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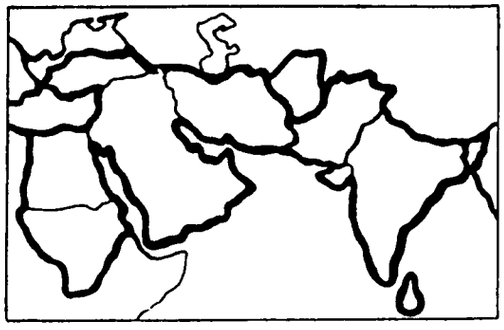


NESA REGION

Office of Agriculture
Bureau for Technical Assistance
Agency for International Development
Washington, D. C. 20523

LAHORE, PAKISTAN

15-26 FEBRUARY, 1960

Sponsored By

GOVERNMENT OF PAKISTAN
AND
U. S. INTERNATIONAL COOPERATION ADMINISTRATION

PARTICIPATING NATIONS

- CEYLON
- INDIA
- IRAN
- JORDAN
- LEBANON
- PAKISTAN
- SUDAN
- TURKEY
- UNITED STATES

FOREWORD

In the Near East-South Asia region, irrigation has been practised for a long time—beyond the memory of man. Today, more than ever, the nations of this region need increased and better irrigation, first to provide an adequate food supply, and second, to support a sound basic agricultural industry on which to build national wealth. Fortunately, modern technology can provide the means for expansion of irrigation, and works necessary to greatly increase water supplies and distributaries are well under way. Now the nations face the task of efficient consummation of the use of this water on the land and of conserving the land from salinity, waterlogging and other depreciation inherent under irrigation. The task of doing this comes under the broad heading of *Irrigation Practice*. Here, not only is science and technology involved,but responsible government officials are pre-occupied with how to implement better irrigation practice; when major joint action of government, the farm population, collectively and individually, and practically every other element of society is required. Thus the responsible irrigation officials of the nations have many common problems and can greatly benefit by mutual discussion and exchange of ideas in *Irrigation Practice*.

Recognizing this need, the United States Operations Missions in the region planned a series of seminars at which such officials could so participate. The first was held in 1956 at Izmir, Turkey, and the second, in 1958 at Tehran, Iran. Each was sponsored jointly by the respective government and the U.S. International Cooperation Administration.

Following the Tehran Seminar, the Government of Pakistan invited the nations to hold the third session in Lahore in 1960. This invitation was accepted and the U.S. International Cooperation Administration joined with that host government as co-sponsor. All of the participating nations shared in the responsibility of making the plans for the Seminar and in preparing and conducting the program.

One evident achievement of this Seminar was in bringing to the notice of both the public and the high government officials a relatively new field in which science and technology can play an important role to boost food production. This field has been neglected in the NESA region. Irrigation was usually brought to the door of a cultivator and in the absence of a proper extension service, the water could be used without paying due regard to its proper application on land. In most cases, serious soil maladies are thus the result of improper irrigation practice.

The objectives of the 1960 Seminar were:

(1) To review the problems in irrigation practices; the achievements of the previous seminars; and the progress made in forwarding new practices since the 1958 Seminar.

(2) Exchange technical ideas and opinions concerning mutual problems in irrigation practice.

(3) Discuss ways and means of forwarding sound practices in the participating countries.

(4) Outline local training needs and plans for implementation.

The deliberations of the Seminar are published herewith. Due to the capability, hard work and enthusiasm of the delegates, we believe the objectives have been achieved.

A. G. ASGHAR

DEAN F. PETERSON

SPONSORS

●

HOST

THE GOVERNMENT OF PAKISTAN

●

CO-SPONSOR

U.S. INTERNATIONAL CO-OPERATION ADMINISTRATION

DELEGATES

CEYLON

V.N. Rajaratnam, Assistant Director of Irrigation (Leader).
S. Kanagaratnam, District Agricultural Extension Officer.
V.E.A. Witramanayake, Lecturer in Agri. Engineering, University of Ceylon.
M.M. Ismail, Superintending Engineer, Gal Oya Dev. Board.
S.I. Phillippi, Water Resources Advisor, USOM/Ceylon.
Tom A. Clark, Water Resources Engineer, USOM/Ceylon.

INDIA

Yadava Mohan, Member CWPC, Ministry of Irrigation and Power (Leader).
J.P. Mital, Irrigation Advisor, Ministry of Community Development and Cooperation.
J.E. Stephenson, Chief Engineering Branch, Industry Div., TCM/India.
Edward M. Davis, Soil Conservation Advisor, TCM/India.
Alan M. Gibson, Agricultural Engineer, TCM/India.
Guy A. Hummon, Regional Agricultural Extension Advisor, TCM/India.

IRAN

Sadegh Ahi, Agriculture Director, Agriculture, Plan Organization (Leader).
Manquchehr Ayazi, Assistant Director, Agriculture Engineering Dept.
Mohammad Rejali, Engineer, Irrigation Bongah.
Fatollah Raji, Engineer, Irrigation Bongah.
G.A. Tamoddoni, Associate Prof. Karadj College of Agriculture.
Bruce Anderson, Advisor, Agriculture Engineering Dept., USOM/Iran.

JORDAN

Fahed Natour, irrigation Engineer, East Ghor Canal Authority.
Jamil Elyafi, Asst. Agri. Research Officer, Scientific Research Dept.
Sami Toufaha, Irrigation Engineer, Ministry of Agriculture.

LEBANON

Salim W. Macksoud, Interim Dean, Faculty of Agri. Sciences, AUB (Leader).
Halim Najjar, Director General, Ministry of Agriculture.
J.H. Sawaya, Chief Irrigation Engineer, Litani River Authority.

PAKISTAN

S.I. Haque, CSP, Development Commissioner, West Pakistan.
A.G. Asghar, Director, Land Reclamation, West Pakistan (Leader).
Mohd. Ibrahim, Chief Engineer, Water Organization, G.O.P.
Aulad Hussain, Chief Engineer, WAPDA, East Pakistan, Dacca.
M.S. Qureshi, Chief, Irrigation Section, Planning Commission, G.O.P.
Ali Asghar, WPASI, Extension Advisor, V-AID Administration.
Nasim Mahmud, P.C.S., Director, V-AID Admin., West Pakistan.
Abdul Hamid, Research Officer, Soil and Water Testing Wing (GWDO).
Nazir Ahmed, Physicist, DIR Institute.
Sayyid Hamid, Deputy Chief Engineer, Water and Power Development Authority.
A.M. Sheikh, Director of Agriculture, West Pakistan, Lahore.
Khan Fazalur-Rahim Khan, Joint Director of Agriculture, West Pakistan.
Hafiz Saeed Ahmad, Extension Service Officer, Soil Reclamation Board.
M.S. Minhas, Director Designs, Water and Power Development Authority, East Pakistan.
K.F. Vernon, Chief Public Works Div., USOM/Pakistan.
Ray E. Davis, Food and Agriculture Officer, USOM/Pakistan.
J.W. Robison, Deputy Chief Public Works Div., USOM/Pakistan.
E.F. Landerholm, Provincial Agriculturist, USOM/Lahore.
Fred M. Tileston, Irrigation Engineer, ICA/Parsons, Lahore.

SUDAN

Sayed Elias Dafalla, Asst. Director, Ministry of Irrigation and Hydro-electric Development (Leader).
Sayed Yahia Abdul Mageed, Chief Hydrologist, Ministry of Irrigation and Hydro-electric Development.
Sayed Kamil Mansour, Sr. Inspector Agri., Min. of Agriculture.
Marshall Young, Agricultural Engineer, Irrigation USOM/Sudan.

TURKEY

Cemil Kaleli, Agriculture Engineer, Soil Conservation and Farm Irrigation Division (Leader).
Nevzat Ozlap, Assistant Director, Irrigation Research Institute, Menemen.
Ragip Boyaci, Asst. at Irrigation Research Institute, Tarsus.
Thomas F. Ramsay, Agri. Irrigation Engineer, USOM/Turkey.

AFGHANISTAN

Walter Begley, Irrigation Farming Advisor, USOM/Afghanistan.

I.C.A. WASHINGTON

Malcolm Jones, Chief Water Resources and Equip. Branch, O/Foods.
Dean F. Peterson, Dean of Engineering, Utah State University, Senior Leader, O/Foods.

OFFICIALS

General Chairman	*Senior Leader Pakistan*	*Senior Leader U. S. A.*
MR. S. I. HAQUE	DR. A. G. ASGHAR	DR. DEAN F. PETERSON

INAUGURAL ADDRESS

Field Marshal Mohammad Ayub Khan, President of Pakistan

Field Marshal Mohammad Ayub Khan, President of Pakistan, addressing the Seminar

Mr. Chairman and Gentlemen :

I have pleasure in inaugurating this Regional Seminar on Irrigation Practices and extend my heartiest welcome to the delegates. In fact, it is always a source of pleasure to me when I find different nations sittiug together and pooling their resources both material and intellectual for the betterment of humanity. Man can only achieve glory if mutual co-operation and assistance are recognised as a fundamental human obligation. Frankly, the more prosperous nations of the world can enjoy the full measure of prosperity only when they share their knowledge and experience with nations who have, through accidents of history, been left behind in the march of time.

I wish to take this opportunity of expressing my appreciation of the help which the International Cooperation Administration of U.S.A. has given in arranging this Seminar.

As you know, in West Pakistan, we have the most extensive irrigation system and the largest single contiguous irrigated area, but I feel that its development and preservation has not been pursued in the past on sound principles. In fact, careless exploitation of soils through unscientific practices has created some very serious problems. The prosperity which we once enjoyed with respect to food production, I am afraid cannot be maintained for the future unless we undertake energetic and comprehensive measures to attack these problems from all sides in a scientific way. This is the right moment, where this body of experts can help us to evolve procedural or organisational methods which our farmers can employ for the improvement of irrigation practices for greater and better production of food and fibre.

A problem which has assumed menacing proportion for us in West Pakistan is that of salinity and waterlogging, affecting several million acres of land. Almost one hundred thousand

acres go out of cultivation every year. We have set up the Water and Power Development Authority primarily to deal with this grave situation. The Water & Power Development Authority has prepared a plan for installing over 2,000 tubewells in an area of over one million and a half acres. It is hoped that these tube-wells will be in a commission by 1961.

Planning

We have constituted a body of experts who will advise us on our future planning with respect to the promotion of agriculture and allied industries. I believe that for the achievement of progress in any branch of human activity a certain tempo has to be created and maintained which takes the workers in its stride towards the ultimate goal. I am fully sure that if we properly manage production from land which is our greatest capital, we cannot fail in our endeavours. We hope to take specific measures in this regard on the findings of the proposed Agricultural Commission.

It is universally recognized that the cultivator is the key man who has to be considered in planning construction investment and extension which ultimately aim at increased production from land. In our efforts to develop farm organisation we must keep in mind that it would match the all-round pattern of rural life and must emerge as an institution with a social and spiritual outlook as well as an agency for imparting technical know-how so that the research and cultural enterprises of such an organisation entitle it to recognition as a counter for the farmers' betterment. All future programme, therefore, must aim at increasing the cultivators' income. I presume that you also have to face an uphill task in your respective countries and have to put in immense efforts and persistent persuations to overcome inertia and reluctance to change which our cultivator has plenty to offer. If the cultivator can accept an integrated philosophy of irrigated agriculture, which I hope you will successfully espouse during your deliberations in this seminar, you will have done immense service to humanity. For it will, indeed, be a tremendous achievement if you succeed in creating in the consciousness of the farmer an urge for better utilisation of water for irrigation purposes with a view to increase and improve production.

I wish all success to the deliberations of this Seminar and sincerely hope that besides fulfilling its objectives of furthering the cause of the farmers, it would result in increasing co-operation and friendship between the scientists and technicians of the various countries of the world.

Governor of West Pakistan, Mr., Akhtar Hussain watching the display of books and photo arranged by USIS Lahore, for the Seminar. With him are (Left) Dr. A. G. Asghar, Mr. S. I. Haque, Chairman of the Seminar (Right) US Delegate, Dean Peterson.

PROGRAM

Third NESA Irrigation Practices Seminar

ASSEMBLY CHAMBER, LAHORE, February 15, 1960

Monday, February 15

A.M.

0800 .. Registration, Assembly Hall.

0900 .. *General Session*, Mr. S.I. Haque, Development Commissioner, West Pakistan, Chairman.

Welcome by the Chairman.
Address, Field Marshal Mohammad Ayub Khan, President of Pakistan.
Address, Mr. Kenneth F. Vernon, Chief, Public Works Division, USOM/Pakistan.

1030 .. *Technical Session*, Mr. S.I. Haque, Chairman.
Introduction of delegates.
Country Reports
Ceylon, presented by Mr. V.N. Rajaratnam*
Iran, presented by Dr. S.M. Ahi.
Lebanon, presented by Prof. S.W. Macksoud, Lebanon.

P.M.

1400 .. *Technical Session*, Pir Mohammad Ibrahim, Chief Engineer, Water Organization, Government of Pakistan, Chairman.
Country Reports (continued)
Pakistan, presented by Dr. A.G. Asghar.
Sudan, presented by Syed Elias Defalla.
Discussion of country reports.

1615 .. Visit Shalimar Gardens.

Tuesday, February 16

A.M.

0900 .. *General Session*. S.I. Haque, Chairman.
Address, Mr. Akhtar Hussain, Governor of West Pakistan.
Address, "Farmer and Government Responsibility in Irrigated Agriculture in Iran", Dr. S.M. Ahi, Agr. Director, Plan Organization.

1100 .. *Technical Session*. Sayed Elias Defalla, Asst. Director, Ministry of Irrigation and Hydro Electric Development, Sudan, Chairman.
Water Requirements for Crops
"Use of Electric Resistance Units in a Modified Soil Moisture Study for Determining the Consumptive Use of Corn Grown on the Bekaa Plain, Lebanon" given by Prof. Salim W. Macksoud, Lebanon.

* Titles of official delegates are given in the "List of Delegates".

"Water Requirements for Crops—Pakistan" given by Abdul Hafiz, Asstt. Land Reclamation Officer, Land Reclamation Directorate, W. Pakistan.
"Consumptive Use of Water in Iran" by Engineers A. Rejali and F. Raji. Presented by Eng. Rejali, Iran.

Discussion.

P.M.

1430 .. *Technical Session.* Dr. S.M. Ahi, Iran, Chairman.

Land Drainage and Reclamation
"Drainage and Reclamation Problems in Garmsar, Ghezelhessar and Shabankareh by Eng. M. Ayazi, Iran.
"Requirements for a Successful Plan of Land Drainage and Reclamation" by James S. Reger, Presented by Malcolm Jones, USA.
Discussion

Evening

Dinner for Delegation given by Mr. S.I. Haque, Gymkhana Club.

Wednesday, February 17

A.M.

0900 .. *Technical Session.* Prof. S.W. Macksoud, Lebanon, Chairman.
"Clearing House for Country Problems" by the delegates.
"Distribution System of Irrigation Projects in Pakistan" by Dr. A.G. Asghar, Pakistan.
"Designs of Distribution Systems to Serve Small Holdings" by V.N. Rajaratnam, Ceylon.

Discussion

1100 .. Inauguration of President Ayub by Radio.

P.M.

1430 .. *Committee Sessions*

Committee I	Education and Training.
Committee II	Organization for Operation and Management.
Committee III	Agricultural Requirements for Irrigation Programs.
Committee IV	Consumptive Use and Water Requirements.
Committee V	Assistance to Farmers for Improved Irrigated Agriculture.

Thursday, February 18

A.M.

0930 .. Attend Inaugural Session of West Pakistan Engineering Congress, University Hall.

1130 .. *Technical Session,* V.N. Rajaratnam, Ceylon, Chairman.
Research and Demonstration Farms.
"Tarsus Irrigation Research Institute of Turkey" by Ragip Boyaci, Turkey.
"Development and Demonstration Farms" by Edwin F. Landerholm, Provincial Agriculturist, USOM/Lahore, Pakistan.
Discussion.

1530 .. Reception given by Mr. Akhtar Hussain, Governor of West Pakistan—Government House.

Friday, February 19

0800 .. *Field Trip*
Visit Chuharkana and Chakanwali Reclamation Farms.
Lunch, Chakanwali Reclamation Farm.

1700 .. Visit to Jehangir's Tomb. Tea. Lahore Corporation.

Saturday, February 20

A.M.

0900 .. *Technical Session.* Cemil Kaleli, Turkey, Chairman.
Opportunities for Education and Training.
Ceylon, V.E.A. Wickramanayake.
India, Yadava Mohan.
Iran, Gh. Tamaddoni.
Lebanon, S.W. Macksoud.
Pakistan, M.S. Minhas and A.G. Asghar.
Sudan, Kamil Mansour.
Turkey, Cemil Kaleli.
Jordan, Fahed Natour and Sami Toufaha.

P.M.

1430 .. *Field Trip*—Visit Balloki Headworks.

Monday, February 22

A.M.

0900 .. *Technical Session.* Yadava Mohan, India, Chairman.

Country Reports
Jordan, presented by Sami Toufaha.
Turkey, presented by Cemil Kaleli.
Visit by Agricultural Commission of Pakistan.
Project Planning for Ultimate Water Use.
"India's Experience in Placing Large Area Under Irrigation" by Yadava Mohan, India.

Discussion.

1200 .. *General Session.* S.I. Haque, Chairman.
Address. Lt.-Gen. Mohammad Azam Khan, Minister of Agriculture and Irrigation, Pakistan.

P.M.

1400 .. *General Session.* S.I. Haque, Chairman.
Address by James S. Killen, Director, USOM/Pakistan.

1445 .. *Technical Session.* S.I. Haque, Chairman.
Project Planning for Ultimate Water Use, continued.
"Harnessing the Rivers of East Pakistan" by M. Chowdhury, Chief Engineer (Irrigation) East Pakistan, Paper read by M.S. Minhas, East Pakistan.

Discussion and Committee Meetings

Tuesday, February 23

A.M.

0700 .. *Field Trip*
Visit Moharanwala Reclamation Farm.
"Water Requirements for Crops Under Lyallpur Conditions" Prof. M.S. Gill, Punjab College of Agriculture.
"Soil Moisture Plant Relantionship Experiments" Dr. Carl Larson, Advisor, Punjab College of Agriculture.

1230 .. *Lunch.* Courtesy Saigol Farm.

P.M.

1400 .. "Water Requirements for Cotton" A. Wahab, Lecturer, Punjab College of Agriculture.

1430 .. Irrigation Demonstration, Saigol Farm. Rafique Saigol.

1500 .. Visit Punjab Agr. College. Dr. A. Sattar, Principal.

Wednesday, February 24

A.M.

0900 .. *Technical Session*, Sami Toufaha, Jordan, Chairman.
Project Planning for Ultimate Water Use, (Contd.)
"Irrigation and Farm Planning on the East Ghor Canal Project" by Sweilem Hadded, Project Engineer and Fahed S. Natour, Irrigation Engineer, presented by F. Natour.
"The Administration and Operation of Irrigation in the Litani Project" by Halim Najjar.

P.M.

Attend Pakistan Horse and Cattle Show and Police Tatoo.

Thursday, February 25

A.M.

0900 .. *Technical Session.* V.N. Rajaratnam, Ceylon, Chairman.
Practical Problems of the Irrigation Farmer. Panel Discussion of When and How to Apply Water to Crops" led by H.S. Zaidi, Research Officer, Soil Chemistry, Land Reclamation Directorate, West Pakistan.
"Crop Rotation for Salinity Control" led by Manzoor Ahmed, Asst. Research Officer, Soil Survey, West Pakistan.

Farm Drainage led by A. Ayazi, Iran.

1115 .. *General Sessions.* S.I. Haque, Pakistan, Chairman.
"Appreciation to Pakistan for Horse Show and Tattoo" for the delegates, Alan M. Gibson, India.
Committee Reports and Discussion
Led by Chairman of Committees.

P.M.

1230 .. *Lunch.* Mr. D. Alan Strachan, Assistant Director USOM to Pakistan.

1430 .. *General Session.* S.I. Haque, Pakistan, Chairman.
Committee Reports and Discussion.
Led by Chairman of Committees.
Recommendation on Drainage.
Report of Executive Committee.
Closing Statements.

S.W. Macksoud, Lebanon, for the delegates.
Macolm Jones, U.S.A.
Dean F. Peterson, U.S.A.
A.G. Asghar, Pakistan.
S.I. Haque, Pakistan.

1700 .. *Adjournment.*

CONTENTS

Foreword ..... *i*
Sponsors and Delegates ..... *iii*
Inaugural Address ..... *v*
Program ..... *vii*

CHAPTER I

General Session

Welcome Address, Mr. S.I. Haque 2
Address, Mr. Kenneth F. Vernon 3
Address, Governor Akhtar Hussain 6
Address, Dr. S. M. Ahi 8
Address, Lt.-General Mohammad Azam Khan 11
Address, Mr. James S. Killen 14
Pakistan Commission on Food and Agriculture 18
General Business 19

CHAPTER II

Recommendations

Education and Training 23
Consumptive Use and Water Requirements 24
Agricultural Requirements of Irrigation Projects 25
Assistance to Farmers for Improved Irrigated Agriculture 26
Drainage and Salinity Control 27
Organization for Operation and Management 28
Discussion Groups for Recommendations 30

CHAPTER III

Country Reports

Ceylon 31
India 37
Iran 45
Jordan 49
Lebanon 52
Pakistan 55
Sudan 64
Turkey 68

CHAPTER IV

Opporunities for Education and Training in Irrigation

Ceylon 73
India 74
Iran 74
Jordan 79
Lebanon 80
Pakistan 84
East Pakistan 85
Sudan 85
Turkey 86
Discussion 87

CHAPTER V

Clearing House for Country Problems

USOM/Afghanistan 89
Ceylon 90
Iran 90
Lebanon 92
Pakistan 92
Sudan 94

CHAPTER VI

Practical Problems of Irrigation Farming

When and How to Apply Water to Crops 95
Crop Rotations for Irrigation and Salinity Control 97
Farm Drainage 101

CHAPTER VII

Field Trips

Chuharkana and Chakanwali 105
Lyallpur 106
Balloki Headworks 107

CHAPTER VIII

Technical Papers

A. Water Requirements and Consumptive Use

Use of Electrical Resistance Units in Lebanon..... 109
Pakistan Report on Water Requirements..... 112
Consumptive Use of Water—Investigations in Iran..... 113

B. Land Drainage and Reclamation

Investigation and Planning Three Projects..... 121
Problem of Irrigated Agriculture in the Punjab, India..... 135
Requirements for a Successful Plan of Land Drainage and Reclamation..... 137

C. Distribution of Water

Distribution System of Irrigation Projects in Pakistan..... 141
Distribution System to Serve Small Holding 151

D. Research and Demonstration Farms

Tarsus Research Institute of Turkey..... 161
Experimental and Demonstration Farms in East Pakistan..... 169
Development and Demonstration Farms..... 172

E. Project Planning for Ultimate Water Use

India's Experience, Problems and Plans for Placing Large Areas of Agricultural Land Under Irrigation..... 175
Harnessing the Rivers of East Pakistan..... 182
Administration and Operation of Irrigation in the Litri Project 188
Irrigation and Farm Planning on the East Ghor Canal Project.... 191

GENERAL SESSIONS

- *Mr. S. I. Haque*
- *Mr. Kenneth F. Vernon*
- *Mr. Akhtar Hussain*
- *Dr. S. M. Ahi*
- *Lt.-Gen. Mohammad Azam Khan*
- *Pakistan Commission on Food and Agriculture*
- *General Business*

ADDRESS OF WELCOME

MR. S. IKRAM'UL-HAQUE, CSP,

Commissioner Development and Secretary to Government, West Pakistan, Planning and Development Department.

Mr. President, Fellow delegates and distinguished visitors.

It is a great privilege for me to extend to the delegates to this Seminar, a warm and hearty welcome. May I also, on behalf of this gathering, heartily thank our President, Field Marshal Mohammad Ayub Khan, for having very kindly acceded to our request to inaugurate this Seminar. I am sure that the deep interest he has in scientific pursuits and for the betterment of humanity will be a source of great encouragement to us in our deliberations.

I am also grateful to the eminent and leading experts from abroad, who have travelled a long way, at considerable personal inconvenience, to participate in this Seminar. Their assistance and advice in tackling our irrigation problems will, I am sure, be most valuable. Such representative gatherings afford a unique opportunity for discussion of problems of mutual interest and for exchange of ideas and experiences.

I am sure you would like me to convey our thanks to the International Cooperation Administration of U.S.A. for having extended all possible assistance to us in arranging and organizing this Seminar, which is the third of its series.

One of the most pressing problems with which the world is confronted today is the shortage of food. In the present period of human history when, owing to the decreasing death rate and high birth rate, production is finding it increasingly difficult to keep pace with the demands of a growing population, the need for the application of modern scientific methods in this particular field cannot be over-emphasised.

Pakistan like any other Near East and South Asia country faces the serious problem of soil salinity and shortage of water. It is known with certainty that due to this menace very large acreages are going out of cultivation every year and that a considerable area of arable land has already been lost. I hope that we can contribute to the solution of these problems by pooling knowledge through our deliberations at this Seminar.

As you are well aware that the objectives of this Seminar are:

(1) Advancement of agricultural improvement throughout the region;
(2) Support of every country's effort and exchange of information regarding common problems;
(3) Creation of interest in spreading information through agricultural and engineering bodies, to give farmers of these countries knowledge of better irrigation methods and the effects of such practices on better farm production and living standards.

These, I am sure, will afford a very wide field for discussion. The problems will, no doubt, vary to some extent from area to area. To all these, experts will find suitable answers. As is known, our own soil and water problems created by unscientific irrigation practices are seriously retarding our efforts to become self-sufficient in food. Pakistan's Soil Scientists and irrigation experts have made very useful contributions towards tackling these problems. The experience gained by their colleagues in other countries would undoubtedly be beneficial to them in their task. I do hope that the recommendations made by this Seminar will be accepted and adopted by the various countries represented here.

Let me say once more that it is extremely gratifying to find a large number of distinguished experts from many countries assembled here. It is a happy augury not merely for the furtherance of the cause for which we have assembled but also for the future development of the Near East and South Asia countries. Indeed it is a great privilege to welcome you all to this historic city of Lahore and I hope that you will enjoy your stay in this City.

With these few words, I now request Field Marshal Mohammad Ayub Khan, President of Pakistan, kindly to inaugurate this International Seminar on Irrigation Practices.

ADDRESS

by
KENNETH F. VERNON
Chief, Public Works Department, USOM to Pakistan.

Your Excellency, President Ayub, and Delegates to the Irrigation Seminar, and Friends,

I bring the apologies of Mr. Killen, the Director of USOM to Pakistan, that he could not be with us today for this opening session. Mr. Killen has just returned from an extended trip to Washington, D.C. and is at the present time heading in Karachi a conference of All-Mission personnel. Mr. Killen will attend this conference after the close of the Karachi conference. Other members of the Mission will also come to Lahore in a few days.

Mr. President, you see here delegates from ten countries in the Near East and South Asia region. All of them are the top people in their countries dealing with the day-to-day problems of irrigation and agriculture. This Seminar will provide an opportunity for exchange of ideas and for tackling common problems.

I wish to express to you, Mr. President, the thanks of the delegates for taking the time from your many pressing duties to be with us. We believe that your doing so is a measure of the importance you hold our work.

On behalf of the United States International Cooperation Administartion, who is co-host of this Seminar with the Government of Pakistan, I welcome to Lahore the delegates of the various countries participating. We are glad you are here and we hope that the time spent here may prove worthwhile to you in your efforts in your own countries. I would also like to greet and welcome all others who come as observers and friends who are interested in the work of the Seminar.

I wish also to acknowledge with extreme gratitude and pride the privilege extended to us, by invitation of the Government of Pakistan, to join with them in sponsoring this seminar. We are happy to do this and we are confident that this work which we are beginning here today will assist us all in the task that must be done in these great countries. The host government of Pakistan and the provincial governments of West Pakistan as well as East Pakistan have assumed great responsibility in undertaking this effort and a great many officials at all levels in each of these governments have done much work to make this seminar possible. We appreciate this effort and I extend my grateful thanks to each of them.

I also want to acknowledge the efforts of the participating countries. Each country has a responsibility to contribute technical material to the seminar and to bring its experience and wisdom to the deliberations of the panels and committees. I am grateful that these delegates and their governments have found the time and made the effort to do this. The countries here represented contain more than two-thirds of all of the irrigated lands in the world. It is in these countries that civilization first began and the practice of irrigated agriculture in these lands dated back to the very earliest records of civilization. Perhaps the need for community effort to capture a common water supply for crops and for animals was one of the important factors which first bound men into civilized communities.

It is quite fitting that this conference is held in Lahore. This location is central to the largest bloc of irrigated land in the world. Irrigation has been practiced in the Punjab for at least 5,000 years and perhaps longer. Here, in the 19th century, was developed some of the basic engineering principles of irrigation canal design and operation, and in this region are the largest irrigation canals in the world.

In all of the nations participating in this seminar, agriculture is the principal industry. In Pakistan, it is estimated that 85 percent of the people engage in agriculture in order to maintain a livelihood. I imagine this percentage applies fairly well throughout the entire region—an area having a population of three-fourths billion people. This vast and important area is almost entirely arid or sub-humid, or at best suffers grave moisture deficiencies during the crop season. This agriculture is highly dependent upon the ancient art of irrigation. The practice of irrigation agriculture so infuses itself in the economic and social habits of the communities of these countries that its practice is literally a "way-of-life".

It is also unfortunately true in the NESA area that food production is not keeping pace with the needs of an expanding population; crop yields are too low and cultivators and farmers are too poor

in the material possessions of this world. The hard facts of agriculture and food production in this area constitute one of the great major problems of humanity in the world today and are of major concern to the governments of the respective nations, all of their friends among the free nations and, I dare say, of every well-informed and humanitarian individual in the world. Certainly the United States wants to do all practicable to help abate the spector of starvation which haunts some of the people of the nations represented here.

Our target, however, is more than simply to avoid starvation. Our goal is that these nations shall share in the wealth which can be achieved by free, informed people using modern technology to develop and more fully use their resources. We want these nations to maintain a healthy, sound economy in their own right. This happy state of affairs will require that the cultivator's income rise, not only to the level of bare subsistence but much higher—to a level which permits him to purchase the consumer's goods, his nation's industries produce, to educate his children, and to pay taxes. To this we are dedicated. In this part of the world the practice of good irrigation agriculture is a vital element in achieving that result.

There are several ways in which food production and agricultural wealth can be increased. Obviously one way is to increase the area of cropped land. The nations here represented have taken the basic initial steps necessary to provide water supplies for this purpose through the construction of dams, reservoirs, diversion works and canal systems to serve great new areas of irrigated land. Vast sums of money and great technological efforts have been made available for this purpose. In Pakistan alone such works are under way to serve an additional 6,500,000 acres and plans are being developed for an additional 11,000,000 acres. Comparable efforts are being made by the other nations. The steps from completion of construction of an irrigation project to its consummation in terms of crops is ordinarily a long and difficult one beset with many problems of settlement, colonization, and technology. Experience in the United States has shown that usually at least one generation is required, and sometimes two or more, to finally bring new land to full production. We must now accelerate this process. We cannot wait this long. It is cultivator on the land who finally has to produce the crop; and this we should never forget. I would like to ask this question here today. Have the nations made efforts, comparable to those made for construction, to provide the man on the land with the know-how and the means other than water supply necessary to accomplish this very vital part of the task? I do not believe they have.

