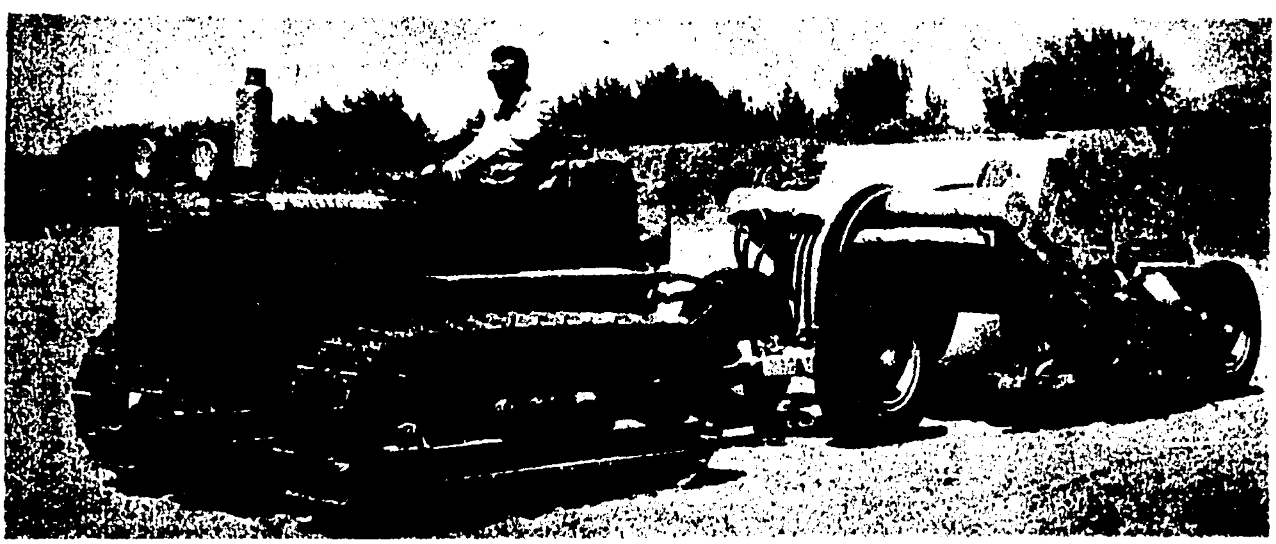
(3) The sponsoring authority should preferably remain the same so that it will be possible for such sponsoring authority to initiate follow-up action in regard to the recommendations and decisions made at the Seminar.

(4) The papers to be introduced in the Seminar should be sent to the participants well in advance so that they may go through the papers more thoroughly before discussions on the papers are initiated at the Seminar. Time should not be lost in reading out the entire paper in the Seminar but the authors should present their papers by introducing only a short summary and the salient points.

This would allow more time to be spent in group discussions and to hear the views of the different country delegates. Such group discussions which we had last evening have really proved of great value to all the participants and I wish we could have more time for taking part in all the or some of the other group discussions as well.

In conclusion, I congratulate the I.C.A. for holding the Seminar, giving us opportunity to express our views and for making excellent arrangements for our stay here.

I would also extend cordial greetings on my behalf and on behalf of my countrymen to our host country. I shall fail in my duty if I do not express our warmest gratitude for the very nice arrangements made by the Government of Turkey in holding our meetings, showing us round the different projects and making our stay pleasant and enjoyable outside the Conference hours.



A 4 - cubic yard carryall and TD - 9 tractor used for land grading on large fields. A smaller bucket - type leveler (John Deere Killefer) may be seen in the left background.

Country Follow-Up Statement

IRAN

M. Ayazi

1. The results of this seminar were very usefu to the Iranian delegates, and we have gained con siderable information and experience.

2. Even though the time was limited we ha the opportunity to discuss our problems and ex hange ideas with delegates of other countries.

3. We believe it is desirable to hold such a seminar each year and rotate them in the different participating countries.

4. We wish to express our thanks to the Government of Turkey for being host for such a wonderful seminar.

5. We greatly appreciate the efforts of I.C.A in organizing this seminar which will have a great influence in developing Middle East countries.

Following are our recommendations in regard to improvement of irrigation and drainage practi ces in Iran :

a. Developing further the Irrigation Training Course, refresher courses and short courses.

b. Increasing the number of farm demonstrati ons through the Extension Service.