Another very obvious way to increase food production is to increase the yield per acre on existing cropped lands. This requires much less new capital investment than does conquering new lands and it also directly tends to improve the economic lot of the cultivator. In spite of this important possibility and the pressing need for more food, there is little evidence that yields per acre have consistently and generally increased over the past few years. Here again, the man who must eventually grow the crop is the cultivator. Should we not work harder to strengthen his hand in this?

A third way to improve food production is to stem the terrible tide of waterlogging and alkali that each year eats away at our precious agricultural lands. Each acre of irrigated land which loses its productive capability from this source makes sterile all of the vast public investment for irrigation works and private investment in money and time and sweat that has been made to bring it into production in the first place. Each such acre remains as a barren ugly monument to our failure. In spite of this, are we actually pushing back this tide of salt and alkali? I'm afraid the statistics show that we are not.

We must regard the man on the farm, the cultivator, as the front-line soldier in the battle for greater agricultural production. The task of all of us is to place in his hands the "know-how" and the tools to do the job. It is he who husbands the land and maintains its fertility and preserves it for the future; and who, over the years, builds its productive capacity. On his shoulders lies the final responsibility for winning or losing the fight against starvation. He needs the full support of his government and all of the services it can render on all fronts. Under a system of irrigated agriculture the cultivator must be supported with the necessary engineering works to provide him with the water when and as he needs it and with, equally as important, drainage. While these works may be simple on small projects they can become highly complicated on large ones, taxing all of the imagination and skill of the best engineers to plan, construct and operate them. Without good operating works the cultivator can not do his job; and without successful drainage, irrigated agriculture cannot long survive.

But the cultivator needs more than the engineering support provided by irrigation and drainage works. If he is to produce more he must take full advantage of modern science and technology. He must become a skilled technician and manager. He cannot possibly meet the responsibility which his government has laid on his shoulders by using eighteenth century knowledge and skill. The difference between the per-acre yields of today and those of tomorrow will depend upon how he utilizes his land, his water supply, his fertilizer and all of the new tools and techniques placed at his disposal. He must change, yet he cannot change in ignorance.

The NESA nations have begun the work of increasing food production and agricultural wealth. The final task falls on the cultivator. Let the nations provide him with the means to finish the job. They must assume the responsibility of seeing that he is taught how to apply water, how to preserve his soil and improve his crops. He must be provided with tools and credit and capital; and the disasterous risk of ruinous price fluctuation must be removed. He must have the full confidence in new methods that comes from understanding them. Only thus will he have the courage to use them. This program involves a mass effort of education on a scale probably never before undertaken. It will take money and effort—lots of both. This Seminar which we are opening here today is but one small step in such a program. but we hope its efforts may be multiplied many times in each of the countries here represented. The work is not glamorous and the path is discouraging and long, yet the task must be accomplished if we are to win our fight against starvation and poverty.

ADDRESS

MR. AKHTAR HUSSAIN
Governor, West Pakistan

It gives me great pleasure to address an international gathering of experts and scientists and to welcome the delegates to this seminar. The presence of distinguished delegates from abroad is a matter of special gratification for us as the chief aim of this seminar is to share the experience of scientists from other parts of the world. Personal contacts and discussions among scientists are, more than anything else, an effective means of promoting scientific achievement for the betterment of human destiny.

Asia is the largest of all the continents and comprises over one-third of the total land area of this planet. More than half the population of the world lives in Asia and the lot of the great majority of them is in abject misery and poverty. The economy of most Asian countries is largely agricultural and, owing to over-population, faulty systems of land-holding and technological backwardness, the largest number of Asians get a meagre subsistence from their agricultural pursuit.

It will need all the effort and techniques of modern science to lift this vast mass of humanity to an adequate standard of living by helping them to increase production. Irrigation practices have an important role in this connection.

The history of irrigation in this country goes back to ancient times. In the days of the Muslim kings, several canals were taken out of the rivers that flow through the Indo-Gangetic plains. Up to the present day, some of these ancient canals are functioning as inundation channels. If the name is any indication, the Sikandari Jala near Multan may have been dug in the reign of any monarch of the name of Sikander. There are several others, while traces of many more which fell into disuse, remain in the populous areas of the sub-continent.

The modern history of canal irrigation in this sub-continent begins from the year 1905 when the Agriculture and Irrigation Departments were established with the object of finding ways and means of increasing yield from crops. While an increasingly greater area of hitherto uncultivated land was brought under the plow. Irrigation practices and methods of agriculture were slow to change largely because the mechanical aids, which revolutionised agriculture elsewhere, were not forthcoming. Industry, especially engineering, was a very late growth, and the implements and tools which make for efficient cultivation, remained inaccesible to the average farmer. Even today, when Pakistan has yet to make her own steel and power units, modern agricultural machinery is out of the reach of all but a small number of agriculturists.

Thus, the cast of much of our irrigation and agriculture has remained antiquated. There, has, however, been considerable expansion both in acreage as well as in the volume of river used for irrigation. In the past, agriculture was moslty looked upon as a vocation but recently as a direct result of land reforms, there is a growing tendency to regard it as an industry which should be made to yield greater profits.

The Government has taken up the task of bringing about an appreciable increase in agricultural produce, especially food. From the size and scope of the irrigational, fertilizer and soil improvement projects, it may well be said that an agricultural revolution is on the way.

While other revolutions in history have often been attended with serious upheavals in society, the agricultural revolution aims at improving the lot of a vast mass of population by gradual development and progress.

Pakistan comprises about 230 million acres, of which agricultural statistics are available for only about 127 million. I am informed that there are no statistics available for about 100 million acres. For which data are available, only two-fifths of the land is actually cropped, about one-tenth is culturable waste, a mere 20th part is covered by forests and the remaining is unculturable waste land. It is, therefore, apparent that three-tenths of our country can be brought under cultivation in the terms of known methods. Here of course, we must remind ourselves of the difficulties in our path. The crops that we need most cannot be grown under all circumstances.

In West Pakistan, the staple food is wheat which needs irrigation. Our engineers channelised the water in the rivers of West Pakistan, and for

some years we reaped rich harvests. It subsequently turned out that we had not reckoned with geological and soil factors and after some years, parts of land began to deteriorate due to salinity, alkalinity, waterlogging etc. in the 16 central districts of West Pakistan.

Salinity and waterlogging have already caused a loss of 1.3 million acres, and such deterioration is increasing by about 30,000 acres every year. The Government is fully conscious of the gravity of the situation, and ways and means are being devised and implemented to arrest soil degeneration. I am certain that with advancement of scientific knowledge, this malady will be conquered. The damaged soil will be reclaimed with considerable accretions to our agricultural output.

For extension of agriculture in the culturable waste, irrigation facilities are being steadily extended, and it is hoped that by 1960 another 10 million acres will be brought under productive cultivation. For an increase in production, a proper soil survey is required. Such a survey is being carried out.

At the same time, suitable methods and controls for particular crops have to be devised through investigation. In regard to irrigation especially, we need to ensure that our new projects do not bring in their wake such problems as salinity and waterlogging. The factors which impede progress will require careful assessment and understanding, and progress will result when adequate steps are taken to counteract these retarding forces.

Another step towards improvement and reform in irrigation and other matters allied to agriculture is the collection of relevant data and statistics through economic surveys. There is at present a great dearth of reliable and authentic published record dealing with agricultural economics. The Government has made plans for such a survey. A commission has been appointed for taking a nation-wide stock of agricultural facts and figures. The findings of this commission are expected to lead to reform and improvement in irrigation methods and practices.

With the march of time our rural society is undergoing a transformation. It is entirely fit and proper that it should be so. In the 20th century, the State makes great demands on the skills, resources and capacities of its population. So far, a great mass of the rural population of Pakistan was living in relative isolation and their contribution to the nation's welfare and security was limited by this fact. The Pakistani villager is now coming closer to the collective entity of the nation and the State, and is called upon to be a more alert, progressive and educated citizen. This change is made possible by the improvement in means of communication.

Pakistan has 8,552 miles of metalled and 49,657 miles of other roads with 7,000 miles of railways. With greater opportunities providing contact with the centers of advancement, the rural citizen of Pakistan is experiencing new urges, and is adopting new values of progress and change. To meet these new conditions vastly greater production is called for.

This brings me to the subject of industrialisation which is an essential compliment of agricultural progress. The mechanical component of modern agriculture is considerable and in this regard Pakistan is far behind the times. For instance, up to the present, we use wooden Persian wheels for lifting water from wells. The mechanical efficiency of this cumbersome device is exceedingly low, and it ought to give place to modern mechanical water-lifts and pumps which should be produced by the hundred thousand. To be able to do this, Pakistan needs to take a stride forward in heavy engineering industry, and produce such appliances as pumps, oil engines, electric motors, iron tubing and similar machinery. Any irrigational expansion which involves millions of acres, is unimaginable without the supporting component of agricultural engineering grounded in the country itself. It is my opinion that this factor should have a high place in our irrigation and other agricultural priorities.

Pakistan's economy is, at the present stage of her history, largely agricultural. About 90 per cent of our population is engaged in agricultural production and auxiliary activity. Our chief industry, textile manufacture, depends upon cotton grown in the country. Of the exports of Pakistan, agricultural raw material constitutes 90 per cent. A big part of the national revenue is likewise drawn from agriculture. It will thus be seen that irrigation, which is essential to agriculture, holds an important place in our national effort. It is, therefore, entirely fit and proper that we devote considerable resources to the development of irrigation.

While so much in this country depends upon agriculture, the standard of living of our agricultural workers is by no means adequate. In other words, the majority of the people of Pakistan face a hard lot. This leads one to think that the country needs to develop those supports to agriculture which modern technology has placed at our disposal, and which have produced enviable prosperity in other lands. Our agriculture stands at a stage when a judicious introduction of mechanisation should produce a dramatic increase in production giving the cultivator that margin of affluence and relief from brutalising labour without which he cannot achieve the level of efficiency and skill which the tempo of the nuclear age demands. I hope that as the number of technicians and scientists increases in the country, they will bend their energies to those improvements in irrigation and other agricultural practices which have caused production and prosperity to rise to great heights in the advanced countries of the world.

Once again, I welcome the distinguished delegates to this seminar and am confident that from their deliberations, ways and means will emerge which will be helpful in improving irrigation, which in its turn will contribute to the betterment of the agricultural peoples of the worlds.

FARMER AND GOVERNMENT RESPONSIBILITY IN IRRIGATED FARMING IN IRAN

S. M. AHI

Agricultural Director, Plan Organization, Iran

Gentlemen and Members of the Seminar:

I am very happy as the Chairman of the Iranian Delegates to attend the seminar and to be given the honour and opportunity to present to you a short talk on the subject of the Farmers and Government responsibility in irrigated farming in Iran.

Iran, extending as it does to more than a million and a half square kilometers, is a land of almost infinite variation in agricultural resources. In the north there are the rich rice lands of the Caspian littoral with beech and walnut woods in the hills. To the north-east and north-west lie the open windy rolling steppe country. In Azerbaijan, Kurdistan and Loristan there is open gently rolling country where the rainfall is sufficient to permit of extensive dry farming of cereals. In the centre there are the great deserts of the Dasht-e-Kevir and the Dasht-e-Lut, hot barren lands where what water there is, is charged with salt or alkali. To the south-west lies the plain of Khuzistan with its five rivers which was once the granary of the Middle East and awaits redevelopment to bring it back to and surpass its previous productive capacity.

Bordering the cental desert and to the south lies much productive country mainly situated along rivers as they ascend their valleys up into the hills. To the east lie the provinces of Sistan and Baluchestan where the standard of living is low and life for the farmer consists of an unremitting struggle for existence.

Of the total area of 165 million hectares 17 million or a little more than 10% is constituted as arable land consisting of about 6 million under crop at any one time while the balance of 11 million hectares is under temporary resting fallow. Of the 6 million hectares of land under crop 1.6 million or less than a third are irrigated. The pattern of cultivation shows great variation from flat open country well suited for mechanisation to patch works of small fields some times not more than a few square metres in area laboriously created on some hillside close to a source of water by clearing away the stones and forming terraces.

Similarly as might be expected in a country of great climatological range and altitude there is much diversification in the crops grown. Cereals in the form of wheat and barley are easily the largest crops, but very considerable areas are planted with rice, cotton, grapes, summer crops and vegetables, sugar-beet, tea, tobacco, and fruits. Lesser but still important amounts of citrus, almonds, pistachios, dates etc., are produced. There is also a very considerable livestock population of horses, cattle, buffaloes, sheep, goats, camels, asses and poultry.

It is often categorically stated that yields are low. This statement, while it is undoubtedly true of the major cereal crops, is somewhat of an over-simplification. Especially in irrigated areas in a good season very good crops of rice, cotton, tobacco, summer crops and vegetables, fruit and citrus are to be seen.

But bad seasons follow good ones all too frequently and at present production is far too vulnerable to numerous limiting factors such as drought or pests and social and economic problems. Until they are eliminated or solved the agricultural potential cannot be realised and maintained.

Undoubtedly the most important and limiting factor is water, its supply, control, conservation, and drainage. The various aspects affecting its use and economic valuation will be dealt with later in this paper.

Basic to any increase in the yields of agricultural crops lies in adequate supplies of improved and selected planting material being made readily available to the farmer. A start has been made with wheat, barley, cotton, sugar-beet and fruit trees, but there will be an inevitable efflux of time before the necessary investigational work has been done, suitable personnel trained and stocks built up, before an adequate service is available on a country-wide basis.

Pests and disease take an undue toll of the farmers harvest. Locusts, the Senn Pest (eurigaster sp) of wheat, and smut, to mention only three, can be very serious. The desert locust problem is an international one and the geographical situation of Iran renders it very vulnerable. Very

considerable sums have been spent including the purchase of 30 aircraft fitted for aerial spraying. Biological control of the Senn Pest is being attempted with considerable success, based on a laboratory in Isfahan, the only one of its kind in the world.

Smut under Iranian conditions can be extremely severe in its depredations causing losses of up to 80% of crop. The preventive treatment of seed dressing is simple and effective but there are the usual problems associated with launching a nation-wide program with conservative farmers many of whom live in isolated areas difficult of access.

There are also a number of economic problems. The farmer suffers from lack of credit; there is a lack of feeder roads which are now being planned to link up with the main road system so that produce can be got to market economically and quickly. So far marketing and grading of produce has not been worked out. At present in country districts the illiteracy rate is high and success in campaigns to tackle these problems will be dependent to a considerable degree on a higher degree of literacy.

Eighty percent of the population are directly and indirectly connected with the land and reform of the present land system is a basic, political, economic and technical issue of the day. Change is in the air and is being debated in the Parliament and discussed everywhere outside both in towns and villages. In the present landlord and tenant relationship in many cases large areas of land are in the possession of individuals or families and much of the land is farmed by tenants on a share cropping basis. One undesirable feature of the system is that the tenant does not necessarily farm the same piece of land in successive seasons with the result that he has no incentive to undertake any improvement or adopt any agricultural practice which would improve the land leaving the benefits he has made to be reaped by others than himself. This system would be almost impossible to adjust to modern agricultural technology with the result that Iran would not be able to achieve production increases in agriculture in line with its other plans for its rapidly developing economy.

His Imperial Majesty the Shah has given a bold and imaginative lead and for some years past has been distributing his lands among his tenant farmers granting them titles to their holdings.

A land reform bill is at present being debated in the Parliament. There are two main considerations in the drafting of the bill. Firstly, the raising of the productivity of the land and secondly the establishment of social justice in the country areas. As the bill stands at present the amount of land any single person can own will be limited.

As can be seen from the above Iran is a country developing rapidly and is on the threshold of great changes both from the social and technical point of view. The responsibility for steering the agriculturists safely through this period of change and development must inevitably lie with the Government. This is freely accepted and the following are some of the considerations and responsibilities which the Government will have to bear in mind with particular reference to development in irrigated farming.

Water, as stated before, is the limiting factor in Iran and has been one of our main problems through the ages. Since ancient times Iranian specialists have been striving to make more available as may be evinced by the remains of dams and reservoirs in most parts of the country such as in Khuzistan, Fars, Isfahan, Saveh and even on Gheshm Island in the Persian Gulf. River diversions constructed as much as 1,000 years ago are also to be seen at Band Amir in Fars. Many of these works have fallen into disuse for various reasons and it is now clear that the mere construction of such works is not enough. It has only recently been recognised and accepted in the light of modern technical achievement that in order to ensure the maximum beneficial use from such works the following preliminary studies are necessary:—

(1) There should be an investigation into soil conditions and soil survey and land use maps prepared, and the capacity of the irrigation project correlated to the area and suitability of the land.
(2) An estimation of the cost benefit ratio of the scheme should be made.

From the foregoing it will be possible to predict not only if the proposed scheme is workable but in addition whether the scheme is economically feasible and would be able to repay capital investment, amortisation charges and maintenance.

Experience in Iran, similar to that of other countries, has shown that due to insufficient preliminary studies, projects have been handicapped due either to technical deficiencies or to insufficient appraisal of the economic aspects, with the result that they have not been self-supporting and the cost has fallen back on Government. Up to this time no appropriate planning and executive authority has been set up, for which there is great need, to fulfil the Government responsibility of ensuring that every project is soundly designed and economically payable.

Once a scheme has been implemented and becomes a going concern the responsibility of Government to the farmer on irrigated land in no wise diminishes. This should start off a complex but coordinated operation to ensure that the best returns possible accrue to the farmer and to the

capital invested in the project whether it is a large dam over a hundred metres high or a simple regulation of a village supply. The farmer will require to be instructed or better shown the most economic methods of using and regulating the water supply. While he should be allowed as free a choice as possible of the type of crop he wishes to grow every effort should be made to satisfy his needs with improved and selected planting material. The levelling of ground in order to facilitate work may be necessary and done better mechanically, the machinery being made available by some central organisation or through a cooperative.

In Iran the laws governing the use and rights to water are founded on ancient and traditional custom and in a rapidly developing country such as Iran it will be necessary to introduce fresh legislation in order to ensure the most beneficial use of water. Further it will probably be necessary to make provision for Drainage and Irrigation Authorities in districts giving them a certain amount of authority in order to regulate and manage all matters in connection with water distribution and drainage.

Equally to the Government, in the new pattern evolving in Iran, the farmers both large and small will also have to accept increasing responsibility. The tenant farmer in the past has relied partly on tradition and partly on practices that conform with the requirements of his landlord. The result was that he has been unaccustomed to think for himself, to plan for the future or to evaluate alternatives and then come to a decision. As the Government services develop he will be brought more and more into contact with the various extension services and will have to develop the ability of shifting the advice and alternatives offered to him and selecting that which is best suited to his own peculiar circumstances. To be a hard and steady worker as he is in the main at present will not suffice. He will have to learn to adopt himself and become receptive to new ideas. At the same time to adopt a new idea just because it is new could be dangerous and the farmer himself will have to learn what to select for his own good.

To summarise in conclusion, there is in Iran a joint responsibility between Government and the farmer eventually to achieve a class of free and independent farmers who are literate and own their own land. Their holdings should be of economic size and every means should be employed to secure the maximum use of the limiting factor-water. With a permanent title to his land and a regulated water supply the way will then be clear to raise the fertility status and the productivity of the soil. The question of indebtedness will have to be tackled and credit at reasonable rates made available. Marketing systems with price differentials for graded quality will have to follow which will give the producer an incentive to ensure that his crop is of high quality. The whole program of developing irrigated farming in Iran will require a coordinated effort involving the Government Ministries and Agencies and the farmers all working together.

ADDRESS

LT.-GENERAL MOHAMMAD AZAM KHAN

Minister for Irrigation and Works, Food and Agriculture.

Mr. Chairman, Eminent Members of Foreign Delegation and ICA members :

This is today for me a big privilege to talk to such an eminent gathering. I extend to you all a most hearty welcome. I know there have already been eminent speakers here, and amongst yourselves you also have had long deliberations. I think I start off at a little disadvantage because most of the points to which I might refer are possibly already tackled by you. You may have already had deliberations on these points and may be you have come to certain conclusions also.

I would like to say that recently I have the honour to be called upon to take over Food and Agriculture, Irrigation and Works. So, therefore, I have to take a quick look around to see how these things are and what are the problems. Having been given this opportunity to talk to you, I will only deal on those points which I have noticed and see what your reactions are to those particular issues. As far as our members here, who have come from friendly countries we know that most of us have our economics based on agriculture and, therefore, we should see whether we are handling the affairs of agriculture, which is based on irrigation in the correct manner. So, therefore, gentlemen, I am very happy to have this enormous amount of talent gathered here to have deliberations on this very vital issue, to see and find out the problems and how scientific techniques may be applied so as to ensure prosperity to our country based on production from our lands.

Irrigation is not a new system in this country. It is an old system. This irrigation system has paid handsomely in the past. At one time in this region, particularly in the Punjab area, there was a big prosperity based on the production of these lands. That prosperity lasted for some time, but now we are meeting all the problems that have arisen from the past—whether these were from lack of knowledge or lack of finance or simply neglect. So, those are the issues on which I am speaking today and we find that Pakistan today is a field where we can learn a lot.

We have spent enormous amounts of money, and there has been a tremendous amount of skill and a particular amount of hard work on expensive projects. We find that in most of these projects we are facing problems. Problems of salinity and waterlogging. Productivity has gone down and the food problem still remains a real problem today. Well, gentlemen, I say this, the whole issue must be planned from the very beginning. We must adopt the correct measures from the very beginning to see that the engineers are doing the task along the correct lines, and we must see that proper education is being imparted to the people who are to use the irrigation systems for high productivity. Drainage was completely neglected and as a result, after 30—40 years, problems have been created for us in these same project areas. You probably will have a chance to see them : Lyallpur, Sargodha, Shahpur, Sheikhupura and Gujranwala, which were really beautiful areas and there was an enormous amount of output coming from those fields in spite of the fact that fertilizers were not being applied in those days. Now we find there is seepage and waterlogging. So, gentlemen, from this point of view, we find that irrigation and agriculture did not go shoulder to shoulder giving each other correct advice and studying the techniques as to how these lands could be kept productive and cleared of salinity and waterlogging. The engineers were concerned with the important issues of maintaining the canals and keeping them going.

When the canals run the whole twelve months; when the canal is high and the ground is low you can imagine the amount of seepage. This has done us tremendous amount of harm. I would particularly like to discuss this issue more in detail because I feel that your deliberations are also aimed at discussing it, so that you can ultimately find a line of action and some decisions as to what has to be done because what is happening here might be also the case in your countries. These things must be watched carefully. In a flat country like ours sometimes the natural drainage is there but in most cases it is not. Always you have to run the drainage toward the river and on to the sea. I give you a small instance. We have the Ghulam Mohammad Barrage. It's a beautiful barrage. A lot of hard work has been done. It is a great achievement of our engineers. Now the fear is that not only the lands which are now under cultivation but the lands which are to come under cultivation, are also in danger of

getting waterlogged and saline.

Now let's go to the high regions, the watershed areas. What are the problems we are facing today ? Floods ! Every year they come. Every year there has been a flood. Every year enormous amount of sand are brought down from those forest denuded areas and the rivers. Every time a flood comes, we have to close the canals because they get silted.

All that silt creates another problem. How you are going to find the bed of the river. Today the bed is running this way, another year it goes that way. There is no question of taming our rivers. This is very difficult. We go forward six paces ; the floods come down, do the damage, then we go back eight paces. We must have proper afforestation in the watershed areas. It affects our economy. When you come to the rivers you find along the rivers—barren waste, or open space—no afforestation.

Similarly our canals have to be desilted every year. I have just had telegrams from two districts. They cannot get water. Why? Because the canals are being repaired and desilted. Every year we have to desilt our canals and when the floods come, big, big chunks are eroded away from them. There have been no syphons constructed underneath the canals in certain areas. When the canals are washed out they call on the Army to get the canals linked up again to save the November crop. Every year we have been facing this problem of floods. Every year we have been repairing our canals. Every year we have to desilt our canals and all this means enormous expenditure.

This drainage system should have been tackled from the very beginning before the canals could come into use; the drainage system should have been complete so as to ensure that the land which comes under the water is kept clear of waterlogging and salinity. So, today, gentlemen, take a lesson from that old Persian proverb, 'MAN NA KARDAM SHUMA HAZAR MEKUNED' "I know that we have not done the right thing but you see that you do the right thing". Take a lesson from our mistakes.

Regardless of the causes we are brought face to face with the big problems of waterlogging and salinity, we are trying very hard to tackle the food problem of the country. We are giving priority No. 1 to see that no more land comes under waterlogging and salinity and to treat land already damaged. At the same time we must get more land under cultivation and step up the food production per acre. This complex problem must be tackled by wise people with understanding to see that whatever line of action we take is the correct one. We cannot afford to waste money. Every penny is important. We must have clear thinking and quick action on this problem. It is important for you to have an opportunity to see what problems are on the ground and I am very grateful to the ICA for having sponsored bringing you here to study these problems.

Now, gentlemen, I know all of you are from top ranks. You have the knowledge and are the qualified people and I welcome you here today sitting together on the problems of Near East and South Asia. All these countries are basing their economies mainly on Agriculture. We must solve our problems by developing agriculture and by developing our irrigation systems. Proper scientific methods must ensure that every penny we spend is properly spent and that the systems built will continue to go on and on, so that our future generations do not have to face this problem. God has given us a beautiful and fertile country, but just imagine the problem that is being created by these untamed rivers, watershed areas which have been denuded of afforestation.

Taking care of our summer floods is a haphazard operation at best. We do not know when and where floods will strike. Dozens of engineers and hundreds of other technicians try to see what can be done to stop the damage. Every time we hope to have a bumper crop. It turns out to be 60%, 50%, may be 30% may be 20%. Why? Because of floods. We cannot ignore this problem. We shall be very happy to have your advice on this matter, after your deliberations have been completed.

Enormous mechanical equipment is required and this must be financed. Should not there be an International Pool of this type of equipment for the Near East and South Asia placed in strategic places as a permanent body? Whatever the results of our deliberations we must see that they are implemented. Equipment is needed for afforestation for bunds, all the headworks and so on, then the canals, the drainage systems, the minor drains and all the subsidiary drains. With the floods and heavy silt all drains need digging every year, but unless the main drain is dug, it only leads to waterlogging.

Very correct planning is required, scientific methods and proper education are necessary. The Irrigation Department must understand that the Agriculture Department needs their expert knowledge. Similarly, the Agriculture Department should have the expert knowledge of the Irrigation Department. These two have to work together and that understanding must come right down to the common man—that fine chap the farmer. He is the man who has been sadly neglected.

Looking at these problems realistically we have to help the tiller and must give him scientific knowledge of farming; we have to give him proper education. But are the facilities of such education

in the village? Our big educational institutions are centred in the cities. We have to shift the emphasis to villages now. The basic economy will now be built up by the people in the rural areas. They have got now the Basic Democracies. They will be asking for advice and guidance of expert. The farmer wants good seeds and *they must be given at his door*. It's no use at any time saying that good seeds are available in the country. Anything may be available in the country. If it does not go to the poor farmer, what good is it to him.

We have got to create conditions so that the villager becomes a proud man and he is supported and ultimately when he has sweated throughout the whole summer or gone through a heavy winter, that he is not pounced upon by the middlemen. The middlemen are the worst people that you come across. They play on the poor farmer's weaknesses. He requires some money. They advance it and then take away his crop at a cheap rate.

Gentlemen, the Government is now going to see that the farmer, the tiller, gets a fair deal. He is the man who is going to build up the prosperity of this country and in all those countries wherever Agriculture is the basis of economy.

I stress again the need for equipment. We want to excavate. We want dredges. We want power—even power lines. We want tubewells. I would suggest that we have an International Pool for this type of machinery, which could ease the annual dredging task that we have to do, so that we could really get down to the job and finish the task in scheduled time and ensure that the drainage water starts running again. As I have pointed out every canal of ours has got to be desilted every year. I know that in many cases you will suggest that canals should be used only for six months in order to provide opportunity for desilting.

The issues I have given you are the practical issues. Once again I want to say how happy I am to have this opportunity to talk to you and to extend to you a very hearty welcome. Once again thank you very much, U.S.A.—I.C.A. for having given us this opportunity to get all these top class specialists to come here; have deliberations on these problems and help us in solving them and also benefit from these deliberations.

Mr. Killen addressing the Seminar

ADDRESS

MR. JAMES S. KILLEN

Director, USOM to Pakistan

I know that all of you have been listening to a good many talks since you convened this Seminar a week ago. Having myself sat in your seat at a great many meetings, I know the time is reached at which further speakers are of no interest and little value. Our Chairman is a very thoughtful and kindly man. I certainly am happy to be here for a few moments and to say hello and to give you greetings from the United States Operations Mission to Pakistan. To those of you who have come from other countries, we are very happy indeed that the International Cooperation Administration was permitted to play some small part in organizing and arranging this seminar.

I am not at all familiar with the work you have been carrying on this past week. I am told that there has been a great deal of interest evidenced by the work of the seminar and I certainly see from the papers that you have had some distinguished visitors here with you during these days, so I am sure that your efforts will be of great value throughout all of the countries presented around this conference table.

I want to say that I am a layman most definitely, in all matters pertaining to agriculture and its specific problems of irrigation and it would be indeed presumptuous of me to try to discuss with the group of experts any of the significant and technical problems in the irrigation field.

I cannot help but be impressed with the fact that there are perhaps very few activities or services to mankind and to the economic efforts which have such a long and fruitful history as irrigation. I am told that man's attempts to control the flow of water to enhance the effort of his hands in producing food dates back, in fact, well before the period of written language. I am told that the people in the Upper Nile had developed the ways of diverting water from the Nile on to barren or parched lands before they developed, or before they received the technique of writing from those in the Lower Delta Area. If this is true it means that irrigation has been a continuing effort of man for nearly six thousand years and the problems remain the same although the technique are somewhat different.

Down through the centuries man has devised all sorts of mechanisms for putting water on land.

I think the name of a device which is still encountered in many parts of the world, at least in Egypt, is called the "Shadouf". Then we see still in many parts of the world the Persian Wheel which is an ancient device. There was a very unique and rather interesting mechanism called "Archimedes' Screw", which was devised a good many hundred of years ago to lift water.

I remember only too well some three years ago when I spent some two months travelling through Vietnam seeing some of the unique mechanisms which have been developed in that part of the country to lift the water from one level to another. Some of these were mechanical. I was particularly impressed by a device, the name of which I do not know, which was a large cylindrical water wheel. The lower portion of it rested in a fast flowing stream, perhaps 40 feet in diameter and anywhere from 20—60 feet long in a cylindrical shape, and this kept turning by the flow of the stream passing underneath it. On the perimeter of this cylinder there were a great number of hollowed-out bamboo tubes, large type bamboo perhaps 4, 5, or 6 inches in diameter and perhaps 4 or 5 feet long—set at an angle across the face of this cylinder. As these passed through the water the tubes were filled and as they came up over the top, they were dumped into a trough parallel to the length of the cylinder. I speculated on one, particular one I saw that it must have been at least 2½ cusecs of water flowing to that trough and irrigating a very large plot indeed on the upper banks of the river. One sees these throughout Vietnam wherever you have streams flowing with sufficient speed to turn this rather large and ungainly device.

Then they have an equally interesting but purely man-operated device with a reed bucket the shape of a cone which was suspended between ropes, one fastened to the top and one fastened to the bottom, and leading to the operator on either side of the pool with perhaps a span of 20-25 feet and two men or two women or two youngsters would dip this down into this pool and lift water 4,5,6,8, or even 10 feet, with an amazing symmetry and smoothness of motion hour after hour. Hundreds of acres of rice paddies were being irrigated by hand with this sort of human lift of water. And when you drive through those coastal plains in Vietnam and see hundreds and hundreds of people lifting water this way, from the canals on to the paddy, and see the beautiful rice crops growing on those paddies, using the Japanese pattern of rice culture, one could get some appreciation of what can still be done, where there is a will to do it, and the energy to do it.

And so, we have not entirely gotten away around the world from the more ancient, but nonetheless effective means of getting water from the water course to the land. When we see these efforts, supplemented and assisted by more modern mechanisms of power pumping we get some picture in our own day of the whole gamut of man's efforts in the irrigation field because we see all of these old methods still with us and then side by side with them we often see the more modern mechanized power-driven irrigation systems. And I think this helps us to recognize, as I said at our ICA conference in Karachi the other day, that all of these efforts spread out over time through the recorded ages provide something of a continuation of man's effort to support himself first, and secondly, as the horizons and expectation arose to raise his standard of living and make life a more pleasant experience for himself and his family.

Now I am sure that all of you are concerned today with the task each of you face in your respective countries in the problem of expanding food production primarily and, secondly, expanding cash crop production so that both your people are fed and your industries have the wherewithal for their operation. This effort will be a continuous effort and you will see there are no simple short cuts to success. I think the very fact that so many of the old methods are still with us is evidence of the difficulty of the problem and the need to maintain a continuing, unending search for more effective ways of dealing with this extremely difficult problem.

We face the unpleasant fact that food and plant life will seldom grow without water, and therefore water becomes almost the first order of business in any community which wishes to support itself and feed itself. This problem of irrigation down through the years has received foremost attention on four rivers and streams in this part of the world. On the Nile, on the Tigress, on the Euphrates and, on the Indus these efforts have been carried on for centuries, virtually all of you here today are still concerned with one factor or another of this same problem and, in some cases, on these same streams.

In the days when I was even more ignorant than I am now about such matters, I used to think that irrigation was just a matter of putting water on the land. I didn't know that there was any problem of getting water off the land. In 1956 I came out to India for two months while two of my colleagues were here in Pakistan and, upon our return to the States, we began to compare notes about the economic task that these countries were undertaking, and I first heard about waterlogging and salinity. I must admit that it took me a long time to grasp the significance of this problem and it wasn't until I came to Pakistan 29 months ago and since that time that I have begun to have, as I say, a layman's grasp of the problem—not necessarily of its solution.

But as one flies over the Punjab as I have done many time flying from Karachi to Lahore

or from Lahore to Pindi or from Lahore to Sargodha or to Mianwali, especially this time of year when you see the green wheat fields below you and see the pock mark of salinity in those green areas, one can get some little concept of the significance of this terrific blot of waterlogging and salinity.

When I first came to Pakistan I found that some of our folks in the United States Geological Survey were working with Dr. Asghar and his people in trying to carry on some exploratory work which they hoped would one day lead to some methods by which this problem of salinity and waterlogging could be attacked. And then, as the time went by and a little more knowledge was gained and a little more experience gathered, the Government of Pakistan undertook to inaugurate what it called the Groundwater Project, now being administered by the West Pakistan Water and Power Development Authority. Today, a large number of wells are being sunk and tubewell pumps being installed in an attempt to find some method of effectively reclaiming these lands that are waterlogged and saline and to prevent the expansion of this land curse.

I don't think any thoughtful man who looks at this situation in West Pakistan could have any other reaction than that this is, of necessity, one of the major, one of the most essential, one of the primary tasks which confront the government in its effort to make the agriculture community more prosperous and more conducive to the national well-being.

And I think all of us want to give our maximum support, moral and otherwise, to this all-important undertaking. There may be some who feel that the complete answer to this problem has not yet been entirely determined and that may be true; it may be that in the process of trying to bring these wells into production and controlling waterlogging and salinity through the use of tubewells, it will be found that other factors enter into the equation which make the answer not yet quite apparent. But the task is so important and so immense that it seems to me that every effort that can possibly be made must be made and I know that in time, with the determination that the government has shown, with the skill of its people and their will to succeed, that ultimately this curse of the Punjab will be removed.

I am sure that if these problems of a similar character prevail in other countries and in another river valley, there too, we can find, through scientific exploration and hard work and real determination, the ways to successfully overcome the problem.

So, Dr. Asghar, I want to tell you that, insofar as the United States Operations Mission can, we hope to work with you so that you may successfully find a productive answer to this extremely difficult problem. Of course, all of these problems of irrigation, these problems of agriculture, and of the improvement of agricultural practices, are all just part, however important parts they may be, of a nation's efforts to engage in this thing which the economists call "economic growth", to broaden the productive thinking of the country, to expand the production of the country, to increase the generation of wealth in the country, to make possible a higher standard of living. And, when we talk about a standard of living, may I add paranthetically that we are not just talking about more money to spend on more goods and services, but we are talking about what I like to call the gradual development of a whole man, a man who materially, socially and spiritually is worthy of the status of the son of his Creator, who is capable of exercising his reason, his intelligence, his talent in a creative way so that life can become more meaningful and more enjoyable, and not just a continuing, never-ending struggle for existence at the very margin of subsistance.

Economic wealth, of course, is the necessary pre-requisite to the satisfaction of man's material needs and to the provision of some leisure through which his intellectual and spiritual needs may be met. And in this process of growth, which is so prominent in the objectives of so many nations today, it often occurs to me that we sometimes place too much emphasis on the purely materialistic aspects of that process: the provision of capital, the provision of resources; and the provision of physical influx that has to be provided to go into the growth process.

But again, important as these things are, they are not all important, they are not an end in themselves, not sufficient unto themselves. There are other requirements to make the growth process effective, to make full utilization of the resources, funds, materials and human skill which are admittedly essential.

It seems to me some of these other requirements might be listed. First, it seems to me there must be a will to grow on the part of the nation which seeks and desires growth; and when I mean the will to grow, I don't mean just a statement of policy by someone saying, "We want to grow"; but a progressive determination on the part of all levels of society to marshall resources on behalf of growth and, if need be, make some sacrifice today for the sake of tomorrow. I think Pakistan is showing increasingly a determined will to grow, and I think that as that will to grow expands, so will the rate of Pakistan's growth.

Secondly, I think there is a need for the capacity to make hard economic decisions in connection with the growth process. These frequently rest on the shoulders of the government but they also rest on the shoulders of private individuals who play an important role in the growth process, and the courage to make economic decisions which might represent a fairly sharp departure from certain past processes, but which seem essential if the growth process is truly to get under way.

And thirdly, it would seem to me that, if growth is going to take place effectively in a country, there needs must be a kind of an organization

through which growth can move forward—organization in government, organization in private industry, organization that expedites the decision making process, and organization that represents adequate delegation of the responsibility and authority to those people who have the task of actually carrying on the program. The kind of organization that draws capable people into its life and give them a chance or permits them to stay there so that their skills may be fully utilized and exploited. The kind of organization which encourages the people to work for its expansion and betterment and the effective conduct of its work. The kind of organization that provides reasonable incentives to men who desire to move forward in their profession and their career and who are willing to work in that direction.

Yes, it seems to me that economic growth to be truly effective, even though all these other things be present, still is going to be sadly crippled if it lacks effective ogranization through which the growth process can actually be implemented.

In our respective countries, if we can either initiate or continue to expand the growth process, it seems to me we are rising to the challenge of the day. In this last 25-30-35 years, and perhaps more specifically since the close of World War II, with the emerging all over the world of a new group of nations, communities are taking on the role and responsibilities of sovereignty for the first time, and are eager to get on with the task of building a nation, and building a prosperous future. Many of these countries, newly independent, have short supplies of resources and skills and many of the other necessary components of growth.

And I think that one of the more encouraging developments in recent years has been the growing realization on the part of the developed, or the more developed nations, that there is some responsibility on their part to lend such assistance as they can to these nations which are so vigorously trying to, as one might say, lift themselves by their own bootstraps.

As we read history we recognize that there has been periods in which man faced great challenges and those challenges have been met in various and sundry ways. Perhaps at times they have not been met, to the detriment of human society, and today we are facing collectively—all of us—this new challenge of what some people call the "revolution of rising expectations." And it behooves all of us to examine our problems carefully, to marshall our resources thriftly, and to exploit them and utilize them wisely so that we can in our respective spheres get the greatest possible returns for the in-put.

Mr. Chairman, I want to close by saying that I think I can speak for all of us of the United States Operations Mission here in Pakistan when I say that it would be difficult indeed to envisage an environment or a job of any kind anywhere in the world which affords us more satisfaction than our jobs here in Pakistan do today. To be privileged to be accredited to a government who with its people are working so hard and so determinedly to face up to and overcome the sometimes almost insurmountable tasks that face them is indeed one of the greatest privileges that any man could have. I find it pleasurable, not only because of the joy of working with the Government of Pakistan in its vast efforts, but because of the extremely friendly and personal associations which all of us have with our Pakistani friends. It is a relationship which is fruitful, very fruitful in a professional way and indeed most satisfying and enjoyable in a purely personal way, and I want to wish our Pakistani colleagues, and specificially those of you who are here today discussing and working with these all-important problems of irrigation, maximum success in your future efforts, and I know you will have that success.

Thank you very much indeed for letting me be with you this afternoon.

PAKISTAN COMMISSION ON FOOD AND AGRICULTURE

The Pakistan Commission on Food and Agriculture visited the Seminar on Monday, February 22. This Commission was introduced to the Seminar by Mr. Haque. The Commission is headed by a very eminent farmer, the Nawab of Kalabagh and has been formed at the national level to examine and appraise the entire national situation and make recommendations for action. Their visit to the seminar demonstrates the great interest they have in the problem of waterlogging and salinity.

Pakistan Commission on Food and Agriculture

GENERAL BUSINESS

The general business of the Seminar was reviewed by an Executive Committee consisting of the leaders of each of the country delegations. Dr. S.M. Ahi of Iran served as Chairman of this committee. Five working committees were appointed and their reports together with a new statement on drainage were unanimously approved and appear in the section headed "Recommendations." The general business session was held in connection with the closing session on February 25. A summary of the general business transacted is as follows:

Executive Committee

Proposal for a Fourth NESA Irrigation Practices Seminar—The following proposal was submitted and unanimously approved by the delegates:

The Executive Committee recommends:—

(1) A fourth of a continuing series of Seminars should be held in 1962 with the following general objectives:

(*a*) To encourage each country to develop and compile reliable data on practices of irrigated agriculture through studies and experiments and to arouse interest in the widespread dissemination of such data.

(*b*) To encourage each country's efforts in the exchange of knowledge and the joint solution of common problems.

(*c*) To consider means of imparting to farmers of each region a better understanding of irrigation practices and how they contribute towards greater production and improved living standards.

(2) The scope of topics discussed in the Seminar should not be restricted, but the technical sessions should include mixed topics related to the management problems of irrigation practices and discussion groups to cover specific problems. In all such work stress should be laid on Irrigation Practices and water usage rather than on problems of project design and providing water.

(3) Specific topics recommended for the 1962 Seminar would be selected by the two leaders from lists of topics presented by each delegation. Such lists should also indicate the topics the specific delegation is interested in presenting.

(4) Copies of all papers to be presented in the 1962 Seminar should be made available to the leader at least one month before the actual meeting of the Seminar, so that copies would be distributed at Registration time.

Sadegh Ali,	**Iran (Chairman)**
Salim Macksoud,	**Lebanon (Secretary)**
A. G. Asghar,	**Pakistan**
Yadava Mohan,	**India**
V.N. Rajaratnam,	**Ceylon**
Fahed Natour,	**Jordan**
Cemil Kaleli,	**Turkey**
S.E. DeFalla,	**Sudan**

Invitation for a Future Seminar

On behalf of his Government, Mr. Halim Najjar, Director General, Ministry of Agriculture, Lebanon extended an invitation for the next NESA Regional Irrigation Practices Seminar to be held in Beirut, Lebanon.

Suggestions pertaining to a Seminar and future cooperation of interested NESA Governments in the field of irrigation practices

The following suggestions from various committees are included in the record in accordance with the unanimous agreement of the delegates. These suggestions were not discussed by the Seminar and formal action was not taken regarding any of these suggestions.

A. *Pertaining to a future seminar.*

Committee II offered the following:

On the assumption that continuing Seminars will be held the Committee offers the following recommendations for consideration by the delegates as a whole:

(1) That in future to save valuable time the "Country Reports" which have been already submitted simply be brought up to date for submission to succeeding seminars and that they not be read in open session. Comments should be limited to progress and new developments made since the proceeding seminar.

(2) That working committees on specific subjects be appointed not later than the second day of the Seminar and that more time be given them for group consultation and preparation of their reports. It is felt that the recommendations of these committees should be made with the utmost care and deliberation for which more time is required than has been allotted in the past.

Committee III offered the following:

(1) That ICA be requested to assist in convening further Seminars on irrigation in this area for the study of the specific problems on this subject.

Committee IV offered the following:

(1) In future Seminars the country reports should include statements and information on the progress achieved by the country in respect to the recommendations of the Seminar. For example, some countries omitted all reference to work they might have done in determining consumptive use of water for various crops.

B. *Pertaining to cooperation of interested NESA Governments.*

Committee III offered the following:

(1) That countries represented at this Seminar exchange information on the development of the irrigation and drainage projects in their respective countries.

Committee IV offered the following:

(1) That a central committee or secretariat be developed to act as a clearing house for such matters as:

(*a*) Encouraging the exchange of technical information as developed by research and investigation programs.
(*b*) Encouraging the implementation of the recommendations of the Seminar by correspondence, visits and in other ways that may be feasible.
(*c*) The consideration of forming a permanent committee or secretariat to continue the cooperation and advancement of irrigated agriculture in the NESA countries.

(2) That the glossary of technical terminology pertaining to irrigation and drainage as adopted by the International Congress on Irrigation and Drainage (Headquarters at New Delhi) India be universally accepted and used. (This recommendation arises from the difficulties and misunderstandings which arose at the meetings and group discussions of this Seminar particularly in the terminology of water use problems).

Statement by Mr. Gibson in behalf of Delegates

In behalf of the delegates Mr. Gibson made the following statement: Mr. Chairman, Dr. Asghar and delegates, I shall not identify myself except as a voice to the NESA Irrigation Practices Seminar. This is an expression of gratitude and appreciation for the hospitality, for the hard work and perseverance of you and your staff in making a very pleasant experience for us yesterday at the Horse Show and Tatoo. We know that there are those of your staff particularly Mr. Abdul Hamid, Mr. Hafeez Khan, Mr. Tariq, Mr. Mohammed Abdullah, Mr. A.T. Khan, who went to a great deal of trouble for us. We want to thank you very much for this stupendous thing that we saw. I think that Hollywood superlatives pale to insignificance when we think of what we experienced, saw and appreciated and enjoyed last night.

Closing Statements

Following approval of the various proposed recommendations Dr. Ahi requested Professor Macksoud to make a statement on behalf of all of the delegates.

Statement by Prof. Macksoud

Mr. Chairman, Dr. Peterson and fellow delegates: This is a special honour for me to be asked by Dr. Ahi to speak in the name of all the delegates to this Seminar. The main reason is to express our sincere thanks and appreciation to Government of Pakistan and the International Cooperation Administration of the United States for their hospitality, assistance and real thoughtful consideration in executing this Seminar. We are really touched by the additional personal care, not only the official, but the personal, unsolicited, unofficial attention that we got was really beyond any expectation. It would be very difficult for me to go through the details, the acts of kindness, and the acts of courtesy and the acts of consideration rendered, but I do believe that I speak for all of us in expressing sincere appreciation. Now we are thankful and we would like to go on record as being thankful to the Government of West Pakistan for the cordiality and hospitality and assistance to the Seminar. We also would like to go on record as expressing our thanks to the ICA of the U.S. Government for its assistance in carrying out this Seminar. We also would like to add personal thanks to Mr. Haque, Dr. Asghar, Dean Peterson and Mr. Jones and to the staff of the Pakistan Government, whom we cannot, unfortunately list by name for the time being, and to the ICA officials in Pakistan. They have really done an excellent job making us feel at home and they have made us work. It was really very nice to do both. We thank you very much and hope that the coming Seminar will take notice of the established practice.

Statement by Mr. Malcolm Jones

Gentlemen, as you can see when I was told I had an opportunity to speak here I really got together lots of reference work, I worked out a good four-hour speech. However, since our friends from Lebanon and one of our friends from Iran have to leave us very shortly, I think we will just let that speech go by the board.

I have been asked to speak briefly to you both on behalf of ICA/Washington and USOM/Pakistan. I have followed the course of your Seminars since

the idea was first proposed back in 1955. It has been a pleasure to note the progress since the first seminar when Turkey was host in 1956, the second seminar to which Iran was host in 1958, and now this wonderful seminar here with our fine host, the Government of Pakistan. It is a pleasure to take note of the invitation to the Government of Lebanon to consider the possibilities of visiting with them in 1962. I think we are all aware from their participation in this meeting that if it becomes possible to meet there, you may be forced to work even harder than was necessary here. On the behalf of ICA/Washington, I would like to join with Dr. Macksoud's statement regarding USOM/Pakistan and express our great appreciation to the people of this nation who have given unsparingly of their time, not only their official time, but almost twenty-four hours around the clock to help make this seminar possible. I cannot name all of them individually, I shall not try. I would also like to extend my thanks to the Government of Pakistan, for without their thoughtful leadership which has extended during the past two years leading towards this seminar, it would not have been possible. I would like to thank our General Chairman for his leadership as a representative of his government in this meeting. There are many people in the back-up to this meeting that we cannot name of course. But we would also like to strike this note, that while these two Governments have been mentioned, this seminar would not have been possible without the cooperation of all the NESA Governments represented here, and so I thank each of your governments. Each of the delegates has also a major share and major responsibility for the success of the seminar or for future seminars.

Now, a very pleasant little task has fallen to me. I have been asked on behalf of the seminar to present two scrolls to our Senior Leaders who have worked unceasingly over a long period of time to make this seminar possible. Many of you first got acquainted with Dean Peterson from Utah State University when he visited your countries last summer. Some of you had known him before at the University. One of the scrolls is to recognize the outstanding work which he has done, the thought and study he has given to the many problems connected with this meeting and the excellent way in which the technical material of the meeting has been mobilized so that we could have this very fine session.

On behalf of the whole Seminar, I would like to pass to Dean Peterson one piece of paper on which he is not required to do any further editing.

It was my privilege to first become acquainted with your other seminar leader back in 1956. It was great pleasure to note that one month after the seminar in Tehran closed an official invitation came forward from Pakistan for this seminar to convene here in Lahore. I think there is no need to mention to any man here the work that Dr. Asghar has done to make the seminar possible. For some future seminar, I would like to suggest that the committee on consumptive use make an investigation in cooperation with this group in Lahore to decide on the water requirements of the tea necessary for a group of this size.

Now, it is my great pleasure on the part of the seminar, Dr. Asghar, to present to you this scroll on which are inscribed the names of all the delegates. In behalf of ICA/Lahore also, I have been asked to present you with this picture. (Mr. Jones presented a framed, large-size photograph of Dr. Asghar).

Statement by Dr. Dean Peterson

I thank you for the scroll, it will be a real momento for me. I have only two things that I would like to cover here in this last minute. First one is, that, I would like to express my thanks to all who have helped me or, I should say all whom it has been my privilege to help, make this seminar a success—if it has been a success; and this extends clear back into last May when I first realized through Malcolm Jones I might come to these countries. The thanks extend right through all the people, in many countries which I visited last summer down through the folks here in Pakistan. This includes 100 or 200 people, I cannot mention them by name.

Here in the host nation, I especially want to express my appreciation. The task of the host nation is a really tough one and I am glad that a lot of what they have had to do did not have to be done by me. Dr. Asghar and his staff are responsible for most of this work.

I did not realize last summer the amount of things that the host Mission would be called upon to carry nor how they have been able to carry and do all the things we asked them to do. I don't know how they got it all done, but they did and I am very grateful for it. There are two persons that I would like to mention, by name, here. One is, my colleague and fellow Irrigation Engineer, Fred M.Tileston; the other is the very fine administrative assistant Mr. Jamil Ahmad Khan.

The other point I would like to mention is, first of all, since I am not a professional foreign service officer, I perhaps have some prerogatives that my colleagues do not have. I am perhaps the more common kind of American citizen who ordinarily stays home. This trip and the one last summer are my first times overseas. We, in America, want to understand as much as we can about the nations over here; however, this is difficult and I have decided that one really cannot understand them very well unless he visits them.

This, of course, is something that 180 million Americans are not going to do, but we do have many of your people coming to our country and we have some of ours coming to yours and I am sure this helps us to understand each other. I want to say without any fear of contradiction that most Americans, and perhaps all Americans, want very deeply to understand the problems of the people and the culture of this part of the world. We are aware that there are problems facing you, we want to help if we can. We also want you to be free, wealthy nations in your own right. We want to help you do this but we do not want to force you to do it, if I may put it in that language. So we want to stand by, and I am sure that this is true in the hearts of nearly every American, regardless of how difficult the problems may seem at the time, how long they may appear to be with us. I personally am very optimistic, and more optimistic having visited here, than I was before I visited and I might say that I was born optimist. I believe that nearly all Americans feel the same way about this. Again, I thank you for the opportunity to be with you here in Lahore.

Statement by Dr. A. G. Asghar

Mr. Chairman and friends: I requested Mr. Haque to give me a couple of minutes so that I can say a few words. But Mr. Jones and other friends of mine have shown a great kindness and appreciation that words fail me to express myself. I know my shortcomings and I would like to request you if there has been any inconvenience and discomforts that was the best we could do. I tried, but I know there are many difficulties in managing things and when there are so many friends coming from various countries. The management of this seminar was in reality due to one personality who gave me the full authority to do whatever I liked, with this assurance: that all good things and credit will come to me and if there are shortcomings he will look after me and that personality is Mr. Haque. He has in reality helped me at each and every stage right from the time when the seminar was proposed to be held, and even up to last minute when I was talking to him about what was going to be the last item under the program. I thank you sincerely gentlemen with all my heart, and I again remind you to forgive what we have not done and the inconveniences which you have been put through for our shortcomings. Thank you very much.

Mr. S. I. Haque

When, some months ago, the idea of seminar was mentioned to me, I welcomed it for many reasons. The problem, however, was the timing. I assure you that it was with some misgivings that I agreed to the seminar being held in Lahore during the Horse Show week. On the other hand, I would have been very sorry if we had had the seminar at any other time of the year and naturally you would not have seen the Horse Show. So, as my friend Dr. Asghar, said, if any one of you has been put to inconvenience, I am sure quite a few of you, must have had to put up with some, please forgive us. Inconveniences, whatever they were, were certainly caused with the best of intentions. We did want you to see the Horse Show and I hope you enjoyed it.

So far as the organization of the seminar is concerned, I am afraid, I cannot claim much credit. For the work, the real hard work was done by Dean Peterson and Dr. Asghar, I was only there to help them to resolve some difficulties whenever they arose. I am sorry some of you have been worked very hard during the week. For that the blame must go to the Chief Organizer. If, however, this is some indication of the earnestness with which we take our problems both in Pakistan and other NESA countries, I think it augurs extremely well for the future and the good wishes which Dean Peterson has expressed for the region as a whole will come sooner than many of us anticipate at the moment. I would be failing in my duty if I did not thank ICA/W and USOM/Pakistan for the very valuable help that they have given and for the opportunity they provided for us to play host along with them. Finally, I would like to thank every one of you individually and the Government and the people of your participating countries for the honor that you have paid us by spending so many days in Lahore in spite of the various inconveniences, and for participating in the deliberations of this seminar. I hope you have enjoyed your stay here. For us, it has been a pleasant experience and I am sure your recommendations will be accepted and implemented properly not only by us but also by the other participating countries. Thank you very much. With these words I would declare the seminar closed, but would like to remind you, those of you who would like to, there is a field trip arranged tomorrow. Good-bye.

CHAPTER II

RECOMMENDATIONS

EDUCATION AND TRAINING

The final aim of education and training in Irrigation Science is the formation of trained water users well versed in the art of executing the irrigation practices best suited to their specific conditions. Such training should be supplied by Village Extension Workers who in their turn would be trained by College graduates in special training centers. These graduates would be the product of the national and / or regional Colleges of Agriculture with a major in Irrigation Science. Their professors would be scientists engaged in a career divided between teaching and research.

In the ideal set-up, both the College graduates serving as teachers of the extension worker and the professors in the College would be available for assisting the extension worker in his training of the water user. Furthermore a continuous flow of research data would be made available to the extension worker who should also periodically come back for refresher courses. To obtain this overall objective, *The Third NESA Irrigation Practice Seminar recommends*:

1. Training of the farmer in the irrigation practices best adapted to his conditions should be done by Village Extension Workers, who have had a general agricultural education. Such workers should normally be able to assist the farmer in other aspects of agriculture.

2. (*a*) District training centers for producing such extension workers should be established to serve sizable areas of similar agricultural conditions.

   (*b*) Applicants with 7 to 9 years of schooling should be given 2 years of agricultural education aimed at the needs of the district in which they are to be located.

   (*c*) The teachers in these centers would be College graduates. Their program in College should have preferably been one with a major or option in one of specialized field of agriculture and they should have had some courses in Extension Methods and Workshop. These graduates handling the teaching of Irrigation to such Extension Workers should have had an Irrigation Science course well balanced between Irrigation Engineering and Agricultural Irrigation.

3. (*a*) The establishment of Majors in Irrigation Science should be encouraged in the National Colleges of Agriculture, though Regional Institutions may, at the start, perform this service.

   (*b*) Professors at these Colleges should be engaged in research on irrigation problems of the country.

4. (*a*) Governments should establish or plan for the establishment of a national organization with district offices devoted to the development of improved irrigation techniques and practices and to the dissemination of such knowledge.

   (*b*) The personnel of such an organization should work very closely with both teachers and graduates of the Extension Centers and with the professors of the national Colleges on the solution of pertinent irrigation problems.

   (*c*) Such an organization could, in time, take over the teaching of irrigation in the Extension Centers along with its research work on irrigation problems.

5. It is recommended that irrigation engineering be established in the national universities.

If these recommendations were followed, then each country would have the source of data required for improved irrigation practices and the necessary trained men who could disseminate such information. Furthermore, the links between the various levels of workers in the field of irrigation would be maintained and the farmer would be assured of receiving the most suitable advice at the appropriate time.

CONSUMPTIVE USE AND WATER REQUIREMENTS

The Seminar calls attention to the recommendations of discussion group IV, "Research Needs in Irrigation" of the 1958 Seminar as reported in the proceedings. Although many of the recommendations were very specific, the Seminar was of the opinion that too few of the countries had tried to implement them.

The Seminar agrees that all the countries participating should re-evaluate their research program in view of the recommendations made at the 1958 Seminar, and proposes that special attention be given to the following:

1. (*a*) That research programs be initiated, continued, and expanded where possible, to determine the consumptive use of water for various crops under different soil conditions.

   (b) That studies be conducted to determine farm irrigation water requirements under the same local conditions.

   (*c*) Wherever possible countries should develop consumptive use of water data by using climatological data and one of the accepted formulas. This will provide data for most practical purposes.

2. That water requirements for leaching be determined for various soil types and in relation to the concentration of salts.

3. That particular attention be given to rice cultivation and the minimum water needs of the crop. Is ponding actually necessary?

4. That research be initiated or continued on the interactions of fertilizers and irrigation water.

CONSUMPTIVE USE : The Water used by plants in transpiration and growth, plus water vapor loss from adjacent soil or snow or from intercepted precipitation in any specified time. Usually expressed as equivalent depth of free water per unit of time.

AGRICULTURAL REQUIREMENTS FOR IRRIGATION PROJECTS

The Seminar noted that in many countries several agricultural problems have arisen after the completion of irrigation projects and recommends the following so as to avoid such problems in the future:

1. Closer coordination between irrigation engineers and agriculturists in the planning, design, and operation of irrigation projects.

2. Provision of drainage should be considered at the planning of an irrigation project, and not after difficulties have arisen.

3. Detailed soil and topographical survey of the project area should be undertaken in the initial planning of an irrigation project.

4. The irrigation system should ordinarily be planned so as to provide for the most intensive system of agriculture practicable in the area.

5. Experimental stations should be established for research work on problems connected with irrigation.

6. Extension services should be organized to educate farmers on proper methods of irrigation farming. Demonstration plots in farmers' fields should form a part of Extension Service.

7. Distribution of water should be done by the agricultural services with the participation of the farmers.

8. Delegates should bring to attention of their Governments the importance of making proper studies and the need for the provision of agricultural and other facilities in connection with irrigation projects.

ASSISTANCE TO FARMERS FOR IMPROVED IRRIGATED AGRICULTURE

For better production of food crops there are certain requirements that are to be met both by the farmer and the government at the *farm level.* The countries of the NESA Region have recognized this important aspect of farm requirements for increasing agricultural production, and certain countries have already taken steps to meet these requirements in some form or other. The President of the host country (Pakistan) himself has drawn the attention of the delegates to this vital need when opening the 1960 Seminar.

The Seminar has considered this matter and recommends the following:

1. Government Organizations to convey water up to a suitable point (outlet) and provide necessary drainage for the system.
2. Land preparation including farm irrigation and drainage etc. over the entire command of the outlet to be accomplished by the farmer, whenever possible government providing technical assistance.
3. The farmer to be given assistance preferably through farmers associations or existing organizations in improved agricultural practices such as improved seeds, implements, proper tillage, crop rotation, fertilizers etc.
4. Guidance and advice to achieve optimum results of land and water use by government agencies such as extension service, men or community development personnel through demonstrations preferably on selected farms in the community.
5. Adult farm education to be undertaken. Training in improved practices to be given to the adult farmers right on the farm through government agencies such as Agriculture Department, Reclamation Organization, Community Development, Extension Service etc. and where possible by qualified progressive farmers.
6. Financial assistance in the form of credit to the individual farmer and to farmer's organizations should be established.