A comparison between a locally made and commercial ditcher. Note that the simple equipment is able to do an excellent job.

c. Irrigation and drainage services similar to the U. S. Soil Conservation Service should be organized to help the farmers with their irrigation problems.

d. Maintain close cooperation with I.C.A. and their technical and other aid programs.

e. Maintain close relationship with other Middle East countries for exchanging ideas and observing their problems and methods of solving them.

B.A. Malak of Pakistan and Saifuddin Shansab of Afghanistan exchange ideas with Naki Uner of Turkey on a technical problem.

Naki Uner and Mehmet Cansikmaz of Turkey demonstrate the trajectory method of measuring the flow of water from a pump.

A small Parshall flume gives a very accurate measurement of water flow with little head loss in the ditch.

Starting to irrigate with the border check method. A simple wooden gate structure controls the flow into the border check from the field supply ditch.

Note that the sheet of water is spread evenly over the border check. The width of the border check is determined by the rate of flow and slope of the land.

Country Follow-Up Statement

IRAQ

W. S. Shamma

Mr. Chairman, Ladies and Gentlemen : We have learned many facts at this seminar related to the field of agriculture and engineering. We have started some of them in Iraq such as : field demonstration blocks for different field crops : projects for soil reclamation concerning salinity, which is becoming a serious problem. Our present Government recommendation is to design both drainage and irrigation systems together. We have quite a few projects started already and some will be established for controlling floods and irrigation.

As a result of our observations we will recommend the initiation of other facts, especially experimental work on water requirement for each crop; and the use of different locally made equipment, which appears to us, quite efficient and practical for small farms.

We feel that we need further research on the different phases of Agronomy accompanying the agriculture engineering research such as using proper rotation, weed control, rate and date of seeding, method of tillage and planting for obtaining proper economical results as far as water consumption is concerned. Thus, for accomplishing efficient scientific results we are convinced that accurate data can be obtained by means of cooperation among agronomists, pathologists, entomologists, soil scientists, economists and agriculture engineers working together as a team on the different technical experimental work to improve crops and find concrete results which can be safely extended to the farmers through extension.

We believe holding such a conference yearly will be a good means of exchanging ideas and results and finding solutions to new problems. Within a few years, when enough information will be accumulated, we will have great pleasure to hold such a conference in Iraq.

We would like to express deep from our heart our appreciation and sincere thanks to the Turkish Ministry of Agriculture and I.C.A. for giving us this opportunity to exchange information, and for their hospitality and cooperation which will leave a pleasant memory.

Country Follow-Up Statement

LEBANON

Elie Chaya

1. I would like to see a seminar of this type held every year in the Middle East countries by rotation. Insofar as possible the same delegates should attend.

2. I would suggest that the time allowed for such a wide program seminar be at least two weeks.

3. I would like to have a copy of the detailed drawings of the light, home-made irrigation equipment we saw operating in Turkey.

4. Detail programs and papers for future seminars should be sent to the delegates well in advance so that they be prepared before arriving.

5. Thanks are hereby extended to the Turkish Government and the I.C.A. representatives along with my best regards and wishes for success.

Country Follow-Up Statement

TURKEY

Adem Karaelmas

1. It was a great pleasure for Turkey to have the opportunity to be the host country for this seminar.

2. This meeting has made it possible for a large number of Turkish participants to meet our brother delegates and discuss and exhange ideas on the subject of irrigation.

3. The seminar was very helpful in bringing out the fact that similar irrigation and drainage problems exist in all of our countries. We can work together in bringing about their solution.

4. We all agree that it is necessary to expand and improve our irrigation programs.

5. We will try to do our best to apply the recommendations of this seminar in our irrigation work.

6. I suggest that another seminar be arranged in the future so that we may further discuss our work and problems. Progress in establishment of better irrigation practices should be checked each year.

7. I would like to express the appreciation of the Ministry of Agriculture to International Cooperation Administration for financing this seminar and helping to organize it in Turkey.

RESOLUTIONS

The following four resolutions were proposed and unanimously adopted by the closing plenary session of the Seminar :

1. Seminars of this type are considered as an excellent means of disseminating information on irrigation practices useful to the Middle East and other adjoining countries, and it is wished that they be made an annual affair to be held in different countries by rotation.

2. Participants to future seminars should be appointed well in advance of the meeting and the same personnel should be considered for attendance insofar as possible.

3. An expression of appreciation is hereby extended to the Government of Turkey, particularly the Ministry of Agriculture, for its part in serving as host country for the Seminar and to the people of Turkey for the hospitality shown to the participants during their stay in Turkey.

4. An expression of appreciation is hereby extended to the American Girls' School of Izmir for making their facilities available for the Seminar, a fact which added materially to the success of the meeting.

Opening furrows with a one-horse cultivator prior to irrigation by the furrow method.

The group studies a furrow method demonstration.

A peach orchard irrigated by the furrow method. Irrigation layout was made by irrigation technicians of Turkish Ministry of Agriculture.

Agenda

September 1 & 2

Participants arrive in Izmir.

September 2

P.M. Official registration - Bristol Hall, American Girls School, Izmir, 15:00 - 19:00

September 3 - Monday

A. M. Opening Ceremonies 10:00 - 12:00, Parsons Hall Governor of Izmir Province, The Honorable Kemal Hadımli ; Ministry of Agriculture Representative, Bay Enver Erlat ; I.C.A. Representative, Mr. Norman Smith ;

Business Manager of American Girls School, Mr. E. C. Blake Announcements of Chairman, Vice-Chairman and Secretary ; Introduction of Participants and Guests ; Special Announcements

Lunch, 12:00 - 14:00

P. M. Country Reports 14:00 - 15:30

(10 minute report on current irrigation situation in each country to be given by a country participant.)

Intermission 15:30 - 15:45

Presentation and Discussion of Papers, 15:45 - 17:15

1. Irrigation Efficiencies, 15:45 - 17:15

September 4 - Tuesday

A. M. Presentation and Discussion of Papers (continued) 9:00 - 12:15

2. Irrigation Methods, 9:00 - 10:30

Intermission 10:30 - 10:45

3. Drainage Investigations and Relation of Drainage to Irrigation, 10:45 - 12:45

Lunch 12:15 - 14:00

P. M. Presentation and Discussion of Papers (continued) 14:00-18:30

4. Water Supply and Delivery Factors as Related to Efficient Water Use, 14:00 - 15:30

5. Economic and Farm Management Factors Related to Irrigation Farning, 15:30-17:00

Intermission 17:00 - 17:15

6. Farm Need and Farmer Interest Surveys, 17:15 - 18:30

September 5 - Wednesday

Field Workshop - Trip to Menemen Area

A. M. Irrigation equipment operations & Irrigation Methods, 7:30 - 12:00

Lunch, 12:00 - 14:30

P. M. Activities of Menemen Irrigation Experiment Station, 14:30 - 18:30

September 6 - Thursday

Field workshop - Trip to Manisa, Gediz Valley & Demirkopru Dam, 7:00 - 18:00

September 7 - Friday

A. M. Presentation and Discussion of Papers (continued), 9:00 - 12:15

7. Extension or Service Organizations to Work with Farmers, 9:00 - 10:30
Intermission, 10:30 - 10:45
8. Training Needs and Courses, 10:45 - 12:15
Lunch, 12:15 - 14:00

P. M. Panel Discussions, 14:00 - 18:00

September 8 - Saturday
A. M. Completion of Presentation and Discussion of Papers
9. Dangers and Results of Poor Irrigation Practices
Presentation of Panel Reports and Recommendations
1. Land Preparation Factors, and Farm Irrigation Equipment
2. Irrigation Research as Related to Efficient Irrigation Practers
3. Soils Data, Water Requipments and Drainage
4. Extension Service Operations Programs and Technician Training
5. Farm Water Delivery and Irrigation System Operations

Roster Of Delegates

IRAQ :

Fathalla Said Orege, Engineer, Irrigation Division, Ministry of Agriculture, Baquha, Iraq.
W. S. Shamma, Director of Field Crops Division, Ministry of Agriculture, Abu-Kraib Baghdad, Iraq.
Fred Locher, I.C.A., Chief of Natural Resources, Ministry of Agriculture, % American Embassy,, Baghdad, Iraq.
James S. Reger, I. C. A., Drainage Engineer, Irrigation Directorate, Ministry of Agriculture, % A merican Embassy, Baghdad.
J. B. Smith, Irrigation Specialist, Ministry of Agr. culture, College of Agriculture, I.C.A.-University of Arizona, c/c Amerikan Embassy,
Baghdad, Iraq.
Warren E. Adams, Professor of Agricultural Economics, Ministry of Agriculture, College of Agriculture, I.C.A.-University of Arizona (Mailing address: c/o American Embassy, Baghdad.)