DRAINAGE AND SALINITY CONTROL

The Third Seminar noted during field trips into the area contiguous to Lahore the problems of salinity and waterlogging requiring solution if this irrigated agriculture is to be made permanent. The Seminar noted the efforts of the Soil Reclamation Board to cope with this problem in the Chuharkana Reclamation Project and the research and demonstration efforts of the Directorate of Land Reclamation in the use of open drains at the Chakanwali Reclamation Farm. We were impressed with the evidence of a reduction of drainage and salinity problems by good irrigation management at the *farm level* and in the project area.

Recognizing that proper drainage is a necessary part of the application of sound irrigation practices; the Seminar restates, as follows, the recommendations of Discussion Group II of the Second Seminar:

1. Drainage investigations should be conducted concurrently with land classification as a part of project planning and, where conditions indicate that waterlogging may occur, main drains should be excavated at the time canals and distributaries are constructed. Before undertaking any development project, it is essential to investigate drainage requirements and the causes leading to such problems. Drainage should form an essential part of any irrigation and land development project.

2. Drainage facilities may be provided through the following, depending upon local and economic considerations:—

   (*a*) Open drains for surface waters.
   (*b*) Open drains for sub-surface waters.
   (*c*) Subsurface-tile drains.
   (*d*) Drainage through wells.

3. All road and railroad projects should invariably be required to include in their development programs drainage works, and to avoid impediments to surface or sub-surface drainage.

4. Proper irrigation practices should be adopted to insure control of salinity conditions and reduce the load on the drainage system to the maximum practical extent.

5. The subject of drainage being very important, and the majority of countries being in the process of undertaking new projects, experience should be interchanged which would be of mutual help.

6. It is strongly recommended that soil scientists and agronomists, along with farmers, should collaborate with drainage engineers for planning and execution of drainage and reclamation projects.

ORGANIZATION FOR OPERATION AND MANAGEMENT OF IRRIGATION PROJECTS

Before an irrigation project or system has been completed or partially completed by the planners and constructors to the point where water is to be delivered to the cultivators, it is essential that an organization be ready to take over the responsibility of operating and managing the completed work. The primary purpose of such an organization is to ensure that the project is operated and maintained in such a way that maximum benefits can be derived from the resources at hand.

There can be no set formulas for the type and size of such organizations as they will be as varied as the types, sizes and scopes of the projects themselves. Irrigation projects will vary from the small cultivator's controlled diversion or tank schemes of about 500 acres such as may be found in Lebanon and Ceylon (and in the larger countries as well), to the multipurpose, multimillion-acres government operated projects of India, Pakistan, Sudan and other large countries. The problems of operation and management will also vary widely between projects of equivalent size and scope depending on numerous factors such as climatic conditions, topography and soil conditions; whether the water supply is from direct stream diversion or from storage; literacy of the cultivator; extent of the use of machinery in maintenance; governmental policy in regard to land tenure and repayment of construction costs and other factors particularly such as the scope of auxiliary services available from other governmental agencies. For the reasons mentioned above it is not possible to set up a fixed framework of an organization for operation and management which can be applied across the board nor would it be proper for this committee to attempt to make recommendations for such an organization in any detailed form. The type of organization and the staff required will depend on the functions required to be performed and some comments are made of this point. In any operational organization, of whatever size or type; or whether it be controlled by government, by private enterprise, or by the land-owners and cultivators themselves, there are certain basic responsibilities which must be assessed and functions which must be performed by the management. These may be divided into the following categories:

a. Those which the management must perform with its own staff and resources at hand.

b. Those which may be performed by the management itself or by others for the benefit of management.

c. Those which normally are a service of other agencies of government but in which management must take an active interest.

The extent and scope of these responsibilities and functions applicable to any one project and the staff and equipment required to perform them will depend on the size and scope of the project itself. For a small scheme; of the order of 500 acres, where drainage is not a problem, and where the cultivators themselves band together to clean the canal and repair the structures etc., management staff would probably be limited to the headman himself supported by a committee elected by the cultivators. Nor would the management be concerned with some of the detailed scientific procedures followed on the large projects such as measurement and recording of canal discharge. The responsibilities of management on the large projects are much more complex. With this in mind a further division of those responsibilities and functions is given below.

A. *Functions which must be performed by management may be summarized as follows:—*

1. Formulating and enforcing regulations governing project operation and maintenance.
2. Apportioning of available water to the area to be cultivated. The assessment of water supply available is a function which is often performed by other agencies of government.
3. Actual control of water through the system and delivery of the water to the cultivator in proper quantities as allocated. Delivery may be to individual units as small for example, as 10 acres or groups of units as high as 500 acres, where cultivator committees or associations can complete the final deliveries. In the latter case the committees or associations becomes a responsible management group on their own.
4. Maintenance and repair of the project system which includes the headworks, canal (channel) system, communication system, drainage system, access roads, buildings and all operating structures.

5. Maintenance and repair of vehicles and equipment used in operation, maintenance and repair of the project works. On larger schemes this may require a large central workshop with several smaller field shops.

B. *Functions which may be performed by management or by others for management may be listed as follows:—*

1. Initial and follow-up assessment of water supplies available to the project for the crop season.
2. Measurement of canal discharge at strategic points for rating of gauges and periodic measurement of drainage discharge, and compilation of records of canal, drain and stream discharges.
3. Maintenance of records of ground water elevations by periodic recordings of sand points, piezometers or wells installed for this purpose.
4. Observation and maintenance of rainfall and temperature records if not available in the area.
5. Assessment and collection of annual water and drainage charges.

C. *Functions normally performed by other government agencies but in which management must take an active interest are:—*

1. Extension services, i.e., continuing advice to the cultivator on irrigation and agricultural practices, Crop patterns and rotations, seed selection and distribution, pest and weed control etc. All this is of extreme importance to management as only through the success of the cultivator can the project be successful.
2. Providing credit facilities to the cultivator for land preparation and purchases of seed, fertilizers, tools and machines or animals needed for efficient cultivation.
3. Analysis of water quality, both irrigation and drainage, and interpretation of analysis in its relation to project crops and soils and domestic use.
4. Periodic check of soils with particular reference to salinity.
5. Collection and recording of crop statistics.
6. Provide relief measures in cases of emergencies caused by floods or other incidents.
7. Extension of soil services.

RECOMMENDATION

Due to the fact that the ultimate aim of any irrigation project is the welfare and improvement of the cultivator's status, this Seminar recommends the following:

1. Whenever possible the cultivator should be encouraged to assume certain responsibilities in the operation and management of minor irrigation and drainage sections of the project, such as the delivery of water to individual units from the small tertiary laterals and the maintenance of such laterals.

   Where necessary, enabling legislation should be enacted by governments to permit formation of legally constructed organizations such as water users associations to serve this purpose.

2. The cultivator should be further encouraged to take an active interest in the operation and maintenance program of the overall project so that gradually he will come to realize that he is the real beneficiary of the system and will look forward toward more active participation in its activities.

3. The operation and management organization should respect and take full cognizance of the existing status of the cultivator and of the practices he is following so that it may develop a reasonable program with which he will willingly cooperate.

DISCUSSION GROUPS FOR RECOMMENDATIONS

Education and Training

Salim W. Macksoud, Lebanon (*Chairman*).
Ghdratollah Tamoddoni, Iran (*Secretary*).
Hafiz Saeed Ahmad, Pakistan.
Nevzat Ozalp, Turkey.
V.E.A. Wikramanayake, Ceylon.
K.F. Vernon, Pakistan.

Organization for Operation and Management

Sayed Elias Dafaalla, Sudan (*Chairman*).
J.H. Sawaya, Lebanon (*Secretary*).
A.G. Asghar, Pakistan.
Fatollah Raji, Iran.
E.F. Landerholm, Pakistan.
Thomas F. Ramsay, Turkey.
S.I. Phillippi, Ceylon.
Yadava Mohan, India.
Fahed Natour, Jordan.

Agricultural Requirements for Irrigation Programs

M.S. Qureshi, Pakistan (*Chairman*).
Mohammad Rejali, Iran (*Secretary*).
Sayyid Hamid, Pakistan.
Sayed Kamil Mansour, Sudan.
S. Kanagaratnam, Ceylon.
Halim Najjar, Lebanon.
Edward M. Davis, India.
Fred M. Tileston, Pakistan.
Sami Toufaha, Jordan.

Consumptive Use and Water Requirements

Ragip Boyaci, Turkey (*Chairman*).
Abdul Hamid, Pakistan (*Secretary*).
Sayed Yahia Abdel Mageed, Sudan.
Manouchehr Ayazi, Iran.
Tom A. Clark, Ceylon.
Bruce Anderson, Iran.
Jamil Elyafi, Jordan.
Alonzo N. Gibson, India.

Assistance to Farmers for Improved Irrigated Agriculture

Sedegh Ahi, Iran (*Chairman*).
V.N. Rajaratnam, Ceylon (*Secretary*).
Ali Asghar, Pakistan.
Cemil Kaleli Turkey.
M.M. Ismail, Ceylon.
Marshall Young, Sudan.
J.W. Robison, Pakistan.
J.P. Mital, India.

CHAPTER III

COUNTRY REPORTS

CEYLON

Geographical Features

The Island of Ceylon is situated at the Southern end of India and lies within the Tropic of Cancer between 5°55′ and 9°50′ North Latitude and 79°42′ and 81°55′ East Longitude. To its west is the Indian Ocean and its east the Bay of Bengal. Its greatest length from North to South is 270 miles and its greatest breadth from East to West is 140 miles. Its area is 25332 sq. miles which is a little more than one-fifth that of Great Britain.

Land Features

Of the total surface area of 25332 sq. miles the mountain zone covers 4212 sq. miles and the inland waters, 335 sq. miles. The Island consists of a central massif of hill country sloping on all sides from the highest peak (Pidurutalagala—8292 ft.) to the sea. In this descent, three terraces or peneplains are recognized at different levels and the rivers radiate from the central massif in many directions.

The first terrace is the coastal plain which is devoid of relief. The only physical features are the erosion remnants which take the form of buttes or monadrock-like hills and are found either isolated or in detached groups. The general level of the coastal plain varies from sea-level to above 400 feet above sea-level while the erosion remnants may rise up to 1000 ft. or more. The 100 ft. contour circumscribes the greater part of the Island except for the narrow coastal belt all around.

The second terrace rises steeply from the coastal plain to an elevation of about 1,600 ft. and this second peneplain shows immature relief and drainage pattern in contrast to the coastal plain.

The third terrace forming the central highland country rises from the second terrace to a general elevation of about 4000 ft. This terrace supports the highest mountains of the Island having peaks ranging from over 6000 ft. to 8292 ft. above mean sea-level.

The hill ranges are usually strike ranges and the main valleys lie between them. One principal physiographical effect of the range is that by it the areas affected by the south-west and north-east monsoons are separated from each other.

Climate

Variations in climate in the different parts of the country are quite marked. The annual range of monthly mean temperature and pressure, however, is small while the diurnal range of temperature is largely a function of the seasonal winds. Owing to the relatively high humidity, the mean annual temperature in the lower areas varies very little from 80°F.

Rainfall

Rainfall is unevenly distributed and is the only form of precipitation which is fundamentally of convectional type though the monsoons dominate during their respective seasons. There are two recognized zones, viz: the Wet Zone and the Dry Zone. The Wet Zone covers approximately the South-west quadrant of the Island, and the Dry Zone the remainder. Average annual rainfall is 113 inches in the Wet Zone and about 64 inches in the Dry Zone. During the south-west monsoon the Wet Zone receives rain almost daily for a period of nearly 4 months from May to September while the Dry Zone does not get any rain at all. During the north-east monsoon the Dry Zone usually gets more rain than the Wet Zone for about 3 months from October to January. This too occurs in the mountainous area, East and North, east of the central massif.

Floods

The area East and North of the central massif receives little rain throughout the year except in violent falls of several inches at a time. Cyclone activity of the tropical variety does occur during the North-east Monsoon period, particulalry from November to February. Thus owing to the physi-

cal features and geographical position of the Island, the concentration of mountains in the central part and the heavy cyclonic rains, practically every river of some magnitude has a flood problem. Water from the mountains and hills runs off rapidly down the steep slopes into the flat coastal plains whence it drains slowly into the sea. The rivers often spill over their banks and flood the surrounding countryside. Flood control measures have been taken on some of the rivers which frequently inundate large areas of paddy land or threaten the safety of populated areas. On other rivers, studies are being made with a view to evolve suitable measures to control the floods.

Soil and Vegetal Cover

The soil types found in the Wet Zone consist of laterite and gravelly loams and in the Dry Zone red loams. Small areas of humid soils are found in the patana grass lands of the Uva and the fern lands of the Sabaragamuwa Strike Valleys. Terarasa grey loams and other calcarious soils associated with the sedimentary lime stones are encountered in areas around the lagoons in the south-western sector of the Island.

It is chiefly the rainfall that determines the nature of vegetation and where the mean annual rainfall exceeds 150 inches, the most luxuriant vegetation exists. Here, occurs the true equatorial forest with tall spreading trees with small dark evergreen leaves. In the Dry Zone, there is the dry jungle or scrub as opposed to the wet forest of the Wet Zone. In areas with rainfall below 50 inches, the growth is usually thin and many of the plants are adapted to drought. In between these two is forest, jungle and scrub with various grades of tree growth which change with rainfall.

Resources

Of the total arable area of 3.7 million acres, tea accounts for 572706 acres; rubber 664836 acres; coconut 920942 acres. The coconut groves are generally near the sea; tea at higher elevations and rubber at intermediate levels. The area under rice is 1.4 million acres which brings in an output of 500,000 tons a year. However, more than 480,000 tons of rice and over 210,000 tons of wheat flour and cereals are imported. The irrigated rice area is 730,000 acres.

Manufacturing industries are confined to producing salt, cement, cotton textiles, soap, shoes, cigarettes, machinery for tea and rubber, glassware, beverages, matches and plywood.

The Island has no known deposits of coal or petroleum and easily exploitable industrial raw material resources are few. The only minerals of commercial significance at present are graphite, limestone, precious and semi-precious stones, glass sands, ilmenite and monzite sands, and various ceramic clays.

History of Irrigation

Conservation of water for cultivation was regarded as a solemn duty due by the monarchs to his subjects, and the kings who discharged this obligation were held in great veneration by the people. The first dam is believed to have been constructed in the year 504 B.C. by King Panduwasa, the successor of Vijaya. From the time of Panduwasa up to the 12th century over 10,000 tanks varying in size from a 4,000 to 100,000 ac. ft. with a network of distributary channels, appear to have been constructed. The King who ranks highest among the ancient monarchs who has constructed and restored large number of works is Parakrama Bahu (A.D. 1164—1197).

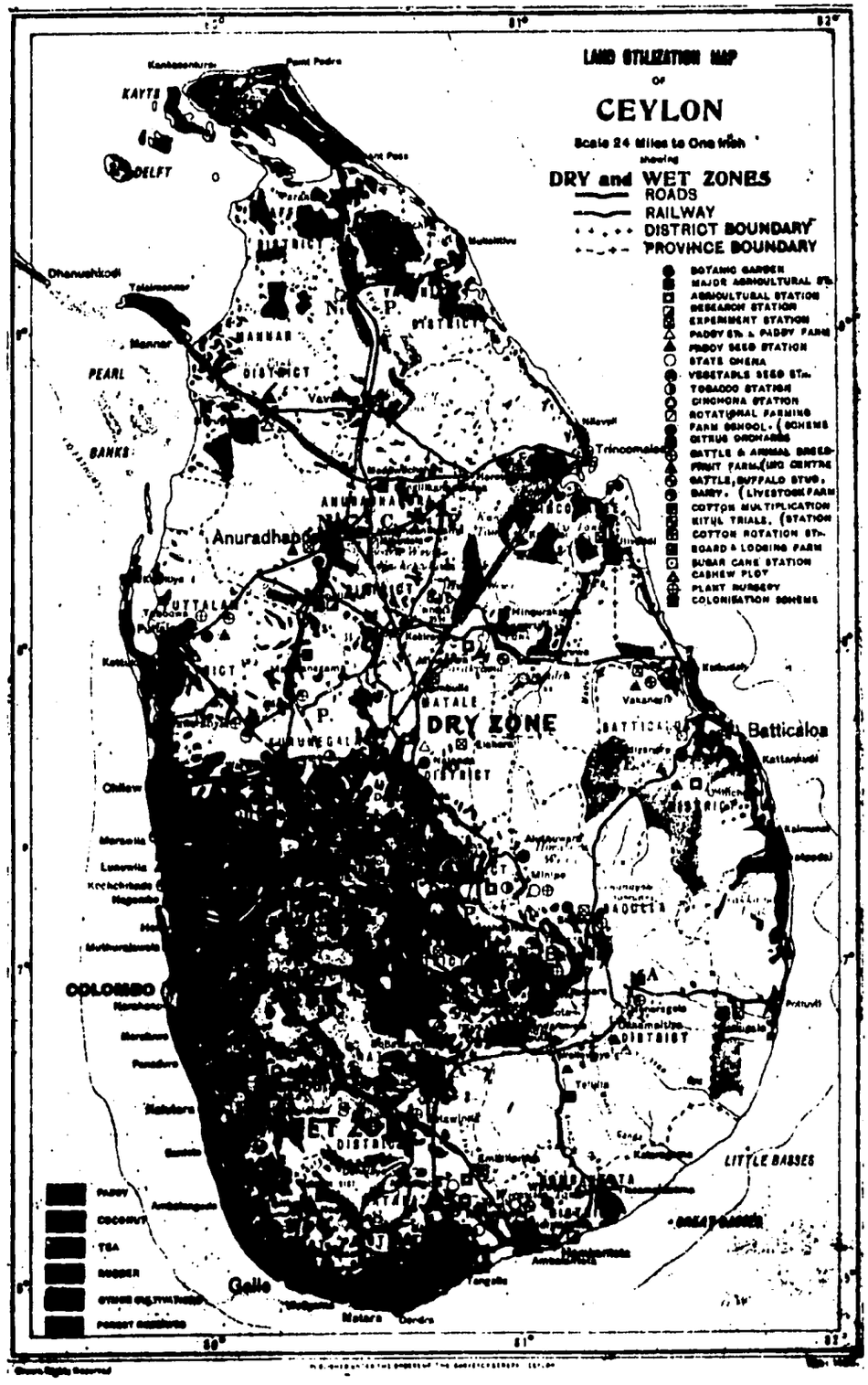
At the close of the Parakrama Bahu era in the 13th century, most of the ancient tanks and irrigation works fell into ruin and little was left of them when the Portuguese landed at the beginning of the 16th century. The Portuguese took no interest in the development of irrigation works or of agricultural pursuits, and works already built were allowed to fall into disuse and disrepair. The Dutch, who came next in the middle of the 18th century, were more interested in agriculture and started some irrigation works, but their chief efforts appear to have been directed towards the development of water-ways than irrigation works.

The British succeeded the Dutch in the Maritime Provinces in 1796 and later took over the administration of the Island in 1815. During the first 58 years of the British rule, no attempt was made to encourage rice cultivation and even the few village tanks which were maintained on the Rajakaria System (service to the King) were neglected and fell into disrepair on the abolition of the System. Villages and communities depending for their existence on the irrigation works, eventually disappeared and a period of neglect followed until British interest in irrigation was aroused by the neglected conditions of the Districts, and in 1857, they undertook a program for the restoration of the old irrigation works which is being continued to this day.

Irrigation Works

The irrigation works are classified as: (*a*) Major Irrigation Works and, (*b*) Minor Irrigation Works or Village Works.

The major works are those which are maintained and supervized by the staff of the Director of Irrigation from general funds and the lands under which works are liable to pay irrigation rates in accordance with the agreement between the Crown and the proprietors under the Irrigation Ordinance.



Land Utilization Map of Ceylon

About 150 schemes are classified as major works. Among those are tanks whose capacity varies from a few thousand ac. ft. to more than 800,000 ac. ft. Their total capacity is about 3.5 million ac. ft. and they irrigate over 500,000 acres annually.

Minor or Village Works include small tanks and small anicut schemes which provide irrigation for small extents of land. The construction, remodelling and improvement of these works and the maintenance of masonry structures are under the Irrigation Department. The land owners do not as a general rule pay any rate but carry out the earthwork and jungle clearing necessary for their construction and maintenance in part or whole. There are 3,000 village tanks in operation at present while the number of anciert schemes or diversion dams is quite large. The village works irrigate at present about 420,000 acres of paddy land.

Program of Development

Irrigation in Ceylon was stimulated under the Six Year Program adopted by the Government in 1947. The first Six Year Program provided irrigation facilities for 90,560 acres. The second Six Year Program envisioned the development of 124, 344 acres, but there has been a serious set back to the progress on account of unprecedented floods which damaged many of the irrigation works. The years 1959 were spent in repairing the damaged works, and very little development work was possible during these years. However, approximately 100,000 acres were provided with irrigation facilities under the schemes taken in the 2nd Six Year Program of work.

Colonization Schemes

A slump in 1931 in the principal commodities of the country; tea, coconut, and rubber reduced employment in the parts of the Wet Zone where these industries are situated and brought about the vital necessity for expansion to the Dry Zone as a means of livelihood to the people. The population pressure in the Wet Zone forced the Government to initiate a scheme of colonization and land utilization in the Dry Zone, and for the first time in the history of the country, lands under Minneriya major irrigation schemes were taken up for development in 1934 as a colonization scheme. The general policy of the Government had been to establish the peasant on a unit of holding consisting of a wet land area and a highland area to enable him to settle on the land and derive from it an income sufficient to maintain himself and his family in reasonable circumstances. He is to obtain the money income from the wet land by rice cultivation. His homestead to be on the highland at a reasonable distance from the wet land where besides his home he can cultivate permanent crops and vegetables mainly to meet his own requirements of food.

In the earlier schemes, the wet land unit was 5 acres and the highland unit 3 acres. These units of holdings were based on the agricultural produce prevailing in 1935. As the price of agricultural produce improved, the demand for land by the peasant settlers increased. It was then decided to reduce the unit of holding, and at the moment it stands at 3 acres of wet land and 2 acres of highland. The schemes taken on the 1st and 2nd year Six Year Plan were planned and constructed on this basis.

Multipurpose Projects

Almost all the schemes undertaken in the past had been single purpose schemes designed for irrigation of existing cultivation or taking new lands for cultivation or for the generation of power. Very little attention was paid, however, to new developments under which river resources were more fully exploited. Progressive opinion in the country became gradually aware of the limited benefits that piecemeal exploitation yielded, however. It was therefore realized, for the maximum utilization of available water resources, that multipurpose projects must be framed.

Gal Oya Basin Development

Gal Oya Project is one of the items in the planned scheme of development along multipurpose lines, which has been constructed and put into commission. The reservoir stores of 0.77 million ac. ft. for irrigation, power and flood control purposes. It provides irrigation for 120,000 acres of paddy and develops 10,000 K.W. of hydroelectric power. The scheme has reduced the extent of flooding in the valley to a great extent and with the provision of irrigation and drainage facilities, the waterlogging problem in the areas affected is gradually disappearing.

Mahaweli Ganga Basin Development

The planning for the development of water resources of the Mahaweli Ganga Basin (Basin area 4,034 sq. miles) has been undertaken by an American River Basin Planning Team on an agreement between the Government of Ceylon and the United States with the following objectives:

The basin is to be used as the specific model and demonstration area for which:

(*a*) complete field investigations and office studies are to be made,
(*b*) all feasible water and power schemes within the basin are to be integrated into an overall multipurpose engineering plan,
(*c*) a reasonable schedule of project priorities is to be established and a long range program of basin development prepared.

Irrigation Organizations in the Country

The Irrigation Department, under the Ministry of Agriculture and Lands and administered by the Director of Irrigation, handles activities relating to water resources development. The activities of the Department are as follows:

(*a*) Irrigation under both major and minor schemes.
(*b*) Flood Protection.
(*c*) Drainage and reclamation of marshy lands.
(*d*) Exclusion of salt water from cultivable lands.
(*e*) Provision of irrigation, drainage, and access facilities to colonization schemes.

The country is divided into 10 Territorial Divisions, each administered by a Divisional Engineer. Each Division is further sub-divided into sub-divisions which are in charge of Irrigation Engineers. Maintenance and construction of major works and construction of minor works are the chief responsibilities of the territorial staff.

District Agricultural Committees under the Chairmanship of the Revenue Officer of the District bring up new items of minor work for construction by the Irrigation Department and are included in their priority lists, viz: "preliminary investigation", "full investigation" and "construction". Thereafter, these items are taken through the various stages of investigation and construction under the direction of the Divisional Engineer. Construction of major works is also one of the functions of the Divisional Engineer but works of larger magnitude like the Gal Oya Project are handled by Development Boards appointed by Government.

The Planning Branch of the Department is responsible for designs of major projects, for carrying out laboratory and field tests and for collecting hydrologic data throughout the Island.

The Gal Oya Development Board, established under the Gal Oya Act, is responsible for treating the entire river basin as a unit and for fostering orderly and proper physical, economic and social development within the Valley. This Board consists of a Chairman and 3 members appointed by the Ministry of Agriculture and Lands. It is responsible for providing irrigation, drainage and access facilities to lands under it, besides clearing and preparing the land for cultivation before turning the lands over to the colonists. The Board functions as a separate organization for the Irrigation Department.

Problems of Irrigation Practices

Irrigated Crops

Irrigation in Ceylon generally denotes the irrigation of rice which is grown under flooded conditions. With the exception of a small area in the Northern Province, which grows cash crops under an intensive handwatered system, the only crop that is irrigated is rice. Priority is given to rice by regulation, and in practice all of the available water from projects of all sizes is diverted to the irrigation of rice fields.

Preparatory Tillage

In the cultivation of rice, clearing of the field channel is the first task performed by the cultivator. This operation is followed by repairs to the small narrow levees forming the bays within the field. Two or three days before ploughing is done, water is let into the fields to soak the sail for the first ploughing. After this, application of manure is made and the fields are kept flooded for several days to enable the decomposition of weeds and stubble. The second ploughing is done three weeks after the first ploughing and along with this operation the levees are strengthened. The fields are still kept flooded till the third ploughing which is generally done 10 or 12 days after the second ploughing. The third ploughing operation is followed by a rough levelling, after which water is let in just sufficient to keep the mudded fields soft and moist. The fields are next levelled with a hand leveller and water completely drained off before sowing.

Levelling of Paddy Fields

Field beds should be level as far as possible to enable the water to be retained at uniform depth. Poor levelling results in:

(*i*) the failure of a considerable number of seedlings to establish themselves,
(*ii*) inefficient and uneconomical utilization of irrigation water, and
(*iii*) difficulty in inhibiting weed growth with the normal supply of irrigation water.

This is one of the problems that confronts cultivators in newly developed lands in the early stages. As time goes on, the cultivator is able to bring his fields to the desired level within the bays.

Weed Control

Control of weeds in paddy fields in Ceylon is of vital importance as climatic conditions throughout the year favour weed growth. Unless fields are ploughed several times, and water impounded for a long period, weeds are not properly decomposed. Considerable weed growth develops in paddy fields soon after they are sown and an excess of irrigation water is required to inhibit their growth.

Method of Application of Water to the Field

Minimum unit of holding is 3 acres which is supplied by a field channel through a 4-in. pipe

outlet. The water is let into field by allowing it to flow from bay to bay and thus the fields are kept inundated through the greater part of the crop growth which results in extravagance in the use of water.

The main problem regarding irrigation practices is therefore the use of more water than is necessary. A system of water conservation will result in more land being taken up for rice cultivation, but the development of such a system is bound up with numerous other problems.

Need for Water Control

Reports from Japan indicate that, contrary to common belief, the water in a rice field does not have to be flowing or even circulating within the field. The standing water serves both as a weed control measure as well as of creating anaerobic conditions in the soil to maintain the Oxydation-Reduction potential in an ideal state for the rice plant. From the point of view of the amount of water needed for rice cultivation it is necessary to pose the main problem as a number of separate studies:

(*a*) Sufficient information is not available in Ceylon to determine at what stage of the growth of the plant it is not essential to have water standing in the field. There are indications that at certain times during the plants' growth, a lack of water does no harm and may even be of some value. Observations of temporary drought periods in the past cannot conclusively pinpoint the exact requirements and it is necessary to engage in a coordinated research program on his aspect.

(*b*) From the point of view of the Agricultural Engineer, the problem concerns the technique of controlling water in each field and of evolving methods of metering the water to each field as necessary. The problem may be briefly stated as follows:

1. The design of cheap and effective turn-out boxes, junction boxes and means of maintaining water levels at the desired height.

2. The improvement of field layout and positioning of irrigation and drainage channels.

3. The improvement of levee construction and design to enable the above methods to be operated, and to control damage by land crabs.

Cultivation Season

Connected with the conservation of irrigation water is the problem of the cultivation season. In the "Dry Zone", where most of the rice is grown under the major irrigation schemes, the growing season for rice is the Maha season or the N.E. Monsoon season which commences in September and lasts till April. Normally, tanks are filled by these rains and the rice crop is irrigated from the water stored during the period. During the S.W. Monsoon season, or the Yala from May to August, cultivation is dependent upon any carry over of water in the tanks. Monsoon rains in Ceylon are unpredictable and notoriously inconsistent and therefore, farmers are loath to prepare their fields until the tank is full. The results of this late preparation of fields is felt on crop yield. The extension worker finds it almost impossible to persuade the cultivator to prepare his land during the rains, before tanks are filled; the cultivator's philosophy being that if the tank does not fill, there will not be sufficient water to mature the crop.

Crops Other than Rice

Cash crops such as tobacco, chillies, onions and vegetables are grown in many parts of Ceylon. In the North they are cultivated intensively on small holdings (¼ acre) and are irrigated from wells, by well sweeps, Persian wheels and pumps. In other parts of Ceylon, such crops depend on rainfall and are rarely irrigated. In any case, priority being given to rice, water from any irrigation projects is not available for these crops.

As mentioned before, the rainfall is inconsistent and hence crops such as tobacco and vegetables frequently fail, even in rainy areas, due to long periods of drought. Studies made at the University of Ceylon at Peradeniya indicate the nature of the frequency of drought in these areas. Figure I shows a frequency curve of moisture deficient periods for a crop of mixed vegetables at Peradeniya. The study has been confined to the four months of December to March. The moisture deficiencies were worked out by the method of Blaney and Criddle and using a coefficient of 0.8 at a root depth of 2 ft. The curve shows no difference between soils of different levels of available moisture. It will be seen that, for instance, a drought period of 10 days will be experienced four years in ten. In terms of income, this means a tremendous loss to farmers, particularly, tobacco growers and justifies expenditure for supplementary irrigation. Studies have been made of sprinkler irrigation equipment and it would appear that such irrigation could be available at less than Rs. 10/- per acre inch. The use of sprinkler irrigation to supplement rainfall for crops such as tobacco becomes all the more feasible in the light of the development of the mechanization of the small holdings. This possibility has been exploited to

the full in Japan and machines improved from Japanese designs are becoming popular. The basic machine is a small power unit that supplies power for ploughing, harrowing, ridging, inter-cultivating, harvesting, irrigation and transport. The financing of the mechanization will be undertaken by Farmers Cooperatives and a beginning has already been made. Over 250 such units have been put in operation in Ceylon in the last three years. More study is necessary both in the techniques as well as in the economics of supplemental irrigation.