AFGHANISTAN :
Saifuddin Shansab, Chief of Soil Laboratory Institute, Ministry of Agriculture, Karta 4 Aliabad, Kabul, Afghanistan. (For the school year of 1956-57, c/o Utah State Agriculture College, Logan, Utah.

INDIA :
M. P. Mathrani, Chief Engineer of Irrigation, Irrigation Ministry, 12 Circular Road, Patna, Bihar, India
D. Mookerjea, Officer on Special Duty, Central Water and Power Commission, Irrigation and Power Ministry, 99/5/11 Ballygune Place, Calcutta 19, India.
Sol Donald Resnick, Agricultural Engineering Advisor, TOM India, Planning and Development Department, Madhva Predeah State,c/o American Embassy, New Delhi, India.
Tom A. Clark, Water Resources Specialist, Irrigation Department, Ministry of Agriculture, c/o Amerikan Embassy, New Delhi.

IRAN :
Hooshang Vessal, Head of Technical Bureau of Irrigation, Irrigation Bongah, 544 Takhtjamshid Avenue, Teheran, Iran.
W. E. (Bill) Wheeler, Water Resources Advisor, USOM/Iran, Irrigation Corporation, Ministry of Agriculture, c/o American Embassy, USOM/Iran, Teheran, Iran (After October 3:- 15-3rd Avenue East, Kalispell, Montana USA).
Manoutchehr Ayazi, Head of Irrigation and Drainage Division, and Assistant of Agricultural Engineering Department, Ministry of Agriculture, Agricultural Engineering Dept., Teheran, Iran.
Aziz Memarbashi, Head, Agricultural Engineering Training Course and Technical Service to the Farmers, Ministry of Agriculture, Teheran, Iran.
Dr. Gh Tamaddoni, Assistant Professor, Agriculture, College of Karadj, University of Teheran, Agricultural College of Karadj, Iran.

Ibrahim Kulahtaş of Manisa expresses his opinion on improved irrigation practices during a visit to his farm. Naki Uner translates.

Farmer cooperation is discussed during workshop lunch hour. Lunch was provided for Seminar participants by a group of Menemen farmers.

PAKISTAN :

Bashir Ahmed Malak, Director, Water Development Organization and Pakistan Irrigation Commissioner, Government of Pakistan, Bengal House, Mauripore Road, Karachi, Pakistan.

Hugh Tolley, I.C.A., c/o American Embassy, Karachi, Pakistan, or A.P.O. 74, San Francisco, California.

EGYPT :

Russel E. Kilogore, Chief, Division of Agriculture, Land and Water Resources, Ministry of Agriculture and Public Works, c/o American Embassy, Cairo, Egypt.

LEBANON :

William T. Walters, I.C.A., Chief, Land Resources Branch, Division of Natural Resources, c/o American Embassy, Beirut.

Elie Chaya, Chief Design Engineer, National Litani Office, Rue Salam, Beirut, Lebanon.

S. W. Macksoud, Head, Division of Agricultural Engineering, School of Agriculture, American University of Beirut, Lebanon.

A. C. Ferguson, Professor of Agronomy, American University of Beirut, Beirut, Lebanon.

TURKEY :

Adem Karaelmas, Director, Irrigation and Soils Section, Ministry of Agriculture (Ziraat Vekâleti), Ankara, Turkey.

Muzaffer Alap, Director of Irrigation Research Institute, Ministry of Agriculture, Sulu Ziraat Inst. Md., Tarsus, Turkey.

Naki Uner, Irrigation Specialist for Ege Region, Irrigation and Soil Section, Ministry of Agriculture, Izmir, Turkey.

Ziya Çekel, Director of Irrigation Experiment Station at Menemen, Ministry of Agriculture, Sulu Ziraat Inst. Md, Menemen, Turkey.

Cemal Koroglu, Director of Irrigation Experiment Station at Çumra, Ministry of Agriculture, Sulu Ziraat Inst. Md., Çumra, Turkey.

Faik Çolpan, Director of Irrigation Experiment Station at Eskişehir, Ministry of Agriculture, Sulu Ziraat Inst. Md., Eskişehir.

Şeref Ozgul, Agricultural and Economic Section, Devlet Su Işleri, Ministry of Public Works, Ankara, Turkey.

Suha Kemahlioğlu, Agriculture and Economics Section, Devlet Su Işleri, Ministry of Public Works, Ankara, Turkey.

Mustafa Ayyildiz, Faculty of Agirculture, University of Ankara, Ankara, Turkey.

Sedat Vidinlioglu, Irrigation Specialist, Nazilli Technical Group, Ministry of Agriculture, Nazilli, Turkey.

Nurettin Madran, Agricultural Director, Manisa Teknik Ziraat, Ministry of Agriculture, Manisa, Turkey.

Mehmet Cansikmaz, Irrigation Specialist, Manisa Teknik Ziraat, Ministry of Agriculture, Manisa, Turkey.

Servet Arer, Irrigation Specialist, Izmir Teknik Ziraat, Ministry of Agriculture, Izmir, Turkey.

Cemil Pasiner, Director, Land Reclamation Section, State Farms Department, Ministry of Agriculture, Ankara, Turkey.

Nurhan Markoç, Assistant Director, Land Reclamation Section, State Farms Department, Ministry of Agriculture, Ankara, Turkey.

Selâhattin Güman, Director, Micro-climate Section, Meteorological Bureau, Ankara, Turkey.

Boris Hristof, Hidrojeoloji Enstitüsü, İstanbul Teknik Üniversitesi, İstanbul, Turkey.

Carl M. Forsberg, Chief, Soil and Water Resources Team, USOM/T Irrigation and Soils Section, Karanfil Sokak 52, Ankara, Ankara, Turkey.

James D. Metzger, Irrigation Advisor, USOM/T, c/o American Consulate, Izmir, Turkey.

Norman L. Smith, Deputy Chief, Food, Agriculture & Natural Resources, USOM/T, 349 Ataturk Bulvari, Ankara, Turkey.

Jack Steele, USOM/T, Professor of Irrigation and Drainage, University of Ankara, 163 Ataturk Bulvari, Ankara, Turkey.

Keith E. Davis, USOM/T, Soil Scientist, c/o American Embassy, Ankara, Turkey.

Irwin R. Hedges, Chief Food, Agriculture & Natural Resources, USOM/T, 349 Ataturk Bulvari, Ankara, Turkey.

Determination of Water Necessary to Refill the Soil to its Moisture-holding Capacity

1	2	3	4	5	6	7	8	9	10
Depth, in feet	Soil texture [1]					RAM [2] holding capacity (inches)	Soil Moisture before irrigation [3]		Moisture storage capacity [4] (inches)
	V	H	M	L	C		Percent	Depth (inches)	
TOTAL	--	--	--	--	--		-------		

USDA-SCS

[1] Check proper space to indicate texture. V = Very heavy; H = Heavy; M = Medium; L = Light; C = Coarse.

[2] Readily Available Moisture soil will hold, in inches of water per foot depth of soil. Under average conditions, the amounts for the various soils are about as follows:

Very heavy	(V)	- 2.00
Heavy	(H)	- 2.20
Medium	(M)	- 2.00
Light	(L)	- 1.25
Coarse	(C)	- 0.75

[3] Use "Practical interpretation chart" for soil moisture determination. (See next page.)

[4] Moisture storage capacity is column 7 minus column 9 or the total readily available moisture holding capacity of the soil minus moisture already in the soil before the irrigation. This is the amount of water required to bring the moisture up to the water-holding capacity of the soil in the root zone.

Practical Interpretation Chart for Soil Moisture

Percent of RAM Remaining	Feel or appearance of soils			
	Coarse	**Light**	**Medium**	**Heavy and very heavy**
0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked, sometimes has loose crumbs on surface.
50 or less	Still appears to be dry; will not form a ball with pressure.*	Still appears to be dry; will not form a ball.*	Somewhat crumbly, but will hold together from pressure.	Somewhat pliable, will ball under pressure.*
50 to 75	Same as Coarse Texture under 50 or less.	Tends to ball under pressure but seldom will hold together.	Forms a ball,* somewhat plastic; will sometimes slick slightly with pressure.	Forms a ball; will ribbon out between thumb and forefinger.
75 to field capacity	Tends to stick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers; has a slick feeling.
At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as Coarse.	Same as Coarse.	Same as Coarse.
Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water forms on surface.

USDA-SCS

*Ball is formed by squeezing a handful of soil very firmly with fingers.