Accomplishments on Farm Irrigation

The Department of Agriculture, under the Ministry of Agriculture and Lands, undertakes the training of youth in scientific agriculture and modern agricultural practices and the extension of agricultural knowledge among the farming community. There are three fully developed agricultural schools for boys and girls of past secondary school level and 21 practical agricultural schools which cater for the needs of nearly 600 boys and girls from rural environments each year. Day practical agricultural schools are in the process of being established to provide instructions to thousands of rural youth in improved practices and methods of agriculture.

The Department has, in recent times fostered the Young Farmers' Club movement with the object of stimulating the interest of school-going children and young men and women in rural districts in agriculture, animal husbandry, and home management. There are nearly 1000 such clubs at present catering to over 30,000 young men and women of the agricultural community.

Another important feature of the activities of the Department is the establishment of Government Farms under which are included different units such as experiment stations, school farms, plant and animal supply multiplication centers, livestock breeding farms and stud centers. There are over 100 such units at present fulfilling their functions as demonstration centers.

Soil surveys of potential irrigable areas are also the responsibility of the Department of Agriculture which furnishes to the Department of Irrigation, soil reports covering the subjects of physiography, vegetation, soil types, chemical characteristics, drainability, fertilizer requirement and suitability for paddy cultivation or garden crops. No work has so far been done in connection with large-scale classification. A start has however been made by the American River Basin Planning Team and a comprehensive land classification survey is in hand.

Power tillage introduced some years ago is now a feature of the agricultural practice of certain paddy areas in the dry zone where labor and animal power are in short supply. There are well over 2000 tractors in operation in the Island at present, which are mainly used for tillage purposes and to some extent for threshing. Experiments are being now being carried out to ascertain other uses for them, such as sowing and harvesting.

Irrigation Research

Duty of water brings both the irrigation and agricultural aspects closer together. Various factors such as, character of the soil, amount of moisture in it, and the depth to which the soil is to be moistened, affect this duty and a vast amount of study still has to be carried out on this subject.

The University and the Department of Agriculture are carrying out consumptive use studies on rice and other crops. The studies so carried out are in the form of ad hoc investigations. A coordinated program of research in this country on water requirements for various irrigated crops therefore is an urgent need.

Discussion

Mr. Haque requested additional information about the Gal Oya Project, Mr. Rajaratnam indicated that the dam had been completed for about 5 years and that the main canals totalled 80 miles with an additional 380 miles of branch canal. The development has been quite difficult due to the rugged terrace however there is no problem of salinity or alkalinity.

Dr. Ali Asghar inquired about the reference to training of workers by the Department of Agriculture. Mr Kanagaratnam replied in some detail, however, this material is included under Education and Training.

INDIA

Introduction

Physiographically, India is divided into four segments of totally dissimilar characteristics:

(*i*) The pennisula of the Deccan, lying in the south of the Vindhyan mountains, which is a solid and stable block of the earth's crust largely composed of some of the most ancient rocks, which the

denundation of ages has carved out into a number of mountain ranges, plateaus, valleys and plains; (*ii*) the Himalayas and associated mountains surrounding the plains in the north and north-east; (*iii*) the Thar desert, an arid region in the north-western part of the country, occuping a large part of Rajasthan and (*iv*) the Indo-Gangetic alluvial plains of northern India extending from the Punjab to Assam. The Indo-Gangetic plains which have been formed by the alluvium brought down by the rivers constitute one of the most fertile tracts of the world; and although they have been cultivated from times immemorial, show little signs of exhaustion.

Climate

India lies partly in the tropical and partly in the sub-tropical regions of the world. The Tropic of Cancer passes almost through the middle of the country. The sub-tropical zone shows extremes of climatic condition, while the tropical zone is more equitable. In most of the country, there are three seasons (*i*) Summer, which is from April to June; (*ii*) the rainy season—from July to October and (*iii*) the Winter—from November to March.

The exact duration of each season, however, varies in different parts of the country.

Rainfall

The outstanding feature of the rainfall in India is its unequal distribution during the year and its variation from year to year in respect of quantity, incidence and duration. The average annual rainfall of India is 50 inches, but it is only of the order of 5 inches in the desert in the north-west, increasing gradually across the plains of northern India from west to east until it is about 100 inches in Assam. In central India, the mean rainfall is of the order of 50 inches a year, and in the Peninsula, except along the west coast, the mean annual rainfall is of the order of 30 inches. Almost the entire rainfall in the country is due to the south-west monsoon and is received during the four months of June to September, with the exception of the south-east portion of the Peninsula, where the rainfall is heavier from October to December. In winter the rainfall varies from ½ to 2 inches except in north-east monsoon areas, and from March till the onset of the south-west monsoon, the country is almost rainless. Apart from its unequal distribution in the year, the rainfall shows considerable variation from year to year. It is not uncommon in many places for rainfall in a year to be less than half the normal; even one fourth of the normal during a critical period in the crop rotation has been experienced.

Soil

The soils of India, which extend from the temperate regions through the sub-tropical in .he torrid zones, display marked differences in character which are again reflected in the vegetation pattern of the country, and can be classified into four major types.

(*i*) Alluvium soils, spreading over Punjab, Uttar Pradesh, Bihar, Bengal, parts of Assam and the coastal areas of South India, particularly in the deltaic region.

(*ii*) Black cotton soils, the typical soil of the Deccan trap extending over Bombay, Western parts of Madhya Pradesh, Mysore and some parts of Madras.

(*iii*) Red soils extending from Bundelkhand to the extreme south embracing south Bengal, Orissa, parts of Madhya Pradesh, eastern Andhra Pradesh, Mysore and major part of Madras; and

(*iv*) Laterite soils, a soil type peculiar to India, existing in Mysore, Kerala, parts of Madhya Pradesh, coastal region of Orissa, South Bombay, Malabar and part of Assam.

Land Resources

The geographical area of the country is 806 million acres of which the land utilisation statistics are available for about 720 million acres. The details of the land resources of India for 1956-57 are:

	(*million acres*)
(*i*) Total Geographical Area	806.3
(*ii*) Area under cultivation	320.7
(*iii*) Cultivable lands not yet cultivated	97.0
(*iv*) Fallow lands	58.7
(*v*) Forests	125.7
(*vi*) Land put to non-agricultural uses	32.6
(*vii*) Unculturable land	85.2
Total reported area	719.7

It will be seen that the cultivable area is about 60 percent of the gross area, and out of this about 2/3 is under cultivation.

Water Resources

In India, as in other countries, rivers have had a powerful influence on national and local life. Successful agriculture in most parts of the country is not possible without the use of river waters. The rivers of India may be broadly divided into two groups:

(1) The snow fed rivers of northern India and (2) the rivers of Central and Southern India. A recent appraisal of the water resources of the country, based on an empirical formula corelating the river flow in each basin with its rainfall and

temperature, gives the total annual flow as equivalent to 1356 million acre feet. Not all this is available or needed for irrigation. The river flow that can be used for irrigation depends on topography, flow characteristics, climate and soil conditions of the region and differs from river to river. It has been estimated that of the available supplies approximately a third, i.e. about 450 million acre feet could be put to beneficial use. Up to 1951 only 88 million acre feet or 5.6 per cent of the total flow had been put to use. A large number of irrigation schemes were taken up in the First Plan and it has been estimated that on completion of these schemes 150 million acre feet or 11 per cent of the available surface water resources would be harnessed. The Second Five Year Plan catered for still many more irrigation schemes and when these get completed the total utilization will rise to 184 million acre feet or 13.6 per cent of the total water resource or nearly 40 per cent of the usable surface water resource.

As regards the underground water resource, no assessment of it has yet been made, but it is obvious that this is of considerable magnitude. This resource is, however, more easily tappable by means of open wells or tubewells in alluvial plains where surface water resource is also normally plentiful. In planning irrigation in these areas, therefore, a balance has to be struck between the use of the surface water resource and the underground water resource.

Agriculture

About 70 per cent of the people are dependent on land for their living. Agriculture and allied activities account for nearly half of the country's national income. India enjoys a virtual monopoly in lac and ranks first in the world in the production of groundnuts and tea. Out of 720.00 million acres of reported land about 320.7 million acres have been cultivated. The area of major crops during the six years ending 1957-58 are:

Foodgrains (*In million acres*)

Crops	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58
Rice	74	77	76	78	79	79
Jowar	43	44	43	44	40	41
Bajra	27	30	28	28	28	27
Maize	9	10	9	9	9	10
Ragi	6	6	6	6	6	6
Small millets	12	14	14	13	12	12
Wheat	24	26	28	31	14	30
Barley	8	9	8	8	9	7
Total Cereals	203	216	212	217	217	212
Gram	18	20	23	24	24	22
Tur	6	6	6	6	6	6
Other pulses	25	28	25	28	28	27
Total Foodgrains	252	270	266	273	27	5267
Other Crops						
Potatoes	0.6	0.6	0.6	0.7	0.7	N.A
Sugarcane	4.3	3.5	4.0	4.6	5.1	5.0
Blackpepper	0.2	0.2	0.2	0.2	0.2	0.2
Chillies	1.2	1.3	1.6	1.5	1.5	1.5
Ginger	0.05	0.03	0.04	0.04	0.04	0.04
Tobacco	0.9	0.9	0.8	1.0	1.0	0.9
(*In million acres*)						
Groundnut	12	10	14	13	13	14
Castorseed	1.3	1.3	1.4	1.4	1.4	1.3
Seasamum	5.9	6.3	6.5	6.0	5.4	5.3
Rape and mustard	5.2	5.5	6.0	6.3	6.3	6.0
Linseed	3.4	3.4	3.4	4.0	4.1	3.3
Cotton	16	17	19	20	20	20
Jute	2.0	1.2	1.2	2.0	2.0	2.0
Mesta	0.5	0.5	0.4	0.6	0.7	0.7
Tea	0.8	0.8	0.8	0.8	0.8	N.A.
Coffee	0.2	0.2	0.2	0.2	N.A.	N.A.
Rubber	0.1	0.2	0.2	0.2	0.2	N.A.
Coconut	1.6	1.6	1.7	1.6	1.6	N.A.

Crop Seasons

There are two well defined crop seasons namely (*i*) Kharif and (*ii*) Rabi. The major Kharif crops are rice, jowar, bajra, maize, cotton, sugarcane and seasamum and main Rabi crops are wheat, barley, gram, mustard and linseed

The season and duration of principal crops are:

Crop	Season	Duration
Rice	Winter	5½—6 months
	Autumn	4—4½ ,,
	Summer	2—3 ,,
Wheat	Rabi	5—5½ ,,
Jowar	Kharif	4½—5 ,,
	Rabi	4½—5 ,,
Bajra	Kharif	4½ ,,
Maize	Kharif	4—4½ ,,
Ragi	Kharif	3½ ,,
Barley	Rabi	5—5½ ,,
Gram	Rabi	6 ,,
Sugarcane	Perennial	10—12 ,,

Crop	Season		Duration	
Seasamum	Kharif		3½—4	,,
	Rabi		5	,,
Groundnut	Kharif		4—4½	,,
		Early	4—4½	,,
		Late	4½—5	,,
Rape & Mustard	Rabi		4—5	,,
Linseed	Rabi		5—5½	,,
Castor	Kharif	Early	6	,,
		Others	8	,,
Cotton	Kharif	Early	6—7	,,
		Late	7—8	,,
Tobacco	Kharif		7	,,
Jute	Kharif		6—7	,,

Irrigation

The practice of organized irrigation in India has been traced to well before the Christian Era. In the Deccan a large number of irrigation tanks have been in existence for many centuries. The Cauvery Delta Canals date back to the second century. The Yamuna Canals were constructed originally in the fourteenth century, and were later remodelled by the British in the nineteenth century. The first major irrigation works constructed in India was the Ganga Canal in Uttar Pradesh, opened for irrigation in 1854. This was followed by the Upper Bari Doab Canal in the Punjab and the Godavari Delta system and the Krishna Delta system in the South. Then came the Sirhind Canal in the Punjab and the Lower Ganga and the Agra Canals in Uttar Pradesh and the Mutha Canals in Bombay, the last named being from a storage reservoir. Further irrigation works were constructed towards the end of the last and the beginning of the present century, and a few more after the end of the First World War. Since then considerable progress has been done in this sphere of development.

Sources of Irrigation

Water for irrigation is obtained from three sources.

(1) Directly from the flows of rivers and streams, i.e. by diversion canals.
(2) From storage of flood waters flowing in rivers or directly of rain-water from small catchments.
(3) From the waters available underground, i.e. by wells or tubewells.

While the North, with its numerous perennial streams, specialised in irrigation by means of diversion works, the South excelled in tank irrigation. Irrigation from open wells has been practised since times immemorial and has been particularly popular in the plains where the ground water-table has been within easy reach. Supplementing supplies in open wells by means of bores made with pipes is a recent feature. Tubewells in large numbers made their first appearance in the thirties of this century, mostly in U.P.

Classification of Irrigation Works

For convenience, irrigation projects are classified in the following three groups.

(*i*) Major projects—costing more than Rs. 5 crores each.
(*ii*) Medium projects—costing between Rs. 5 crores and Rs. 10 lakhs, and
(*iii*) Minor projects—costing less than Rs. 10 lakhs.

Minor Irrigation

This category includes open wells, tubewells, tanks and irrigation from small streams. For the purpose of classifying the older works which do not lend themselves to satisfactory classification on a financial basis, having been executed at different times with different price indices, the classification is based on area irrigated by a scheme; old schemes irrigating less than 4000 acres are classed as minor irrigation works.

Relative Merits of Major and Minor Schemes

A balance has to be struck between major and medium irrigation schemes on the one hand and minor irrigation schemes on the other. Minor schemes are advantageous in that

(*i*) The initial outlay involved is small,
(*ii*) They can be executed quickly and yield quick results,
(*iii*) They generally require no special assistance by way of foreign exchange,
(*iv*) Local resources can be easily mobilised for their execution.

The disadvantages of such schemes are

(*i*) Their high cost of maintenance,
(*ii*) Their relatively short life, and
(*iii*) The limited protection they give.

There has been a long neglect of customary obligations in the past in regard to minor irrigation works with the result that many of these works are in disrepair and areas irrigated by them have been diminishing.

The major schemes, on the other hand, have the merit of

(*i*) Utilising surplus waters of the river system, which otherwise run to waste,
(*ii*) Give better protection in years of scarcity when water is needed most,
(*iii*) Are often multipurpose in nature, i.e. apart from irrigation they confer other

benefits, such as, hydro-electric power, flood control, navigation etc.

They, however, take longer to execute and have higher initial cost. In regions of low rainfall, however, such as, part of Rajasthan and certain areas in Andhra Pradesh, major irrigation schemes are the only satisfactory means of providing irrigation.

Development of Irrigation

In 1950-51, i.e. in the commencement of the First Five Year Plan, the total area irrigated from the various sources was 51.5 million acres, out of which 20.7 million acres were irrigated by canals, 8.8 million by tanks, 14.7 million acres by wells and 7.3 million acres by other sources.

The projects undertaken in the 1st Plan are expected to bring under irrigation an additional area of 33 million acres on full development. This is inclusive of irrigation of 11 million acres from minor irrigation schemes including tubewells.

Apart from some of the continuing schemes from first plan to second plan, about 216 new major and medium irrigation schemes have been included in the second plan to bring an additional area of 16 million acres under irrigation on full development. In addition, 9 million acres are expected to be irrigated from minor irrigation schemes including tubewell.

Achievements

Major and Medium Schemes—The total additional area to be irrigated under major and medium schemes of I & II Plans on full development is 38 million acres. Irrigation facilities were provided for an additional area of 5.3 million acres by 133 major and medium irrigation projects during the First Five Year Plan and this was raised to 7.2 million acres by the end of 1957-58.

Tubewell Schemes—There were about 2,500 tubewells in India prior to 1951, about 2,300 of which were in Uttar Pradesh. These tubewells irrigated about a million acres. Under the scheme for the construction of tubewells sponsored by the Government of India under the Indo-American Technical Assistance program 2,998 tubewells were drilled, 2976 completed with pumping sets and 2,952 energised and put into commission till the end of November 1951. These include 350 tubewells of the project of 700 tubewells taken up in 1954 with Grow More Food assistance; which were financed partly from TCM funds. Out of the remaining tubewells of the 1954 GMF project, 270 were drilled and energised up to November, 30, 1958. This brings the total of tubewells in the country to more than 8,000, which are irrigating between 2 to 2.5 million acres depending on weather conditions in a year.

Under the ground water exploration of 350 exploratory tubewells, drillings were completed in Bihar, Kerala, Kutch, Madras, Andhra, and Punjab. Of the exploratory bores drilled in different States about 92 wells yielded sufficient quantities of water and were converted into production tubewells.

Financial Outlays

The total cost of irrigation works in the country at the time of independence in 1947 was about Rs. 100 crores. The estimated cost of multipurpose, large and medium projects included in the first and second five year plan is Rs. 1330 crores. By the end of the first five year plan, Rs. 380 crores was spent on such works, and by the end of the second plan the total expenditure will amount to over Rs. 800 crores. Considerable importance has also been attached to minor irrigation projects, and Rs. 85 crores were allotted for these works in the first five year plan and Rs. 118 crores in the second five year plan. In addition, small irrigation works are carried out with public participation through the agency of the community development program and it is estimated that works costing Rs. 8 crores and about Rs. 50 crores will have been executed through this program in the first and second plans respectively.

Irrigation Organization

Irrigation is a state subject and not a Central subject. In most states, there is now a separate irrigation department to handle the schemes, both major and minor. Small schemes costing a few thousands of rupees are dealt with by the state revenue, agriculture or community development departments. The coordination of minor schemes is done by the Ministry of Food and Agriculture at the Center and of major and medium schemes, by the Union Ministry of Irrigation and Power. This Ministry is assisted on the technical side by the Central Water and Power Commission.

The execution and maintenance of the projects are carried out by the irrigation department of the states concerned. Assessment and realization of revenue from irrigation is generally done by the Revenue Department in the southern states while in North India assessment is done by the irrigation department and realization of revenue is made by the Revenue Department. The irrigation department consults the Agricultural Department for fixing intensity of irrigation, duty, crop pattern etc. for adoption in new projects.

Further, the states have constituted working groups at various levels starting from the state right up to the Tahsil to ensure the full use of irrigation

facility in relation to each project which has been completed or taken up in the I and II Five Year Plans and to review carefully and at regular intervals, the progress of such projects. The working group at the state level is generally composed of the Development Commissioner and officers of the agriculture, irrigation, co-operative and community development departments. Half-yearly reviews are submitted to the state cabinet regarding the measures taken and the progress made, with a copy to the Planning Commission at the Center. It has also been suggested that for each project there can be a working group of officers directly concerned with it, so that they would follow the various steps needed at each level down to the village. The working groups are functioning in almost all the states.

Irrigation Research

The Central Board of Irrigation and Power has been the co-ordinating authority for research work in the field of hydraulic and hydro-electric engineering. The board has established contacts with about 231 engineering research organizations throughout the world for exchange of publications.

The following are the irrigation and power research stations in the country which carry out research on hydraulic and hydro-electric and irrigation problems.

(1) Central Water and Power Research Station, Poona.
(2) Silt and Construction Materials Directorate (Flood Wing), New Delhi.
(3) Hirakud Research Station, Hirakud.
(4) Hyderabad Engineering Research Laboratories, Hyderabad—Daccan.
(5) Bihar Institute of Hydraulic and Allied Research, Khagaul, Patna.
(6) Kosi Project Research Laboratory, Birpur.
(7) Poona Irrigation Development Division, Poona, Bombay.
(8) Concrete Research Laboratory, Koyna Project, Koyna.
(9) Indian Institute of Science, Bangalore.
(10) Mysore Engineering Research Station, Krishnaraja Sagar.
(11) Soil and Material Testing Laboratory, Raipur.
(12) Irrigation Research Station, Poondi, Madras.
(13) Concrete and Soil Engineering Research Station, Chepauk, Madras.
(14) Punjab Irrigation and Power Research Institute, Amritsar.
(15) U.P. Irrigation Research Institute, Roorkee.
(16) River Research Institute, West Bengal.

Agricultural Research

The Indian Council of Agricultural Research, established in 1929, sponsors research in both agriculture and animal husbandry in the country. The program of agricultural research continued to be progressively strengthened and expanded so as to help in raising the tempo of agricultural development in the country. There are 483 agricultural research stations in the country. Most of these research stations in the states carry on research on a number of crops but a few are meant to carry on research work on particular crops, such as rice, wheat and horticultural crops. On the basis of crops handled, the state research stations and farms in the states are given in Appendix A. Some of the important schemes on the agricultural side, include the evolving of new strains of paddy, resistant to saline, flood, blast and drought conditions: the progressing work relates to breeding of maize and of important millets and the creation of institutions for research on cotton, oil seeds, fruits, cashewnuts, spices and other crops on which research is called for. The research work as regards application of water to land is being conducted in a number of agricultural research stations and agricultural colleges. Model agronomic experiments for determining the optimum manurial, irrigation and cultural requirements of various crops are also in progress. The entire research is co-ordinated by the Indian Council of Agricultural Research. The states are represented on the governing body of the council. To organise research work more effectively, research problems have been considered under three main categories, namely (*i*) fundamental (*ii*) regional and (*iii*) local. Fundamental problems are allotted as far as possible to Central Institutes and Universities.

Education and Training

Facilities for imparting training in irrigation and agriculture exist in all states and steps have been taken to establish new institutions and to expand the existing institutions in order to provide sufficient trained personnel for the agricultural development programs.

For disseminating the results of researches carried out in the fields of agriculture, the Indian Council of Agricultural Research has continued to expand facilities for training of agricultural and veterinary personnel required for the production, distribution and use of various types of extension teaching aids and mass communication methods for the benefit of the farmers. Good progress has been made in distributing literature pertaining to improved techniques of agriculture, animal husbandry etc. Arrangements have also been made for producing agricultural films.

Besides the activities of the agricultural departments, the Community Development program initiated in 1952, aims at the individual and collective welfare of the rural population on aided self help basis. About 2,700 blocks have already been

set up comprising over three lakhs villages with a population of about 180 million, and the entire country will be covered (by about 5,200 blocks) by October 1963. Agriculture receives the highest priority in the program among other activities such as provision of better communications, improvements in health and sanitation, better housing, wider education, etc.

Sixty-four basic agricultural schools, 75 extension training centers, 20 workshop wings and 27 home service wings were functioning in different states in 1958 and their numbers have increased since then. Apart from regular courses, short term intensive training in improved irrigation and agriculture practices are being imparted to selected progressive farmers of every village who not only benefit themselves by adopting these practices on their own fields but also disseminate their knowledge to the neighbouring cultivators. Particulars of a two week course in farm water use being currently run in Mysore state are given in Appendix B.

The usefulness of irrigation-cum-agriculture demonstrations is fully appreciated. Trial-cum-demonstration farms are set up under various irrigation projects to evolve proper use of water, manure and fertilizers and cropping patterns best suited to the area. In addition, demonstrations of the cultivators own fields are also organized by the State agriculture and community development agencies in order to convince the farmer of the efficiency of improved methods and techniques in increasing yield for his land under actual field conditions.

Action on the Recommendations of the Second Seminar

With a view to propagate modern irrigation practices and the benefits derived by such practices, as also the experience of other countries in overcoming the problems of irrigation practices, the recommendations of the II Seminar held in Tehran in May 1958 have been forwarded to all the States for necessary action. Some of the points covered in the recommendations have already been implemented through agencies like irrigation, agriculture, and community development departments of the State.

Further these recommendations are being considered while taking up the irrigation projects for inclusion in the III Plan.

Discussion

In reply to a question by Mr. Ismail relative to salinity and alkalinity in the Gangetic Plain and as to crop yields, Mr. Mohan replied that there is some salinity in Uttar Pradesh; but that serious salinity occurs in East Punjab. There are said to be 3,000,000 acres affected there. Due to the concern for the necessary future of agriculture, some program of reclamation will probably be included in the Third Plan. Yields in India are among the very poorest in the world. Wheat is about 1,000 pounds per acre; rice 1,400 or 1,500; sugar cane, 600 maunds. Of course, there are farms where the yields of sugarcane are in excess of 1,000 maunds and as high as 1,500.

Dr. Nazir Ahmed inquired regarding the reasons why there is so much less salinity in Uttar Pradesh than in Punjab. Mr. Mohan stated that there were four reasons (1) greater intensity of water applied; (2) poorer soil texture; (3) in the Punjab, slopes are flatter and not sufficient attention has been paid to the drainage problem; and (4) except in the Punjab, drainage has been a very important part of irrigation planning and now it is always included.

Mr. Vernon requested more information about the tubewell program and wanted to know if they were primarily for drainage or for water supply and what had been their success. Referring to the statement on tubewells in the Country Report, Mr. Mohan further indicated that tubewells have not been used for drainage in the Punjab. However, there is a feeling that this might be given a cautious start. But by and large the feeling is that drainage in Punjab will have to be done by open drains.

Dr. Asghar pointed out that there must have been quite an impact of settlers from West Pakistan into East Punjab leading to more intensive agriculture, and inquired if this had had any affect on the salinity and waterlogging problems. Mr. Mohan stated that undoubtedly settlers had had an impact on irrigated agriculture because they had to be settled on land on which irrigation was necessary. In the particular area where most of them settled, he indicated that they have not been there long enough for waterlogging to develop. The salinity problem has been progressive and most of the problem areas are areas which have been irrigated longer and not the new areas.

In reply to an inquiry from Mr. Ismail, Mr. Mohan stated that the flood problem was an acute one, particularly on the Kosi River. The Kosi rises in the mountains and the first part of the course is very steep, suddenly emerging on the flat plain. Since it is so fast, it carries detritus and silt which tends to deposit out very quickly and has caused the river to change its course by 70 miles in the past 100 years. This is one of the rivers of sorrow. It is the first river on which the flood problem has been tackled in a big way. About Rs. 25 crores (250 million Rupees) have been spent and the results have been as expected. Embankments have been constructed on either side of the river for about one hundred miles. There was great controversy about the damages and benefits of the embankments; but the conclusion is that this is the only method for this stream.

Appendix A

CROPWISE CLASSIFICATION OF RESEARCH STATIONS & FARMS IN THE STATES

	General	Rice	Wheat	Millets	Maize	Potato	Tapioca	Cotton	Sugarcane	Jute	Tobacco	Coconut	Arecanut	Oilseeds	Mango	Citrus	Banana	Apple	Cashewnut	Cloves	Cardamom	Total main research stations.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Andhra ..	15	16	2	8	4	1	—	4	5	—	2	2	—	5	3	2	—	—	2	—	—	33
Assam ..	6	7	—	—	—	—	1	2	1	4	1	1	1	3	—	—	1	—	1	—	1	15
Bihar ..	20	3	3	1	2	—	—	—	2	1	—	—	—	3	—	1	—	—	—	—	—	22
Bombay ..	41	20	13	36	5	—	—	26	6	1	3	—	—	27	3	4	3	—	—	—	—	66
Himachal Pradesh ..	15	3	3	—	4	6	—	—	2	—	—	—	—	—	—	—	—	1	—	—	—	21
Jammu & Kashmir ..	13	7	9	—	6	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	18
Kerala ..	5	8	—	—	—	—	4	1	1	—	—	4	2	1	1	3	3	—	2	—	2	15
Madhya Pradesh ..	44	21	36	15	—	2	—	8	12	—	—	—	—	15	—	—	—	—	—	—	—	52
Madras ..	14	9	1	5	2	1	—	8	2	—	—	1	—	6	—	1	3	1	—	1	—	27
Manipur ..	6	3	4	—	5	5	—	1	2	1	—	—	—	—	1	5	1	1	—	—	—	7
Mysore ..	36	16	8	14	2	—	—	12	6	—	—	1	—	9	—	1	1	—	1	—	—	40
Orissa ..	41	2	—	—	—	—	—	2	1	—	—	2	—	—	—	1	—	—	—	—	—	46
Punjab ..	38	5	23	10	13	2	—	16	10	—	3	—	—	8	3	3	1	2	—	—	—	46
Rajasthan ..	9	—	5	4	3	—	—	1	2	—	—	—	—	1	—	—	—	—	—	—	—	10
Uttar-Pradesh ..	34	9	14	2	1	3	—	4	7	1	1	—	—	2	—	—	—	1	—	—	—	41
West Bengal ..	20	7	6	—	1	4	—	4	3	5	—	—	—	6	1	1	2	—	—	—	—	24

Appendix B

FARMERS IRRIGATION WORKSHOP

Moka Farm, Bellary, Mysore State

February 14, March 12, 1960

Fifty farmers from villages within the Tungabhadra Irrigation Project will assemble at Government Irrigation Demonstration Farm, Moka, Bellary, for an intensive two-week workshop in farm water use. Two batches of twenty-five farmers each, will take a two-weeks training program. Daily maintenance allowance plus demonstration cost will be furnished to the farmers participating in the program.

1. **Sponsorship**

The irrigation workshop is sponsored by National Extension Service and Mysore State Department of Agriculture in cooperation with the Special District Agricultural Officer, Tungabhadra Project.

2. **Objectives of Workshop**

(*a*) To help the trainee understand simple methods of irrigation layout which he can apply to his own farm and to farms of his neighbours.
(*b*) To acquaint the farmer through field experience with various methods of irrigation.
(*c*) To give actual field experience in the use of simple local-made implements for effective irrigated farming.
(*d*) To assist farmer trainees in selecting a system of irrigation suitable to their own soils, crops and water availability.

3. **Subject Matter Demonstrations**

(*a*) Basic irrigation concepts.
(*b*) Layout of irrigation plan.
(*c*) Border strip levelling and preparation.
(*d*) Border strip irrigation.
(*e*) Check plot irrigation.
(*f*) Furrow irrigation.
(*g*) Corrugated irrigation.
(*h*) Simple irrigation devices.

1. Canvas check down 2. Wooden turn out
3. Drops and checks 4. Use of float
5. V-Ditcher 6. Border Ridger
7. Buck Scraper, wooden and steel

4. **Problems**

(*a*) Farmer's adaptability, financially and educationally.
(*b*) Farmer's irrigation problems.

1. Cost of land preparation and availability of funds.
2. Insufficient technical guidance.
3. Soil salinity and waterlogging.
4. Drainage.
5. Over irrigation.
6. Soil erosion.
7. Water supply.
8. Maintenance of the irrigation system.

5. **Cropping Demonstrations with Special Irrigation Practices Advocated**

(*a*) Cotton (*b*) Jowar
(*c*) Sugarcane (*d*) Paddy
(*e*) Alfalfa (*f*) Green manuring crops
(*g*) Ground-nut.

6. **Evaluation of workshop by farmers**

1. What is practical. 2. Cost factors involved.
3. Practices adopted by local farmer.

IRAN

by

THE IRANIAN DELEGATION

Introduction

Iran has a land area of 1,650,000 square kilometers and has natural resources suitable for agriculture and industry. The climatic variation allows cultivation of tropical, sub-tropical and temperate zone crops.

A breakdown of the land area of Iran shows the area devoted to agricultural activities. This illustrates the importance of proper utilization of the available irrigation water supply, and the need to further develop all potential sources.

Gross Land Areas

Total Area	165,000,000	hectares
Desert Area	55,000,000	,,
Forests	19,500,000	,,
Pastures	20,000,000	,,
Agricultural lands	10,000,000	,,

Annual Cultivated Areas

Irrigated Areas	1,530,000	hectares
Dry Farming Areas	4,270,000	,,
Lands which might be cultivated in case of water existence	33,000,000	,,

In the past thirty years Iran has developed improvement programs in the following fields: (1) Seed Improvement, (2) Orchard Improvement, (3) Pest Control, (4) Animal Diseases Control, (5) Forestry, (6) Extension, (7) Rural Health and (8) Farm Mechanization. In addition some increase has been made in the cultivated area and in the productivity of the land. Approximately six million (6,000,000) hectares are now under cultivation with irrigation or dry farming. The following tabulation shows the crops, approximate yields, and the area under cultivation for each crop:

Crops	*Cultivated Area in Hectares*	*Total Yield in Tons*
Wheat	3,400,000	3,000,000
Barley	1,300,000	1,270,000
Rice	325,000	624,000
Cotton	273,500	276,200
Cereals	119,700	174,200
Oil Crops	45,500	36,000
Sugar Beet	42,900	805,000
Summer crops and veg.	175,600	1,722,455
Hemp and flax	4,400	4,300
Tobacco	12,600	8,700
Tea	13,000	6,000
Millet & corn	28,100	26,500
Grapes	173,400	9,090,000
Forage crops	157,500	1,090,300
Fruits	53,400	14,392
Pistachia	18,300	9,300
Almond	43,400	33,700
Dates	48,600	314,600
Citrus Fruits	8,200	111,200

Iran is divided into thirteen main drainage basins. The most important are named below:

1. The area north of the Albroz Mountains, draining toward the Caspian Sea, which is about 12 percent of the total area.

2. The area west and south of the Zagros Mountains, which drains toward the Persian Gulf, and which represents approximately 25 percent of the area of Iran.

3. The closed system of the river basin draining toward Lak Rezaich, about three percent of the area of Iran.

4. The closed basins of central Iran covers altogether about 50 percent of the total area of the country.

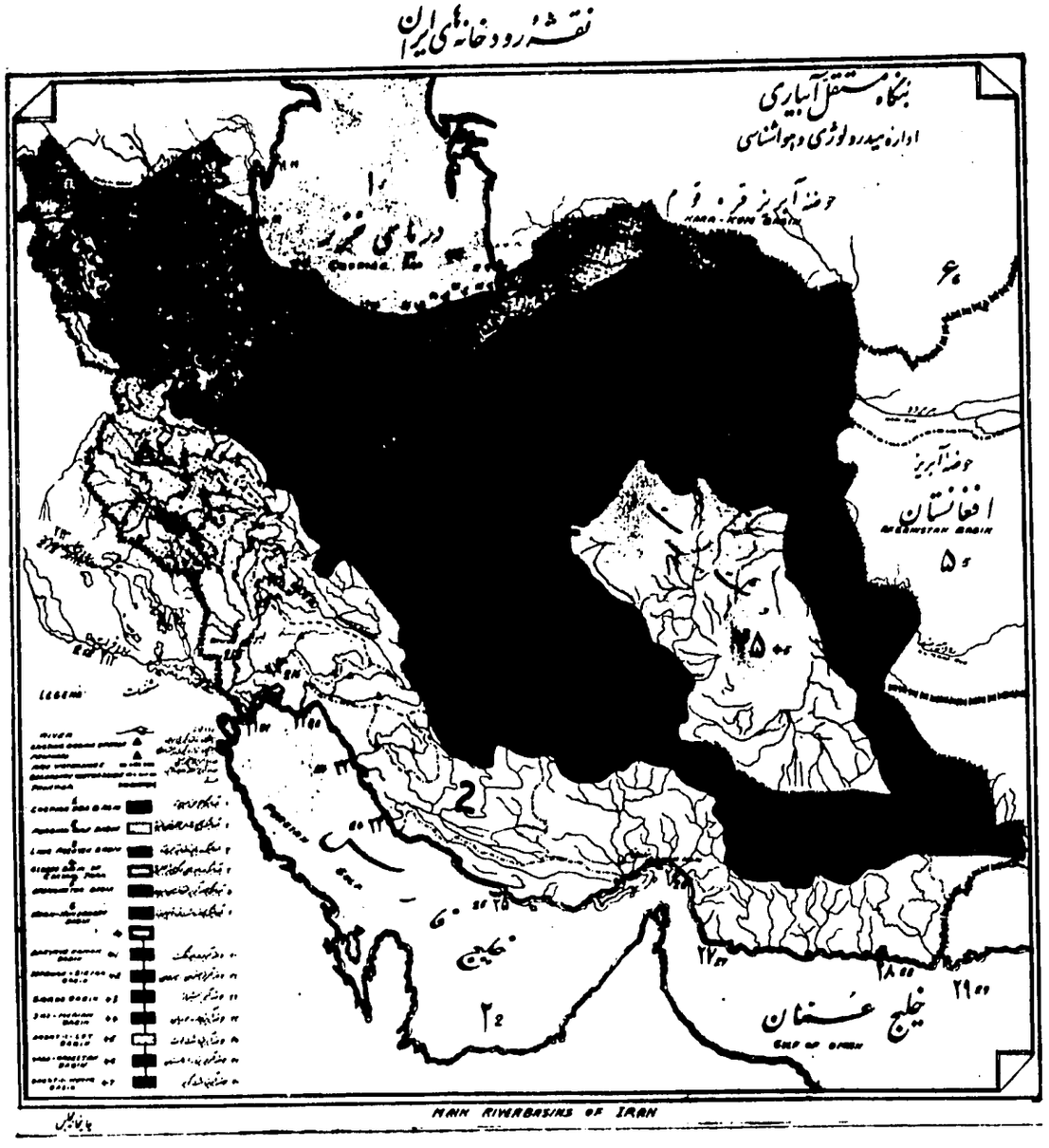
5. The closed basins extending from Central Afghanistan, draining to the lakes near border between Iran and Afghanistan. The Iranian part of this basin covers about seven percent of Iran.

6. The basin extending from north-eastern part of Iran, through the north-western part of Afghanistan—Drainage into the Kara Kum desert in the USSR. The Iranian part of the basin covers about three percent of Iran.

The various river basins of Iran are indicated on the general hydrological map of Iran attached to this report.

No figures are available on the quantity of available water in Iran but it is apparent that a large part of the water supply flows unused into the Caspain Sea, the Persian Gulf and swamp and desert areas.

Irrigation water generally comes from rivers, kanats (an underground system of water supply developed in Iran many centuries ago) deep and shallow wells, artificial reservoirs and diversion dams of recent construction and a few that date back many years. The irrigated area is still considerably less than the dry farm areas. Wherever precipation is adequate dry farming is of considerable importance.



Drainage Basin Map of Iran

Water Utilization Problems

The available water supply for irrigation limits the area that can be used for crop production, yet there is considerable waste due to primitive methods of distribution and application. Present estimates of conveyance and distribution losses on farms is a high as 70 percent, which means that only the remaining 30 percent is available for plant needs.

The causes of irrigation water losses are: poorly levelled 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, and lack of knowledge of how to apply water efficiently. To help overcome some of the above problems the Government of Iran has undertaken many irrigation development projects throughout the country. The programs of land tenure reform, extension education, rural community development are also being used to help in improving the overall agriculture situation in Iran. Some of the irrigation development activities are listed below.

Works Under Construction

Sefidrud Dam—The height of Sefidrud dam is 101.75 meters and its length at the top is 425 meters. The capacity of the lake behind the dam is 1,668,000,000 cubic meters and the height (level) of the river is 75 meters above the level of Manjil Bridge. The surface area of the lake is 60 square kilometers.

By constructing this dam 60,000 hectares of new lands will be placed under cultivation. Electrical energy totalling 340,000,000 killowatt-hours per annum will be generated. This will be produced by five power stations operated according to the available water.

Dez Dam Project—The initial phase of the Dez Project consists of:

(*a*) A 190 meter, thin-arch, concrete dam which will impound 3,350 million cubic meters.

(*b*) A hydro-electric plant with an initial installation of 130,000 Kw and a planned ultimate installation of 520,000 Kw.

(*c*) An electrical transmission system linking the hydro-plant with the load centers of Andimeshk, Dezful, Haft Tapeh, Ahwaz and with the present Abadan Khorramshahr transmission line.

(*d*) A 20,000 hectare first-phase irrigation area south of Dezful which will serve as the model for an ultimate 125,000 hectare development.

The Dez Project will provide:

(*a*) Sufficient minimum regulated flow to irrigate the first-phase irrigation area and an ultimate 125,000 hectare irrigation development.

(*b*) The opportunity to demonstrate the increase in food production and agricultural prosperity obtainable through proper irrigation and intensive cultivation with the cooperation of government, landlord and farmer.

(*c*) Power capacity sufficient to serve the growing electrical energy needs of the region.

(*d*) A substantial degree of flood control on the Dez and lower Karun Rivers permitting the utilization of lands now unusable due to floods, and the improvement of navigation conditions in the Arvand-rud.

Karadj Dam Project—This dam has a capacity of 205,000,000 cubic meters, all of which are being transmitted to Tehran for the city's water supply. The hydro-electric installation produces about 150,000,000 Kw of electricity annually. Construction is expected to be completed by 1961.

Completed Projects

Golpayegan Dam Project—The Golpayegan plain is a vast and fertile area and every year the spring and winter floodwaters of Golpayegan River are wasted into salt lakes. In view of this the government made studies of this area and constructed a storage dam.

Specification of the Golpayegan Dam:

1. Height of dam: 52 meters
2. Capacity of dam: 35,000,000 cubic meters
3. Increased cultivable area: 5,000 hectares
4. Kind of dam: Rockfill dam with impervious diaphragm of earth.

Karkheh Dam Project—This project consists of a diversion dam situated on the Karkheh River, which has a minimum discharge of 40 cubic meters sec. The diversion dam is 192 meters long and 4.5 meters high, on both sides of which ten metallic floodgates (sluices) have been installed, so that during floods, by lifting the floodgates or sluices, the floodwater of the river passes through them. This dam diverts flow into two canals, one on the right side with a capacity of 15 cubic meters sec., and the other on the left side with a capacity of 45 cubic meters sec. With such an amount of water 60,000 hectares of land can be irrigated.

Bampour Dam Project—This project consists of a diversion dam on the Bampour River.

Specifications of the Bampour Dam:

1. The average length of the dam: 80 meters
2. The average width of the dam: 30.5 meters

A main canal 2,300 meters long carries the water to the cultivable lands. This canal has a sluice or floodgate which can be closed during floods to impound the water. It is connected with the intake.

Specifications of the intake:

1. Height of the intake: 4.5 meters
2. The height of the abutments: 5.5 meters
3. The maximum amount of water that can pass through this spill-way: 1500 meters sec.

The main object of this project is to control the river so that during floods and overflow periods of the river erosion and damages may be prevented and also so that during a scarcity of water, irrigation water can be conducted to higher lands.

Kasr-Shirine Irrigation Project—A diversion dam was constructed on the Alvon River 1.5 meters high and 34 kilometers long, four kilometers of which compose an underground tunnel. Capacity of the canal is 4 cubic meters sec., and increased the irrigated land area by 8,000 hectares.

Others—Some other dams like Shaban Kareh diversion dam, Seygholan dam of Roodbar, Heshmat Rood dam, were constructed many years ago and have been utilized for a long time.

Shahnaz dam in Hamedan is under construction now and some other irrigation projects have been organized in Kazeroon, Jahrom, Nain, Moghan and Systan.

The above projects will not be discussed in this brief report. Designs of large reservoir dams of Doroodjon, Zarrineh Rood and Latian have been approved for construction.

The development work of recent years consists of large dams and artificial reservoirs, diversion dams, distribution systems, deep and shallow wells and pumping some rivers. In some areas pumps have replaced oxen and horse power for the shallow wells.

Kanats—In addition to the above mentioned water resources, 22,000 Kanats are available for irrigation, and provide approximately 35 percent of the present available water supply.

Improved use of Water Resources

In past years little attention was given to efficient use of the soil and water resources, and in most irrigated areas there are problems of water distribution, efficient utilization and drainage. Additional lands are avenable for irrigation if a supply of water could be developed. Increasing and decreasing the distribution system losses will help in making additional water available for crop production.

The following activities have been undertaken by the Iranian Government to help solve the above problems:

1. Proper utilization of the soil and water resources.

2. Use of mechanized farming and the proper utilization of machinery.

3. Training of specialists in Agricultural Engineering.

4. Demonstration farms to show the results of mechanization and proper cultural and irrigation practices.

5. Guidance and encouragement of land owners and farmers in redesigning their irrigation systems. This service is provided free.

6. Reclamation of saline and alkali soil, and preventing the accumulation of excessive salts in irrigated areas.

7. Drainage of high water-table areas.

Government Action—To help accomplish the above program the Government has developed:

1. Soil laboratory where soils can be chemically and mechanically analyzed, and the quality of irrigation water can be determined.

2. Irrigation experiment stations at Karadj, Varamin and Lahijan for consumptive use of water requirements for sugar-beets, cotton and rice.

3. Studies on conveyance losses from canal and water application efficiencies on farms.

4. Soil and water conservation program to control wind and water erosion on water sheds.

5. The establishment of demonstration farms at Karadj, Ahwaz and Miandoab to demonstrate good farming practices of irrigation.

6. Research on the best types of plows for different areas of the country.

7. Training of Agricultural Engineers in the technical aspects of soil and water conservation. Sixty have been trained to date. Also training has been given to mechanics and tractor and bulldozer operators to help meet the need for this type of personnel.

8. Rural construction plans have been prepared and are available to farmers.

9. Land reclamation and drainage investigation stations are established at Garmsar, Ghezelhessar and Shavoor. These stations are for demonstration and training.

10. Mechanical equipments and modern machinery are working now in Shavoor area of Khuzestan plain to solve irrigation and drainage problems. The extent of this project is about 26,000 hectares.

Small Projects—In general the agricultural policy of the country, from the view point of providing irrigation water, is based on building small dams in a short time in addition to those larger ones which are under construction now. Using underground water developed by kanats and deepwells; and increased economical use of irrigation water will help to increase cultivated areas.

Discussion

In reply to a question by Dr. Ali Asghar, Mr. Ayazi replied that farmers are assisted for technical purposes in two ways. Photographic surveys and ditching, land levelling or drainage plans are made free upon request. However, if the area exceeds 100 hectares, this service is postponed to a later time. Some equipment is available for executing the work; but the farmer is charged for this service, which is limited to small projects.

JORDAN

Introduction

To us and to every farmer in the world water means more than it does to the rest of people. Water means life. It is always said in desert and semi-desert areas, "Give me water and all the arid unproductive lands will be green meadows."

If we are facing a problem in our country; that problem is the deficiency of water. This is why practically more than 80% of the area of Jordan is considered as a desert or a semi-desert land. That does not mean that no effort is being put to utilize every possible drop of water available in Jordan. On the contrary enormous efforts were put into such a case and problem and I am more than glad to tell you that the success that we attained has been quite satisfying. It was not as a result of one hand's work or one mind's thought. It was the result of a cooperative work in which our responsible government agencies, our private agencies, our farmers and laymen participated. This came to be as such because the life of our people has been endangered as a result of the several droughts that overwhelmed the country in the past decade. It is now a need that every person is feeling and to which he is ready to contribute all that he can because it means to him his life and his country's livelihood.

I may point out to you a very important fact, which we considered and which resulted in our success. This fact is education. If the people are educated towards an objective and they come to believe in it they will soon reach it. As a result of such an attitude, several places that were mere dry-farming areas came to be now the best fruit and vegetable producing centers of Jordan.

The educators who did this job in Jordan are called extension agents or the friends and assistants of farmers. They started work some seven years back and the progress that was attained in their presence as compared to what used to be is no doubt a manifold one.

Water Resources and Irrigation Development

To talk to you about my country in as far as its water resources are concerned I may say:

The main water resources are:

1. Rain
2. Rivers and streams
3. Underground water

The rainfall in Jordan is a very unreliable source of irrigation. Dry years are frequent with unfavourable consequences to the farmers. Rainfall averages from 50 mm or less in desert areas to 1000 mm in mountainous and high regions during the months December, January, February and March. The rest of the year is usually dry. In general, people depend on rain for cereals and mixed crops in the deciduous fruit areas. About 2,000,000 donums[1] are planted that way through dry farming, depending on rainfall only.

The second source of water is the rivers and streams. The main river is our Jordan River which discharges annually about 1350 million cubic meters. Farmers on both banks of the river make use of its water. At present there are about 350 pumping units delivering about 106 million cubic meters of water every year to irrigate 59,000 donums. More and more pumps on this river are

1. A donum is 1000 square meters; about 1¼ acre.

used every year to develop the rest of the land on both banks.

The Yarmouk River having a capacity of 624 million cubic meters annually provides great possibilities for the country. The East Ghor Canal scheme is the biggest irrigation project on this River and in fact in the whole country. It will be sufficient to irrigate 120,000 donums of otherwise dry lands. The project also includes a programe for developing the land to be irrigated from the point of view of drainage, soil analysis, farm planning and water duty.

Next comes the Zerqa River which discharges about 96 million cubic meters annually. The water of this river has been fully made use of. A reinforced concrete dam was built across it, an aqueduct 60 meters long and 7 meters high with a bridge underneath it for people to cross the river was also constructed. 15 Km. of concrete canals (of rectangular and parabolic cross-section) capable of supplying 2.6 cubic meters per second of water were constructed to irrigate over 50,000 donums of lands adjacent to the river. This project included a hydro-electric power station capable of supplying 50 kw. The water drives a turbine which in turn operates a pump to raise water 122 meters high to the irrigation forms.

The other streams are of small capacity. The total discharge does not exceed 250 million cubic meters annually. An irrigation project was completed on each of these streams or "Wadis" of which we mention the following:

Wadi Husban, Wadi Kufrein, Wadi Yabis, Wadi Kuffrenje, Wadi Jurum, Wadi Ziglab and Wadi Arab irrigation projects which included diversion dams and concrete canals 34,000 meters long. The area irrigated under these projects is about 100,000 donums.

Advantages are taken of the springs which exist throughout the country. A programe for developing all springs and lining earth canals with concrete and constructing stock water dams and cisterns, mostly in desert areas, has been carried out in order to reduce the loss of water to a minimum. Since 1948 more than 100,000 meters of canals have been lined with concrete, thus saving a huge amount of water which would otherwise be lost through seepage.

The third source is underground water. About 300 wells have been drilled between 1954-1959 by the concerned government drilling department. Seventy-three million cubic meters are produced annually from these wells.

In the Jordan Valley the water-table is not too deep. Water is usually struck at a depth of 30 to 100 meters. The capacity of many of those wells varies between 20 to 200 cubic meters per hour. Experience showed that 30% of these wells drilled produced salty water unsuitable for irrigation.

In the high and sea-level areas underground water is not as abundant as in the Ghor areas. The water-table is from 50 to 200 meters deep and the capacity of the wells varies between 5 and 100 cubic meters per hour. Private land-owners and farmers have had wells drilled in their farms with pumps installed on these wells, especially in the Ghor and sea-level lands.

Irrigation Practices

Farmers are urged to improve their irrigation practices by many government departments such as the Irrigation, Agricultural Extension and Research Departments. The Ministry of Agriculture has established many research centers and experimental stations where the best available technical services are put into practice. Farmers are following the advice of agricultural extension agents to improve their farming methods and indeed great progress has been achieved in all aspects of farming which resulted in raising the income of the individual farmer.

To help the farmers develop their land, an agricultural credit corporation has been established. The objective of such an institution is to provide material help and to supervise agricultural programs especially for the improvement of irrigation practices and hence the conservation of water. The benefiting farmers follow such plans and agree to accept the suggestions of the corporation representatives and technicians. It also provides credits for agricultural services such as processing and marketing.

Through this institution the following work has been carried out:

64,000 donums have been put under irrigation by means of pumps and wells and concrete canals.

198,000 donums were developed through terracing, land levelling and subsoiling.

140,000 donums were planted with suitable fruit trees. The corporation is aiming towards an extensive programe to put 340,000 donums under irrigation (excluding the East Ghor Canal irrigation project), to develop 4,000,000 donums through terracing and levelling and to plant another 2,000,000 donums with orchard trees.

Realizing that the country does not have enough water for intensive irrigation, the Jordan Government has established a research institution to study various problems which include water duty and improved irrigation practices. Experiments have been and are still being carried out on these

subjects since 1954 on many plants such as tomatoes, wheat, sugar-beet. In order to determine the exact quantity of water necessary for a certain plant under certain conditions many factors were considered such as:

(*a*) Type of plant
(*b*) Type of soil
(*c*) Climate
(*d*) Quality of water
(*e*) Water-table

The results of a water duty experiment on sorghum were obtained as follows:

Treatment No.	No. of Waterings	Quantity of Water cubic meters/ donum	Yield kg/donum
I	3	165	45
II	4	215	103
III	6	323	62
IV	8	408	160

Such a table indicates that the last treatment gave the best results.

An experiment on berseem was made similar to the previous one and gave the following results:

Treatment No.	No. of Waterings	Quantity of Water m^3/donum	Yield kg/donum
I	5	462	4040
II	6	530	4546
III	9	785	5435
IV	10	1000	4755

Thus showing that the third treatment is the most economical one although the water used is less than treatment IV.

Other experiments are being carried out on a similar basis on various crops but the results are not yet available.

Conclusion

To conclude I may say that water use needs a continuous research program in order to make available good and correct information that solves all or most of the existing problems.

The present awakening that farmers are having together with the service of the various government departments is sure to result in the best technical and economical advantages to the needy farmers who in turn will put them to practice.

We believe that problems facing irrigation development have no end, and that such problems are not unique to any one area alone, but are considered as mutual and common to many countries. Such seminars and conferences where a good number of technicians in the field of irrigation meet could contribute much to solve such problems. We are here to exchange views and experiences in the field of irrigation and its many aspects. We hope that much can be done towards developing the skills of farmers to give them better techniques and methods of utilization and conservation of the available water resources, especially in the countries whose resources are limited and deficient.

Discussion

Dr. Asghar requested additional information regarding the quality of the ground water used. He was particularly interested in the S.A.R. or sodium ratio. He asked regarding changes in irrigation practice referred to by the paper and wanted to know if consideration was being given to the quality of the water in making these changes; both in terms of quantity of water to be applied and how the water is to be applied. What observation have been made at the government farm of the effect on the soils of using the waters referred to by the paper.

Mr. Toufaha stated that experiments are too new to answer the question with regard to the quality of water, but stated that improved methods of irrigation practices such as corrugation and sprinkler irrigation had replaced flood irrigation, but indicated there were some disadvantages in sprinkler irrigations. He mentioned that the canals were concrete lined and stated that where the quality of water is unsatisfactory, it is not used. However, sometimes well water may be mixed with water from other sources; or, of adequate quality, used directly.

Mr. Mital inquired as to the percentage that canal losses had been reduced by the concrete lining and what was the cost. He also inquired as to the method of constructing the lining. Mr. Toufaha replied that there was great saving especially in sandy soils but did not present data taken from actual measurements. The width of the canals varies from 2 feet to 2 meters. The cost of one meter of lining for a 2-foot side canal is about two pounds. Lining are made with a parabolic shape in order to avoid the necessity for forms.

Mr. Abdel Mageed inquired as to what percentage of the total flow of the Jordan was flood flow: what types of crops are grown under the pumps

and what is done for water supply during the low water period. Mr. Toufaha stated that winter crops are primarily vegetables, while summer crops are generally fruits. No floods have occurred for a long time because of the extensive use of the Jordan water. Development has caused the flow to be 1,350,000 cu. meters per year—formerly it was much greater.

Mr. Ismail pointed out that one of the advantages of concrete canals is the increased velocity, and inquired if Jordan was taking advantage of this. Mr. Toufaha indicated that, in addition to the increased velocity, there were other advantages including seepage and erosion prevention.

Mr. Ozalp inquired regarding the texture, the field capacity, and the wilting point of the soil. What was the irrigation interval for different treatments and what were the results between intervals of irrigation and quantity of crop yields?

Mr. Toufaha stated that the experiments mentioned that the soil of the station reported on has a salinity condition but no drainage system has been made. Treatments included chemicals and fertilizer. The results are not yet available due to the newness of the experiments. Both sprinkler and furrow irrigation have been used.

LEBANON

by

SALIM W. MACKSOUD[1]

Introduction

The Republic of Lebanon, situated on the eastern shores of the Mediterranean Sea, is a small country with an area of 10,000 square kilometers, about half of which is rocks, sand, roads, cities, and beaches. Its length, in a North-south direction is 190 kilometers and its maximum width is 75 kilometers. Syria lies to the North and East, and Palestine to the South. The population is just over 1,500,000 with a yearly increase of about 25,000. Literacy is over 80 per cent, and even in the mountain villages many people speak French, English, Spanish or Italian, in addition to the native Arabic.

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 Lebanon gained its independence and has since taken a leading role in the affairs of the Near and Middle East. Here, Christians and Moslems live peacefully together sharing their responsibilities as citizens.

There are two mountain ranges, the Lebanon and the Anti-Lebanon, separated by a flat high valley—the Bekaa. Half of the Bekaa is drained by the Orontes River which flows north and the other half by the Litani River which flows south. Both rivers and all the western slopes drain into the Mediterranean Sea. Elevations of agricultural lands range from coastal plains to hand-made terraces at close to 2,000 meters. The Bekaa valley is at an average elevation of 800—900 meters.

Mediterranean-type climate, with cool, wet winters and warm dry summers, prevails. 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 vary from 500 to 1500 mm. Most of this precipitation occurs between November and April, with January as the wettest month. During winter moderately low temperatures occur at the higher elevations and snow falls on both the Lebanon and the Anti-Lebanon mountains.

Irrigation in Lebanon

Agriculture is varied, ranging from citrus and bananas on the coast, to olives, grapes, deciduous fruits, vegetables and cereals. With rain falling mainly in the short winter season most spring crops do better when irrigated. Summer and fall plantings are only possible with irrigation.

Irrigation is an old art in Lebanon but unfortunately time has not given it great refinement. Only recently has the government stepped in to control, develop and improve the irrigation situation. Most of the actual water distribution is still privately controlled, generally wasteful and

[1] *Associate Professor of Irrigation Interim, Dean, Faculty of Agricultural Sciences, American University of Beirut, Lebanon.*

not well coordinated. No storage of rain water is effected and no attempt at recharging ground waters has so far been initiated. The Litani River Project, when completed will be our first attempt at making use of our over-generous winter run-off.

Presently, cultivated land in Lebanon is estimated at 300,000 hectares, of which 115,000 hectares are irrigable but only 45,000 hectares are actually receiving full or part irrigation. Irrigation and drainage projects will not increase the area cultivated, but would improve its yields and broaden the crop adaptability.

With very few exceptions lands are irrigated by surface methods (as differentiated from over-head or sub-irrigation methods) and derive their waters from one of the following sources:

(*a*) Village Springs :

Lebanese villages, and they are scattered all over the western side of the Lebanon mountain range, usually spring up around a natural spring. Any water left over from culinary purposes is used for irrigating the small gardens located around the central built up area. The water users form their own organizing authority and the water is meticulously divided up in well established rotations. Nevertheless disputes over water rights or divisions of streams do arise and are a sore spot in most every village.

(*b*) Stream irrigation :

The few small streams existing in Lebanon, never reach the sea during the dry season. They are divided up by the villages through which they pass and their waters are used for irrigation.

In some areas the water is diverted at a higher point and flows by gravity to all the fields, while in others the water is pumped by each individual user from the stream to the land he owns. The number of pumping units has dramatically increased since 1941. So much so that in many localities well established orchard owners are finding themselves attempting to pump out of a dry stream due to increased pumps just before them on the same stream. The government has had to step in in an attempt to restrict further installations of pumping plants. Again the Litani River Project will remedy this situation along the flow of the Litani river and some of its tributaries, but for all the other streams the situation remains a serious one.

(*c*) Wells :

The digging, drilling or boring of wells has gained considerable popularity in Lebanon within the past few years. This has been the result of the general decrease in actual stream flows and, to a major extent, of the increased availability and reduction in cost of well drilling and boring equipment. Many land owners, weary of the troubles connected with assuring ones crop of his due share of the village stream or spring, have been willing to give up their share and dig a well. The concept of supplying ones demand from his private well matched the general individuality concept of the Lebanese, and if for no other reason than this, investments in wells have increased at a fantastic rate.

Irrespective of where the source of his water lies the Lebanese water user is becoming increasingly aware of two serious and disturbing situations:

(1) The general natural water supply for irrigation is getting scarcer as time goes by, because more land is being put under irrigation and this requires more water. (The last several years were relatively dry years, with below average snow coverage and the general ground water levels have been steadily going down. This, it is hoped, is temporary and is only part of a general cycle which will eventually resume its normal level of precipitation and snow coverage).

(2) The methods of applying water he has been using for many many years, are beginning to seem very wasteful to him. He is concerned with saving his precious irrigation water and the methods he has so far been using are not serving this purpose as well as he wants.

Without realizing it, the concept of Field Application Efficiency is gradually entering his normal trend of thinking.

Thus the scene is set for an efficient Water Resources Division that will develop, and distribute all the potential irrigation waters, and for aggressive Irrigation Extension Service that will step in to teach efficient field irrigation practices. So far little of both has been done, but it is hoped that the future will bring them forth.

Government Irrigation Projects

Through its Ministry of Public Works and semi-autonomous "Irrigation Authorities" the Lebanese goverenment, has, in the past several years, executed several irrigation projects. The operation and management of these projects is still in the hands of such agencies also.

(1) The Kassimyeh Project diverts its water from the lower reaches of the Litani River and, through a system of concrete lined canals and aqueducts, approximately 20 kilometers long, and a net work of supply ditches, distributes water to about 5,000 hectares.

(2) The Yammouneh Project, making use of a hitherto disappearing spring, brings water to an area of about 2,000 hectares. The major part of the tunnelling and construction required have been completed, but detail distribution plans are not yet in operation.

(3) The Nahr Ibrahim Irrigation Project diverts water from the fast flowing Ibrahim River and through a series of concrete flumes and inverted siphons distributes the water over an area of 500 hectares of the coastal plain.

(4) The Bared Project, mainly a hydro-electric project developing 18,000 kilowatts, distributes the waters of the Bared River over an area of 1,500 hectares of coastal plain lands in the north of the country. A small storage lake has been built by the Power Company.

(5) The Beirut River Project will distribute water to an area of 1,000 hectares along the course of the Beirut River.

(6) The Litani River Project, which is the only properly integrated project Lebanon has, will bring water to around 30,000 hectares of land and cheap power to all the country for further ground water development and a general increase in the standard of living of the whole nation.

Briefly Lebanon faces the following irrigation problems:

(1) The lack of a single agency that is concerned with the general problem of Water Resources and Irrigation. The responsibility for such work is divided between the Ministry of Public Works, Ministry of Agriculture and several semi-autonomous River Authorities.

(2) No basic research in water use and water requirements is being carried out.

(3) No extension in field irrigation practices is in existence. Such a program could become possible only after considerable local research has been carried out.

(4) The lack of cooperative water users associations, where all those benefiting from one stream or spring would form a cooperative for better organizing the development and distribution of their water supply.

(5) The absence of schemes utilizing more of the winter run-off. One very likely scheme would be "water spreading" for increased ground water. Storage of run-off on the westerly side of the Lebanon is not very feasible, but the possibility of diverting this run-off to the easterly slopes and the Bekaa Plain should be seriously investigated.

(6) Land and soil surveys are in progress, and should be adequately correlated with water use studies, production costs and prices of produce, so that water would be used on the highest yielding lands producing the most profitable crop.

Notwithstanding all the above, present day irrigated agriculture in Lebanon is generally profitable with high yields and good quality produce. The Lebanese farmer is enterprizing and eagerly willing to learn. Irrigation techniques in Lebanon today are probably among the best practised in the Middle East—there is less waste and more careful land preparation. The problem is different from that in most of the other countries in that it is one of prompting the government to rise the level of the individual farmer, whereas in most other areas, the problem is bringing up the water user to the level of the well planned schemes of the governments. The problem remains, nevertheless, a serious one; and it is hoped that gradually progress will be effected along the right track and towards the common goal.

Discussion

Dr. A.G. Asghar inquired as to the quality of the tubewell water, whether or not the water-table was receding; and, if so, what action may be taken to check this condition. Prof. Macksoud replied that the salt problem is nil, such salts as did occur being principally calcium carbonate. A well permit system has been set up in Lebanon, but unfortunately this is not enforced. Some cases in which junior, deeper wells have dried up senior wells have occurred and some are now in the courts. The law is that the first owner, providing he is properly registered, has priority on a reasonable amount of water from his well. Water and irrigation people are concerned with the situation, however, and are trying to get the government to become more interested, but so far positive steps have not been taken.

In reply to a question by Mr. Stephenson, Prof. Macksoud stated that average flow of the largest river was in the range of 4.2 to 4.3 cubic meters per second and that there were many streams called rivers in the range of one cubic meter per second.

Dr. Nazir Ahmad inquired regarding the type of wells installed and Prof. Macksoud replied that there are circular-type dug wells to depths of 10 to 15 meters. Deeper wells are drilled using machine cable percussion tools and are 6 to 14 inches in diameter. Dug wells are preferred if possible because they are cheaper. Centrifugal pumps are frequently used on dug wells. Electricity is normally used for power if available, otherwise diesel power is employed.

In reply to a question by Mr. Anderson, Prof. Macksoud stated that the maximum irrigation efficiency noted was 42 percent. This was the maximum observed and is not typical, however, and there were cases as low as 20 percent. Prof. Macksoud was requested by Mr. Anderson to amplify his statement regarding extension work. Prof. Macksoud replied in essence that there are about 40 to 60 employees as extension agents, but that they "don't have anything to extend". The government has announced that they will tell them something that will increase their yields and now for the last 4 or 5 years this has not happened." Prof. Macksoud felt that the extension service should do this before the farmers lose confidence in the service.

PAKISTAN

Presented by

A. G. ASGHAR

Introductory

Geographically Pakistan consists of two parts with about a thousand miles of India territory between. East Pakistan lies between 21°N and 27°N and has an area of 55,000 square miles. Two great rivers, the Brahamputra and the Ganges with their innumerable tributaries form a net-work of inland water-ways. The climate is humid and warm during the summer and mild and dry during the winter. The mean temperature during the winter months is 64°F and in summer 84°F. The rainfall is heavy varying from fifty to a hundred and thirty-five inches and the bulk of it falls during the monsoon season which extends from May to September. Summer floods are of common occurrence but the winter months are fairly dry.

West Pakistan lies between 24°N and 37°N and has an area of 310,000 square miles. The landscape varies from the snow covered peaks of the Himalayas in the north to arid desert in the south and south west. There are five rivers running through the province. The rainfall varies from four inches a year in the south to forty inches in the north. Most of the rainfall occurs during the later half of summer and the winter season is generally dry with short and infrequent spells of rain during December and January. The climate is continental. On a summer day temperature in the shade may go up to 120°F and may not fall below 90°F during the night. During the cold weather, while the maximum temperature on a calm and clear day may touch 75°F, it falls almost to freezing point after mid-night. Along the sea coast, the climate is fairly hot in summer and mild in winter.

Existing Irrigation in the Country

East Pakistan—There is no flow irrigation from river canals in East Pakistan. The irrigated area in a year varies from 3 to 4 hundred thousand acres only irrigated mostly by lift irrigation by indigenous appliances from surface water sources. The major portion of the province, however, gets regularly inundated by annual floods during monsoon season. Agriculture is still gambling with nature as the source of water supply is monsoon rains, and while there is excess of water at certain periods during the year the amount of water required by crops at other periods is not available. Ganges-Kodabak and Teesta Barrage Projects have now been undertaken to ensure availability of water supply as required.

West Pakistan—Rivers flowing through West Pakistan are fairly spaced and ideally suited for the construction of diversion dams for irrigation. As the climate of West Pakistan varies from arid to semi-arid and rainfall, from 4" to 40", agriculture without irrigation is limited both in extent and in crop out-turn. The river resources had, therefore, to be tapped for irrigation and we now have one of the world's greatest irrigation systems. A barrage across the Ravi river was put up at Madhopur (now in India) in 1859. The off-taking canal is known as Upper Bari doab. Successful completion of this work gave confidence to the engineers and the government of the time, resulting in more canals—the Sidhnai, Lower Chenab and Lower Jhelum being constructed.

Jhelum and Chenab rivers still had some surplus flow and there was a big tract of desert South of Ravi. This led to a trans-basin development known as the Triple Canal Project. Surplus Jhelum river water was carried by the Upper Jhelum Canal off-taking at Mangla, to river Chenab above Khanki to feed the Lower Chenab Canal. The excess potential thus available was diverted at Marala into the Upper Chenab Canal which delivered it to Ravi above Balloki. A diversion weir at

Balloki was thrown across the river Ravi to take off the Lower Bari Doab Canal. The triple canals came into commission in 1912-15.

Having utilized the full potential of Jhelum, Chenab and Ravi rivers, attention was diverted to Sutlej river. The Sutlej Valley Project came into existence during 1921-33. With the completion of this project the dependable flow potential of all rivers except Indus was utilized. The mighty Indus was now the only river left. The first barrage across it was the Lloyd Barrage constructed in 1932, the second at Kalabagh in 1946. Three more barrages were simultaneously taken up after independence viz. Ghulam Muhammad, Taunsa and the Gudu, out of which the first two are complete by now.

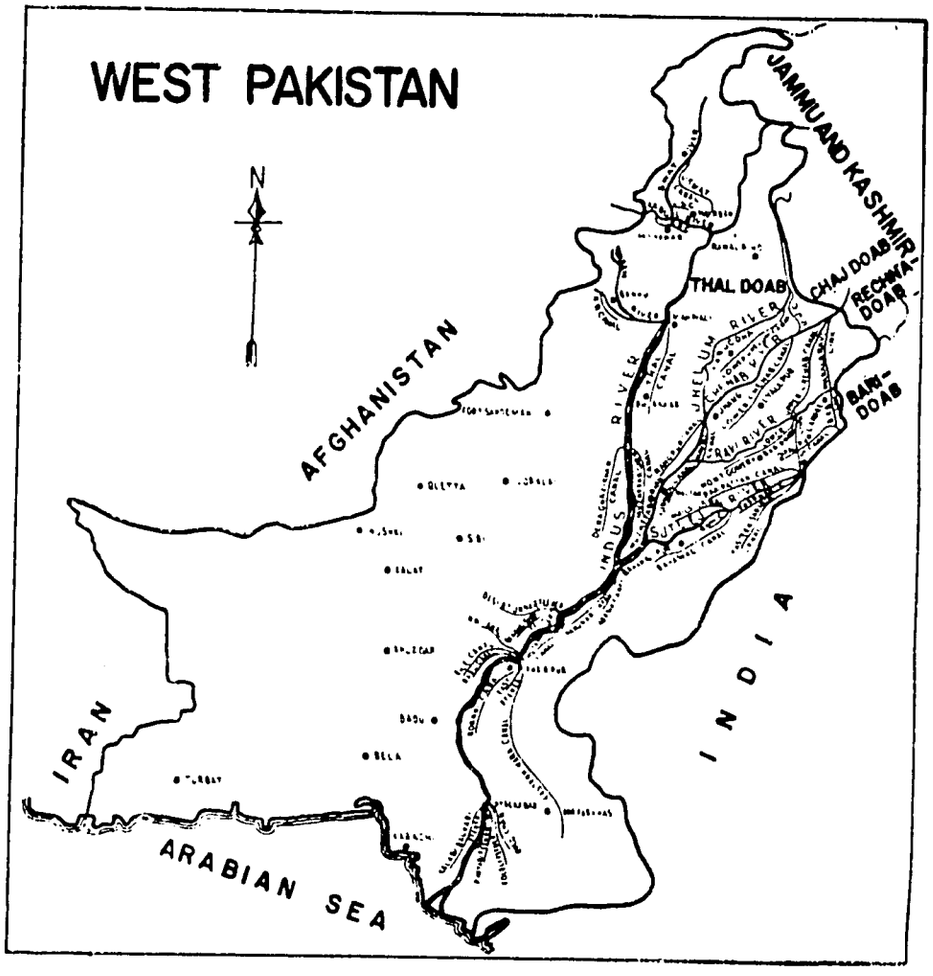
Partition of the sub-continent brought several problems in its wake, one of them being water supply in the canals depending upon sources now under the control of India. This consideration necessitated construction of costly link canals namely the Bambanwala-Ravi-Sutlej link, the Marala-Ravi link, and the Balloki-Sulemanki link.

The position of water supply for irrigation on the Pakistan side of the Indus basin as it now stands is as below:

Name of River	*Name of Head Works*	*Name of Canal*	*Commanded Area (Acres)*	*Discharge at Head (Cusecs)*
		I.—ALREADY RUNNING		
Sutlej	Ferozepur	Dipalpur Canal	983,117	6,950
	Sulemanki	Pakpattan Canal	1,261,042	6,594
		Fordwah Canal		3,356
		Eastern Sadiqiah Canal		4,917
	Islam	Mailsi Canal	688,255	4,883
		Qaim Canal		558
		Bahawal Canal		5,400
	Punjnad	Abbasia Canal	688,770	1,064
		Punjnad Canal		7,769
Ravi	Madhopur	Central Bari Doab	642,378	2,693
	Balloki	Lower Bari Doab	1,460,659	7,000
	Sidhnai	Sidhnai Canal		4,005
Chenab	Marala	Upper Chenab Canal	1,444,922	13,064
	Khanki	Lower Chenab Canal	2,934,324	11,530
	Trimmu	Haveli Canal	1,007,650	5,242
		Rangpur Canal	347,347	2,710
Jhelum	Mangla	Upper Jhelum	540,755	8,783
	Rasul	Lower Jhelum	1,499,674	5,200
Indus	Kalabagh	Thal Canal	1,629,638	6,000
	Sukkur	Eastern Nara Canal	2,091,000	13,602
		Rohri Canal	2,472,616	10,887
		West Feeder		1,940
		Dadu Canal	483,700	2,837
		Rice Canal	455,077	10,215
		N.W. Canal	896,310	5,042
			21,547,164	151,945 Cusecs.
		II.—UNDER CONSTRUCTION		
Indus	Taunsa	Muzaffargarh Feeder	595,743	8,235
		Dera Ghazi Khan Canal	730,000	14,500
		Gothi Feeder		8,490
	Gudu	Begari Feeder	565,246	15,494
		Desert Feeder		12,945
	Kotri	Gudu Baluchistan Branch		
		Lind Channel	464,000	4,100
		Pinyari Feeder	108,085	20,635
		Fulali Feeder	1,191,056	16,622
			3,654,130	101,021

III.—LINKS

Chenab	Marala	Marala Ravi Link	22,000
Upper Chenab Canal	Bambanwala	Bambanwala Ravi-Bedian Link	7,125
Ravi	Balloki	Balloki-Sulemanki Link	15,000
Lower Bari Doab Canal	Balloki	Montgomery-Pakpattan Link	700
			44,825



River System of West Pakistan

Out of the total area of 198 million acres of West Pakistan the culturable area is 75 million acres, out of which with the completion of the projects in hand 31 million acres will be irrigated by canals.

We are obliged to find ways and means of utilizing every drop of water flowing in our rivers and to use it for irrigation. To achieve this aim two dams, one at Mangla and the other at Warsak are already under construction for storage of flood waters and to regulate the water supply so stored for irrigation all the year round.

The other source of water for irrigation is ground water. Shallow wells have long been used for irrigation on a limited scale. A survey of ground water resources is presently in progress. Use of tubewells for lowering the sub-soil water-table in high water-table areas and for supplementing the irrigation water resources is presently receiving much attention. The area being irrigated from sources other than canals is approximately 1,588,000 acres.

The Problems of Irrigation Practices

The salinity problem—The foremost and most

serious problem of the Indus Valley is the salinity problem. The soils of the Indus basin are of alluvial origin and have salts distributed in the profile. The canal irrigation system set up is designed to provide much less water to the land than is required for keeping it free from accumulation of the salts and the irrigation practised has resulted in the creation of a zone of accumulation of salts which rises up to the soil surface, and has turned once fertile lands into saline lands unfit for crop production. In the 16 central districts which comprised the former Punjab province more than 3 million acres out of 12.5 million acres irrigated by canals are seriously affected by salinity which includes 1.3 million acres completely gone out of cultivation. In the whole of West Pakistan, 7 million acres are estimated to be seriously affected. Each year at least 100,000 acres are added to the seriously affected area.

Temporary reclamation is carried out by providing excess water for three years for leaching down the salts but permanent eradication of this menace from lands already affected and prevention of its spread to other areas warrants lowering the water duty from the present high figure of about 3 cusecs for 1,000 acres to 1 cusec for 150 acres. To achieve this aim the Soil Reclamation Board has formulated 29 projects out of which 3 projects are already in operation in the former Punjab area.

Flat Topography—The land of West Pakistan is more or less level having a down valley slope of only 1 in 5000 with an underground ridge running across the upper region. The soils are porous near the foot hills and the porosity shows a progressive decline towards the sea as the soil becomes finer. As a such the water added to the soil by various sources viz. rain, floods and seepage from canals does not find quick drainage to the rivers or the sea. This absence of natural drainage is the cause of waterlogging. Efficient artificial drainage which should have been made simultaneously with the canal system was not provided and we are faced with rapid rise of sub-soil water-table. About 1.9 million acres area has water-table within 5 feet and this area is increasing. The Irrigation Department has already constructed about 3,000 miles of open drainage channels and further works for this purpose are being planned. Attention has been given to installation of tube-wells for lowering the water-table by pumping. About 1800 tubewells have been installed along the canals in Chaj and Rechna Doabs[1]. In its project areas the Soil Reclamation Board is installing tubewells to serve the dual purpose of augumentation of supply for lowering the water duty, and of providing drainage.

Irrigation Practices—The irrigation practice of the farmer of West Pakistan is dictated by the objective of cropping the maximum area with the minimum irrigation water. This is not only detrimental to sustained productivity of soils due to the salinity hazard but does not allow the consumptive use requirement of water for maximum yield to be met. With its own shortsighted objective of Government revenue the Irrigation Department has always encouraged the maximum area being cropped. The use of even inadequate water by the farmer is not efficient. Although basin irrigation was advocated and pressed for by the Irrigation Department in the earlier stages, the emphasis was lost and the ignorant and backward farmer is always tempted to the labour saving practice of flooding.

Irrigation of sandy areas—In some of the project areas like Thal and Taunsa Barrage the soil is mostly sandy and has low moisture holding capacity and high rate of infiltration. These areas lie in tracts having negligible rainfall, high temperature and frequent wind and sand storms. Crop raising in these areas raises problems of soil stabilization, crop protection from sand storms, conveyance losses of water and frequency and depth of irrigation. Work done on these problems is coming up for discussion in subsequent sessions of this Seminar.

Land grading—Although the topography of the Indus plains is flat but microtopography creates problems for irrigation. All the area irrigated from an off-take is not irrigated with equal ease. Conveyance losses in irrigation of fields of higher contour level increase. In serious cases additional allowance of water is made. Additional labor on silt clearance is involved. Generally crop outturns in the higher contour areas are lower than in the lower areas. Efficiency of irrigation in many cases can be increased by land grading and terracing.

Non-perennial irrigation—Due to low supply in the rivers during winter months and in some cases on the wrong conception that in high and rising water-table areas relief will be given by non-perennial irrigation instead of by providing efficient drainage, some of the canals are run only in summer. In tracts being served by such canals normal irrigation is done during summer, and winter crops are grown on a limited scale on conserved moisture. Non-availability of irrigation water in winter lowers yields. As fallow is more favourable for upward movement of salts and as most of the area irrigated by non-perennial canals remains fallow in winter all these areas are more seriously affected by salinity. Temporary reclamation of saline fields in these areas also receives a set-back and salts reappear sooner than in areas under perential irrigation.

1. Doab is a Persian word for the area between two rivers.

Successful cultivation of sugarcane and cotton which are the main cash crops is also a problem in such tracts. Optimum sowing time of sugarcane is March before the summer supply is let in. Both these crops require irrigation after the summer supply is withdrawn. Supply on non-perennial canals is usually available from April 15 to September 30. Such water supply is neither available at the optimum sowing time of sugarcane nor till the end of the growing period of either sugarcane or cotton. Work was done on these problems at Chak 7/3L Experimental Reclamation Farm. It has been concluded that sowing of sugarcane in such tracts can not be delayed to middle of April without adverse effect on outturn. The crop has, therefore to be sown on well irrigation. It was however determined that by applying additional water delta, in August and September, and by mulching, sufficient moisture can be conserved for utilization by cotton and sugarcane after withdrawal of summer supply and both the crops can be successfully matured.

Irrigation Organization

Under the laws of the State, ownership of all surface water resources vests in the Government. Development of the river sources has been financed and organised entirely by Government. The Department of Irrigation controls the works and organization of the canal irrigation system. The Chief Engineer is the head of the Department who deals with the Government through the Secretary Irrigation, Communication and Works. The province is divided into eight regions, each in the charge of a Deputy Chief Engineer. The canals in a region are in the charge of Superintending Engineers. Each Canal Circle under the Superintending Engineer is divided into two or more canal divisions. The Executive Engineer is the head of a canal division. A canal division consists of two or more sub-divisions each under the charge of a Sub-Divisional Officer. Subordinate to the Sub-Divisional Officer is the Irrigation Overseer who has a masonry assistant, gauge readers who report gauges of canal and distributaries and perform regulation, manual labour for maintenance, and contractors who execute engineering works.

The Executive Engineer has under him, besides the engineering branch, a revenue branch of establishment for record and check of area irrigated for assessment of Government revenue on crop rate basis. The revenue branch consists of the Patwari or village scribe who records the irrigation, Zilladar who supervises and checks the work of a number of Patwaries, and Deputy Collector who is the Executive Engineer's advisor in revenue work and supervises the work of the revenue establishment. The establishment of Patwaries and Zilladars is also directly under the Sub-Divisional Officer. The amount of revenue assessed against each occuppier of land is communicated to the occuppier as well as to the Collector of the civil district through a demand statement for the whole or part of a canal division in a district. The revenue is collected by the Collector.

Accomplishments on Farm Irrigation

Training—At the earlier stage in the case of older canal colonies, basin irrigation was obligatory on the cultivator but emphasis on this irrigation practice was relaxed after the completion of colonization operations. The majority of cultivators came from the older districts in East Punjab now in India and had considerable experience in irrigation from shallow wells. Therefore, they had a sense of economical use of water but had no experience in handling large streams of water taking off from canals. In general, under the flat topography of the Indus plains the irrigation practices followed by the cultivators are fairly efficient. The more efficient cultivator generally practises basin irrigation, border irrigation and furrow irrigation, but the backward cultivator generally likes to adopt labour-saving practices like "flood irrigation".

Sufficient importance to training in farm irrigation has been given either at the educational institutions for agriculture or by the Department of Agriculture or the Department of Irrigation. It is with the rise of the soil salinity problem that the Land Reclamation Directorate of the Irrigation Department has interested itself in getting the cultivator to adopt efficient levelling and basin-irrigation of the saline lands to be put under leaching for reclamation. Temporary reclamation operations carried out by the Irrigation Department in scattered fields and projects of the Soil Reclamation Board for permanent reclamation and development both have layout of fields for basin irrigation as an obligatory condition on the cultivator. It is hoped that as the projects of the Soil Reclamation Board are extended to cover more and more areas irrigation practice will improve in the country.

Demonstrations—Layout of land by an efficient cultivator is a good demonstration to the tillers of the soil in the surrounding area. Government farms of the departments of Agriculture and Land Reclamation are a source of demonstration to the farmers. Demonstration is also provided by the work under the projects of the Soil Reclamation Board. Despite all this, this side of the subject is lagging behind and needs extension work by the Department of Irrigation and the Soil Reclamation Board.

Land preparation—Land preparation includes land grading, layout of fields into basins, borders or furrows and cultivation of land for obtaining optimum infiltration of water in the soil. The highly permeable sandy soils need different type of preparation for irrigation than do soils which

need improvement in moisture permeability. Generally the cultivator pays attention to grading but is tempted to save himself the labour on layout and irrigation by adopting flood irrigation.

The tillage implements used by the common cultivator are the same which have been used for centuries past. Neither deep tillage nor soil turning is accomplished by the bullock driven plough in use. Mechanical cultivation cannot be taken up on a large scale due to cheap manual labour and due to employment not being available for agricultural labour rendered surplus by mechanical cultivation. Ordinary loamy soil free from excess salts is well cultivated before the first irrigation for sowing a crop. Most crops are sown with a single ploughing after this pre-irrigation as soon as the soil up to the ploughing depth is dry enough for ploughing. Some crops like rice and berseem are sown in standing water. Hard alkali soils like 'Bara' in Lower Bari Doab Colony can not be cultivated even after irrigation. They have to be reclaimed by impounding water in basins and opening up the soil by growing a deep and tough rooted crop—sesbania aculeata (Janter). This is cheaper than the use of soil amendments like gypsum. Ordinary saline soil is reclaimed by leaching in well levelled basins followed by a high delta crop like rice. Cultivation is not required for the leaching operations and is done when rice is to be sown. In sandy soils like Thal much preparation besides local levelling and layout is not required for irrigation. The soil profile has to be built up by growing of leguminous crops and the use of silted water and wind erosion has to be checked by the strip cultivation practice developed at one of the experimental reclamation farms.

Land Classification and Soil Survey—No land classification and soil survey was carried out for the older irrigation projects of the Indus Valley. After the salinity and water logging problems had raised their head and when problem areas like Thal came to be considered for extension of irrigation, some importance was given to soil survey. A utilitarian type of soil survey of the Thal area was carried out in which a topographical classification of the land showing the presence or absence of sand dunes, a chemical classification showing the salt content and pH value and a mechanical classification showing whether the clay content was above or below 10% was made. Similar types of surveys were later carried out in Rangpur area, Mailsi Canal Circle and in Jalalpur area for determining the extent of the salinity and alkalinity problem. A million acre salinity survey was also carried out in Lyallpur district to assess the actual and potential damage due to salinity.

The importance of basic soil survey and land classification of the Punjab Doabs was realized after independence. These surveys were started in 1952 with the help of soil survey experts of F.A.O. In 1954 the Ground Water Development Project was taken up in the former Punjab with the assistance of I.C.A. of U.S.A. Under this project a soil and water survey has been in progress in the three Doabs viz. Rechna, Chaj and Thal. Of the total area of 18 million acres of the three doabs, an area of 9.8 million acres has so far been surveyed. The details are given below:

Name of Doab	Total area to be surveyed	Area surveyed to end of 11/59	Area surveyed up to 12/59	Balance
	(In thousand acres)			
1. Rechna	7,040	3,631	3,631	3,409
2. Chaj	3,229	2,711	2 711	518
3. Thal	7,898	3 270	3,466	4,432
Total	18,167	9,612	9,808	8,359

The following soil series have been established in these soil surveys:—

1. *Jhang Series*--These soils are sandy throughout the profile and the size of particles varies from sandy to loamy fine sand. Logically these are highly permeable with low water holding capacity. Usually there is no organic matter in such soils and any definite zone of lime accumulation is also absent.

2. *Farida Series*--The soils in this series are moderately sandy, comprising sandy loams to fine sandy loams. These are permeable with a good moisture holding capacity.

3. *Buchiana Series*—The sub-soil texture ranges from loam to silt loan and silt. These are medium textured soils moderately permeable and have good to excellent water holding capacity.

4. *Chuharkana Series*—These soils are moderately heavy in texture. The sub-soil includes clay loams, silty clay loams and sandy clay loams. The permeability relatively low but water holding capacity is high.

5. *Nokhar Series*--Soils of these series are fine textured and usually are situated in depressions. Clays form the main sub-soil material. Permeability is very low and internal drainage poor.

This soil survey and land classification is being made use of in framing the reclamation and development projects of the Soil Reclamation Board. The information supplied by this survey will be available to other Government departments interested in soils such as the Revenue Department, Agricultural Department etc. and to farmers as the interest in scientific agriculture developments.

Farm Irrigation Equipment—For flow irrigation from canals hardly any farm irrigation equipment has been used. In some cases well-to-do and progressive farmers use a "weir gate" for water diversion at the farm. Use of syphons for furrow irrigation has not been made. Syphon irrigation is being done on an experimental and demonstration scale at some of the Experimental Reclamation Farms. Sprinkler irrigation has neither been practised nor it is necessary to use it under West Pakistan conditions.

For the indigenous methods of irrigation from wells, equipment like the persian wheel and some more primitive devices have been used. For irrigation of land at higher contour levels, lift irrigation is done from the canal source by a bucket equipment worked by bullocks and locally known as "Jhallar".

Irrigation Research

In the papers presented in the last Seminar, one on "Use of limited water supply", another on "Use of brackish water" and the third on "Causes and remedies of excess salinity in irrigated land" the outlook and results of the work done in West Pakistan were described. Irrigation research in this province was taken up with the coming up of the soil salinity and water logging problems. The need for soil and water research is becoming more and more pressing with the high rate of soil deterioration which has resulted from the irrigation practices followed in the areas served by the Indus Valley Canals. The work was initiated in the Physical Chemistry and Land Reclamation Sections of the Irrigation Research Institute at Lahore before independence and has been continued by the Directorate of Land Reclamation after independence.

Since the last Seminar, work has been done on salt tolerance of crops to salt content of soil and irrigation water.

The salt tolerance study showed that 0.2% total salt content commonly taken as the critical value between good and deteriorated soil by no means holds true for all salts and all crops. For wheat variety C 591 the critical value of sodium chloride was 0.3% salt on dry soil basis and for sodium sulphate this value was between 0.7 and 0.8 percent. With 1 to 1 mixture of sodium chloride and sodium sulphate the value was between 0.4 and 0.5%. For the mineral content of irrigation water, it was found that there was decrease in yield above conductivity of 1,500 in case of wheat, cotton and sugarcane but in the case of wheat it was observed that up to conductivity of 6,000 the fall in yield is not very serious while in the case of cotton and sugarcane it is a linear one. However, the decrease in yield of the three crops was observed to be equal at the conductivity range of 6,000 to 6,500 and was 40%.

Consumptive use studies on various crops have been taken up by the Land Reclamation Directorate at Moharanwala, Ballohwala and Shorkot Farms.

On non-perennial canals water supply is not available for the sowing of sugarcane from the end of February to mid March. Experimental work was done at 7/3L Farm on Rangpur Canal to determine if sowing of sugarcane could be delayed till the middle of April when supply is received in the canal. The results showed that the sowing time of sugarcane cannot be delayed to the middle of April without effect on yield. Well irrigation, therefore, has to be provided for sowing of sugarcane at the optimum sowing time.

Work has been in progress to determine the suitable frequency and depth of irrigation for different crops under the severe meteorological conditions and with the predominantly sandy soils of Thal area. The results are described in a technical paper to be presented in this Seminar. These show that under the Thal conditions the water distribution system should have not more than 7 days length of turn and if possible there should be a bi-weekly turn for the severely hot and stormy months of May, June and July.

Progress Made on the Recommendation of the Previous Seminar

There is a growing realization in Pakistan of the importance of scientific soil and water management for agriculture. The mistakes made in the conception and execution of irrigation projects in the past are being recognized. To cope with the serious problems of salinity and rising water-table with which agriculture in this wing of Pakistan is faced the Soil Reclamation Board has seven reclamation projects already sanctioned by Government, one under sanction and 21 more under preparation. The projects being formulated comply with the following fundamentals:

(*i*) Provision of extra water supply for increasing the existing meagre water allowance—3 cusecs per 1000 acres to one cusec per 150 acres by tapping the ground water through installation of tube-wells.

(*ii*) Maintenance and lowering of the water-table by withdrawal through tube-wells, supplemented by provision of open drainage system.

(*iii*) Framing a scientific cropping pattern based on the needs of the soil as well as the crop assessed by a modern soil capability and land classification survey.

(*iv*) Making available an efficient extension service to bring the cultivators problems to the expert and take back the solution to them as well to provide on the spot guidance.

(*v*) Opening of experimental-cum-demonstration farms for demonstration of improved modern techniques of soil and water management to the cultivator and to study and find solution for any local problems arising now and then.

Three of these projects are already in operation at this stage. Within the next 5 years all these projects will be operated and will cover a total area of about 6 million acres.—Particulars of these projects are given below:

Doab	*Name of Reclamation Project*	*Culturable area in acres*
Rechna	1. Jaranwala	83,235
	2. Chuharkana	11,000
	3. Pindi Battian	7,969
	4. Chichoki Mallian	6,556
	5. Khangah Dogran	114,782
	6. Shahkot	23,100
	7. Sangla Hill	138,000
	8. Zafarwal	192,000
	9. Shadman	138,000
	10. Hafizabad	126,000
	11. Beranwala	114,000
	12. Horse Sheikh	27,000
	13. Jandiala Sher Khan	262,000
	14. Gujranwala	426,000
	15. Satiana	148,000
	16. Muridke	131,000
	17. Nawan Kot	496,000
Chaj	18. Mona	230,000
	19. Mandi Baha-ud-Din	223,000
Thal	20. Hudali	460,000
	21. Bara Ghar	260,000
	22. Kalur Kot	140,000
	23. Leiah	250,000
Bari	24. 2-L Dhaya	19,249
	25. Shahbore	8,265
	26. Renala	96,000
Bahawalpur	27. Minchanabad	232,000
Sind	28. Sind No. 1	1000,000
	29. Sind No. 2	2500,000

As the river water resources including the reservoir potential of summer floods are far less than the water requirements for sustained agriculture in the area to which irrigation has been extended, exploitation of ground water resources has become indispensible. The Ground Water Development Organization set up with aid from the I.C.A. and the Ground Water survey as well as a land classification and soil survey has been carried out since 1955. This survey will be of help in the management and development of our land and water resources.

The work of reclamation of deteriorated land and prevention of further land deterioration and further development of land and water resources is spread over five different Government agencies.

The Directorate of Land Reclamation is the research and advisory branch of the Irrigation Department. The Ground Water Development Organization is carrying on the ground water surveys and the land classification and soil surveys.

Provision of canal water supplies for temporary reclamation and administrative control of this work is the responsibility of the Irrigation engineers.

The Soil Reclamation Board is the statutory body created for implementation of projects for permanent reclamation and development of large seriously affected areas.

The installation and running of tubewells for drainage and additional water supply required is entrusted to the Water and Power Development Authority.

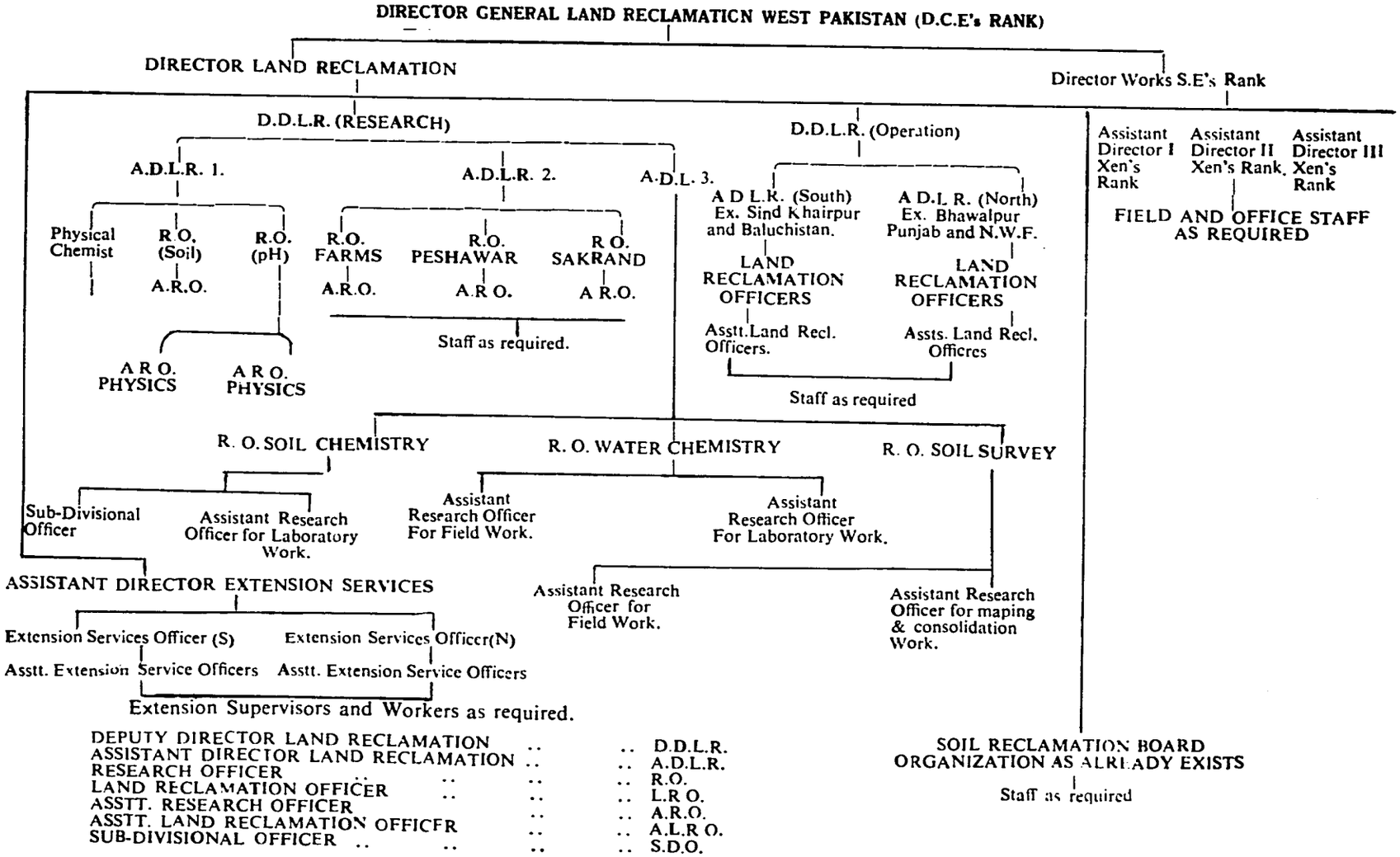
The feeling is gaining ground that there should be greater co-ordination of these different aspects of soil and water management work. A set-up providing for an over-all control and co-ordination of the entire work is being considered at the present stage. If the proposals materialise the set up will be as shown in table attached.

Discussion

In reply to a question by Mr. Vernon, Dr. A.G. Asghar stated that the proposed duty of water of one cusec per 150 acres works out very nearly to water requirements predictions using the Blaney-Criddle formula.

Recalling that Dr. Asghar in an F.A.O. Conference at Tehran in 1954, referred to a figure of thirty to forty thousand acres annual loss of crop land due to salinization and waterlogging Mr. Anderson asked for clarification of the 100,000 acre figure referred to in the paper. Dr. Asghar stated that this has increased in the Punjab area to 70,000, which is average for 1946 to 1956. Lands which, on a one-acre basis, are covered by 20 percent or more area of salts are classified as salinized; however, such areas may not go completely out of production. The salts were originally distributed throughout the soil profile, but under unscientific farming, have become concentrated in the upper 2 to 5 feet. About 25,000 acres per year are being temporarily reclaimed so only a portion of the salinized land receives temporary reclamation. Temporary reclamation may make cropping successful for from 3 to 8 years depending on depth to water-table. This relief program has been fitted into the permanent program of the Soil Reclamation Board for which ICA aid has been provided.

Dr. Ali Asghar Khan raised the question of tillage mulching during the growing season for sugarcane and cotton, stating that this would harm the crop. Dr. A.G. Asghar commented that the mulching referred to was straw mulching and pointed out that he did not recommend growing of sugarcane and cotton under non-perennial canals; however, people on these lands required some such crops, so that the method presented was worked out as best under the circumstances. He further stated that such yields should not be compared with those from perennial canals. Dr. Qureshi amplified the matter by stating that under the practice of


DIRECTOR GENERAL LAND RECLAMATICN WEST PAKISTAN (D.C.E's RANK)
DIRECTOR LAND RECLAMATION
Director Works S.E's Rank
D.D.L.R. (RESEARCH)
D.D.L.R. (Operation)
A.D.L.R. 1.
A.D.L.R. 2.
A.D.L. 3.
Physical Chemist
R.O. (Soil)
R.O. (pH)
A.R.O.
R.O. FARMS
R.O. PESHAWAR
R.O. SAKRAND
A.R.O.
A.R.O.
A.R.O.
Staff as required.
A R O. PHYSICS
A R O. PHYSICS
A D L.R. (South) Ex. Sind Khairpur and Baluchistan.
A D.L R. (North) Ex. Bhawalpur Punjab and N.W.F.
LAND RECLAMATION OFFICERS
LAND RECLAMATION OFFICERS
Asstt.Land Recl. Officers.
Assts. Land Recl. Officres
Staff as required
Assistant Director I Xen's Rank
Assistant Director II Xen's Rank.
Assistant Director III Xen's Rank
FIELD AND OFFICE STAFF AS REQUIRED
R. O. SOIL CHEMISTRY
R. O. WATER CHEMISTRY
R. O. SOIL SURVEY
Sub-Divisional Officer
Assistant Research Officer for Laboratory Work.
Assistant Research Officer For Field Work.
Assistant Research Officer For Laboratory Work.
ASSISTANT DIRECTOR EXTENSION SERVICES
Assistant Research Officer for Field Work.
Assistant Research Officer for maping & consolidation Work.
Extension Services Officer (S)
Extension Services Officer(N)
Asstt. Extension Service Officers
Asstt. Extension Service Officers
Extension Supervisors and Workers as required.
DEPUTY DIRECTOR LAND RECLAMATION .. .. D.D.L.R.
ASSISTANT DIRECTOR LAND RECLAMATION .. .. A.D.L.R.
RESEARCH OFFICER .. .. .. R.O.
LAND RECLAMATION OFFICER .. .. .. L.R O.
ASSTT. RESEARCH OFFICER .. .. A.R.O.
ASSTT. LAND RECLAMATION OFFICER .. .. A.L.R O.
SUB-DIVISIONAL OFFICER .. .. S.D.O.
SOIL RECLAMATION BOARD ORGANIZATION AS ALREADY EXISTS
Staff as required

"Bosi Rabi", land is flooded in September if the requirements of the Kharif crop is not too great and there is additional water available for flooding. Such land is plowed and sown to wheat in November and any irrigation if at all required could be provided by tube-wells or from shallow wells.

Dr. Peterson inquired regarding the leaching ratio and suggested that "*irrigation allowance*" be explained in terms of inches applied per crop. Dr. A.G. Asghar stated that leaching ratio ranged from 10 to 20 percent depending on the water-table depth. He pointed out that land with higher water tables required the largest leaching ratio. However, he stressed that drainage and flood protection must be provided.

SUDAN

The Sudan is a vast country of one million square miles area with a population of about 12 millions. The country as a whole is a dry one and less than one-fifth of it receives annual rain fall of 30 inches in three years out of four. In the north third the rainfall averages less than 6 inches per annum. The economics of the country is dependent on agricultural resources; cotton growing is the back-bone of the country. It is the present national policy to develop the agricultural resources of the country to raise the living standard of the people and increase the national income. Only by irrigation practices can vast areas of rich soil be put under agricultural development. Half a century ago only about 100,000 acres were cropped by the tradition methods of irrigation namely the Sagia and Shadouf.* Now under systematic irrigation 3½ millions acres are already under irrigation and some 4 millions additional are either under development or being planned for development.

Types of Irrigation

Irrigation in the Sudan may be classified as follows:

Systematic Irrigation by Free Flow—The Sennar Dam was built to act as a barrage in the period of flood of the Nile to command the Gezira Scheme of 1,000,000 acres by a Main Canal 204 km. long having a capacity of 186 cubic meters per second. The dam stores about 930 million cubic meters at the end of the flood to be used for watering the cotton up to the end of March. Another canal of a capacity of 186 cubic meters per second and about 134 km. long is being dug, removing 28 million cubic meters of earth, to extend the Gezira Scheme by a further area of 800,000 acres under the Managil Scheme. Further development of 3,000,000 acres area is now under study for irrigation by free flow from the Nile from the proposed Roseires Dam, and Khashm El Girba Dam.

Systematic Irrigation by Pumps in the River—Pump irrigation began on a small scale early in the present century. The gross area under pump irrigation totals some 1,600,000 acres and the total number of pump schemes count to some 2,600. An area of 160,000 acres is operated by the Government and the rest is owned under licenceship by individuals or companies. The Guneid Scheme on the Blue Nile is perhaps the biggest pumping scheme in Africa with a total area of about 30,000 acres.

Flush Irrigation—Flush irrigation is practiced on the Gash and Baraka rivers in eastern Sudan. The Gash Delta covers roughly 720,000 acres of which about half is available for irrigation by canal system and training works. There are 380,000 acres in Baraka Delta of which 50,000 are available for irrigation by natural flooding from the River Baraka.

Basin Irrigation—Basin irrigation is confined to some 20 small depressions totalling 80,000 acres in the North Sudan which are topped during flood.

Tubewell Irrigation—Irrigation by tubewells from ground water resources has been started in a small scale in North Sudan and is still in the experimental stage.

Irrigation Practices and Water Control

Systematic irrigation in Sudan is based on a night storage system. Irrigation in this country usually is suspended by night and the water, which is continuously flowing in the main canal and major canals, is stored in the minor canals. The minor canals are so designed with bigger section and good banks to allow for a night storage level normally 30 cm. above full supply level.

Water Control

It will be realised that the flow of water in a large canalisation scheme, once started, must continue night and day as steadily as possible, and that changes in discharges can only be effected in stages, with careful cooperation between the controlling staff throughout the scheme. It was decided that to ensure satisfactory working, and economy in water, the system in the Gezira should be quantitative, involving an exact knowledge and

*Sagia = Water wheel; Shadouf = Lever system

control of the discharges passing every regulator at all times. The main sluices in the dam, and all regulators, from those at the head of the Main Canal, down to the small pipe regulators on minor canals, were calibrated from model experiments, and from the beginning, the daily discharges at all regulators in the scheme, down to the heads of the minor canals, have been carefully recorded. Further, by means of a complete telephone system, indents for water required in each channel are submitted weekly to the Engineer in charge of each Sub-Division, and there compiled and passed up the line from Sub-Division to Sub-Division, until the total demand, including an allowance, usually small, for losses on the way, reaches the Resident Engineer Sennar Dam, who makes any change required on the setting of the Main Canal Head Regulator.

Rotation

Irrigation in the Sudan is based on a rotation system as follows:

Gezira Scheme 1:4	rotation
Cotton	10 feddan*
Dura	5
Lubia liguminus	5
Fallow	20
Total holding	40
Managil Scheme 1:3	rotation
Cotton	10 feddan
Dura	5
Lubia liguminus	5
Fallow	10
Total holding	30

Irrigation Problems

Siltation—The River Nile is a silt laden river of about 4,000 parts per million of fine silt. Due to the night storage system the minor canals act as silt traps and a huge amount of silt is removed yearly from these canals totalling some 1,000,000 cubic meters. Usually hand-labour and machine excavation are used for canal clearance. The main canal, which is continuously running, is free from silt except in its tail reach.

Weeds—Aquetic weeds are a source of menace in the small and major canals. Local species are a very quick growing type and are wide spread and usually lead to canal difficulties. Launches fitted with mechanical cutters, or hand cutter chains are used to clear the weeds, the second method worked better at first, but is not very effective once plants became established as it does not root the weeds out. Experiments introducing weed eating fish in the canal were not successful. At last the use of copper sulphate has proved effective in killing the weeds. Copper sulphate also kills the snails which carry bilharria (liver flake).

Soil Classification for Irrigation Schemes

Gezira Scheme Soil—The soil of the Gezira Scheme, comprising about 1,750,000 acres including Managil Extension, is classified as a heavy black cracking clay with an average clay content of about 60%. The soil is alkaline, with an average alkalinity of 8.5. The average depth of clay is about 20 meters with a maximum of up to 60 meters. The water table is at about 20—60 meters and there are therefore no problems of under surface water drainage. Drainage is practised for surface water during heavy showers of rain.

Pump Schemes—The soil of the pump schemes on the Nile are similar to the Gezira clay, except that the areas nearer to the river are less salty and contain a big amount of silt. The gross area under irrigation by pumps from the Nile is about 1,600,000 acres.

Flush Irrigation Schemes Soils—At Tokar about 60,000 acres are irrigated annually by uncontrolled flush irrigation from the Baraka River. Tokar Delta comprises an area of about 380,000 acres. The Delta is formed by the alluvial deposits laid down by the Baraka river which rises from the Eritrean highlands. The soil has a high clay content (about 60%), but it is friable and is very fertile, retains moisture for a long time and allows for deep root penetration. After flushing for 20—30 days, the soil carries a cotton crop for 8 months without further irrigation. The salt content is very low indeed.

The Gash Delta is formed by the deposits of the River Gash rising from Eritrea. The total area of the Delta is about 720,000 acres of which about 50,000 acres are irrigated annually, on a rotation of once every three years. Part of the soil is similar to Tokar and part of it is a heavy black cracking clay. Crops of cotton and dura are grown after the land has been flooded for about 20—30 days, similar to Tokar.

Land Preparation and Rotations

In the Gezira and the pump schemes on the Nile, the main crop grown is cotton. Land is ploughed up to a depth of about 5 in. mainly for weed control and also for aeration and improvement of soil texture. The land is ridged, ridges being made 75 cms. apart, just before sowing the crop and the crops are sown on the top of ridges.

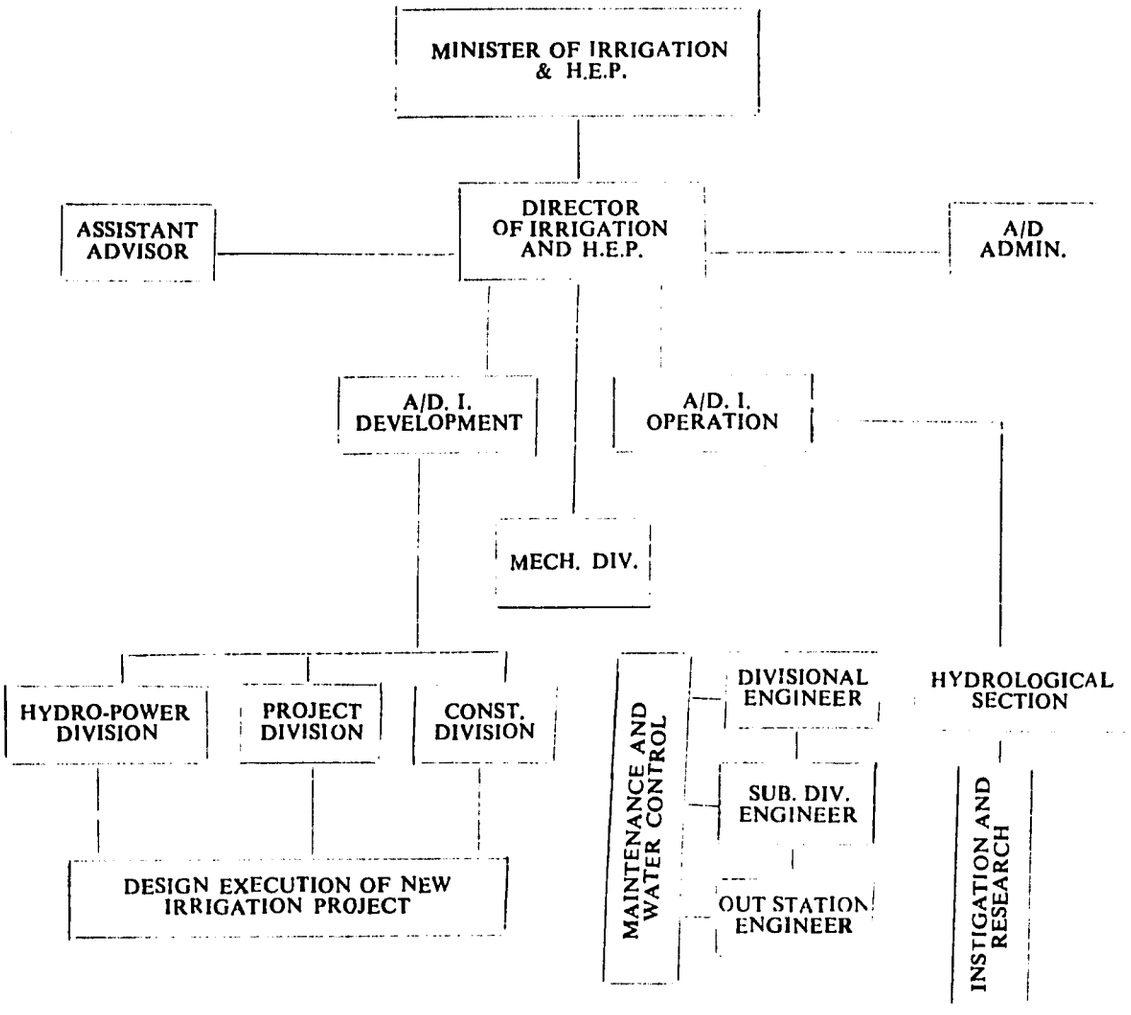
Better germination has always been obtained

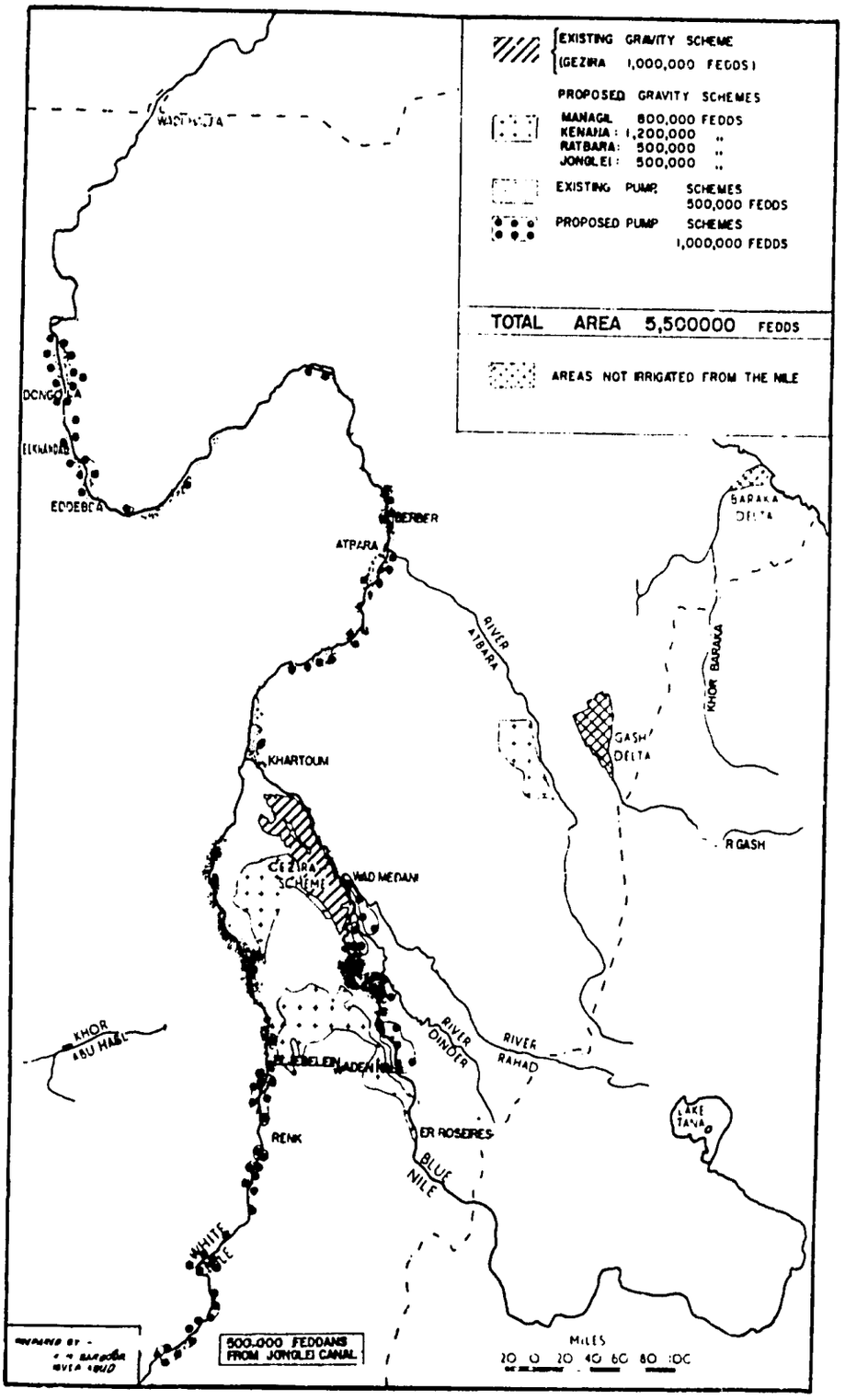
*One feddan equals approximately 1.04 acres.

when seeds are planted on ridges than when seeds are planted on the flat, as planting on ridges enables the seeds to be moistened by seepage.

In the main Gezira scheme, cotton is grown in a four course rotation. That is cotton comes on the same plot once every four years. Sorghum and leguminous crops follow cotton in the rotation. The last year before cotton is sown is always left fallow. In the new extension of the Gezira and in the pump schemes on the Nile, the rotation is a three-course rotation. That is cotton comes on the same plot once every three years. The purpose of these rotations is to restore soil fertility by natural means, although fertilizers are also used to increase yields.

ORGANIZATION OF IRRIGATION IN THE SUDAN





Irrigation from the Nile in Sudan

TURKEY

Introduction

In Turkey, the population is increasing very rapidly. The standard of living also is becoming higher. Therefore, we are faced with a big problem: that is, to achieve much higher production to meet the nutrition needs of our people.

We intend to do this by:

1. Treating and managing existing cultivated lands to get the higher yields which they ara capable of producing.
2. Reclaiming lands not now being cultivated.

There are many factors which influence the production which we expect to achieve, namely: irrigation, fertilizer, proper tillage, applicable crop rotation, improved seed, insect and disease control, soil and water conservation practices which keep the soils fertile, etc. We are not overlooking the matter of marketing and transportation.

One of the main factors to which we need to give special attention is irrigation.

Existing Irrigation in Turkey*

Areas in Government Irrigation Projects--We have 24 completed irrigation projects. These projects were planned to supply irrigation water for 227,500 hectares, however, at the present time 82,617 hectares of land are actually being irrigated. The main reason that all of the planned project areas have not been served with water is that the irrigation systems have not been completed on 86,650 hectares. The remainder of the project areas cannot presently be irrigated efficiently because of the following factors:

(*a*) Insufficient land leveling.
(*b*) Farm irrigation systems inadequately developed.
(*c*) Inadequate or no provisions for main and farm drainage.
(*d*) Poor methods of irrigation.
(*e*) Large water loss from the primary and distribution systems.
(*f*) The water supply and distribution systems do not have sufficient control structures.
(*g*) Proper rotation schedules for water application have not been developed.
(*h*) Capacity of ditches is decreasing due to silting and lack of weed control.

The distribution of crops in the existing 82,617 hectares of irrigated land is as follows:

51.4% Industrial crops (cotton, sugar beets, etc.)
16.5% Orchards and vegetables.
32.1% Grain.

Irrigation Projects Under Construction--There are 30 projects under construction. Twelve of them have been almost completed. Sixteen will be opened for operation at the end of 1960 and two in 1961. The projects under construction will provide irrigation for 190,350 additional hectares of land in 1961.

Proposed Irrigation Projects--Thirty-eight additional irrigation projects have been proposed to provide 508,000 hectares of land with irrigation water.

Private Irrigated Area--Although the exact figure is not available, more than one million hectares of land are estimated to be privately irrigated.

Problems of Irrigation Practices

Problems of applying irrigation water to the fields are as follows:

(*a*) Uncontrolled Irrigation.

1. Improper irrigation methods. The farmers are usually conservative and it will take time to instruct them in the use of proper irrigation methods instead of the wild flooding system which they are accustomed to using. Continued efforts are being made to influence them to adopt modern irrigation methods on their farms.
2. Insufficient land leveling.
3. Inadequate farm irrigation systems.
4. Poor timing of irrigations and over- or under-irrigation.
5. Land ownership pattern prevents efficient layout of farm irrigation system.
6. Suitable implements not being used on irrigated land.

(*b*) Drainage and Salinity Problems.

1. The lack of adequate main and farm drainage systems.
2. Poor topographic location and soil types and misuse of water resulting in high water-tables and salt accumulations. The inexperienced farmers were unable to anticipate this problem.

*All data reported under this section are taken from the Ministry of Public Works, General Directorate of State Hydraulic Works Publications.

3. Application of irrigation water of poor quality.

Irrigation Organizations in Turkey

The responsibilities for irrigation in Turkey are divided between the State Hydraulic Works Department within the Ministry of Public Works and the Soil Conservation and Farm Irrigation Division of the Ministry of Agriculture. The Hydraulic Works Department is responsible for the planning, construction and operation of large scale irrigation works and the Ministry of Agriculture is responsible for irrigation, extension, research on soil moisture-plant relations, crop rotations, fertilization, drainage of farm lands, and efficient use of water on farms.

In 1952 an irrigation section was set up in the Department of General Agriculture in the Ministry of Agriculture. In 1957 it became the Soil Conservation and Farm Irrigation Division of the Ministry of Agriculture.

A General Directorate of Soil Conservation and Farm Irrigation is proposed under legislation now pending in the National Parliament. If this is approved the responsibilities and potentialities will be greatly enhanced. All of Turkey can then be better served, by providing wherever needed and justifiable, comprehensive assistance on agricultural lands as follows:

1. Soil and water conservation.
2. Flood prevention.
3. Conservation irrigation.
4. Conservation drainage.
5. Hill culture (government lands).
6. Reclamation of stony, alkaline, acid, peat and muck lands (government lands).
7. Small water resource development.
8. Soil survey and land classification.

This legislation also provides authority for a number of functions to accomplish the above efficiently such as:

1. Research in soil and water conservation, irrigation, drainage, etc.
2. Construction of laboratories, warehouses, greenhouses, and other buildings and grounds.
3. Acquisition of equipment.
4. Fostering formation of cooperatives, associations and private companies and permitting utilization of a revolving fund.
5. Land consolidation.

The soil conservation and farm irrigation organization is being developed on three organizational levels: (1) a strong, central or national office, (2) regional offices, (3) technical groups for work areas, usually for a province.

The central or national organization has the responsibility of supervision of the national farm irrigation assistance program; it formulates the policies under which the field organization works. The central office is also responsible for training, legislation and budgets and for the delegation of authority to the field offices.

The field work is organized in two levels; (1) Regional offices to provide for programming of work, provide technical guidance and supervision to the operational offices, adjust technical standards to local conditions and provide general administrative support for field work. (2) Technical groups or work areas to provide the actual technical assistance and training for improved farm irrigation practices to the land-owners. The personnel of these two technical groups varies somewhat according to the actual problems of the area, but normally consists of trained irrigation engineers, trained irrigationists, drainage specialists, soil conservation specialists and soil survey specialists. Assistance and planning is normally based on a soil survey of the land area.

The central or national office has six sections as follows:

(*a*) Small Water Resources Development
(*b*) Soil Conservation
(*c*) Soil Conservation and Farm Irrigation Machinery and Equipment
(*d*) Soil Survey, Land Classification and Drainage
(*e*) Farm Irrigation
(*f*) Irrigation and Soil Research

At present there are two regional offices located in the western and southern parts of Turkey and ten work unit offices attached to the regional offices. In addition, there are nine independent work unit offices directly responsible to the central office.

Forty irrigation specialists of the Extension Service of the Ministry of Agriculture are located in forty provinces. Their responsibility is to establish close cooperation between the Extension Service and the Soil Conservation and Farm Irrigation Division and the farmers.

There are four irrigation experiment stations, four sub-stations and the Soil and Fertilizer Research Institute which has three sub-laboratories. These sections are working on the research aspects of land and water use.

Accomplishments on Farm Irrigation

Training—Thirty technical people from the Soil Conservation and Farm Irrigation Division and the Extension Service have been trained for 60 days in the practical and theoretical aspects of soil conservation and irrigation practices.

Fifty county agents and 150 agricultural village teachers have received practical training in the use of locally made equipment for irrigation and soil conservation practices. Each of these agents and teachers was provided with locally made equipment for demonstrations in his work area. Forty agricultural workers have taken part in short courses on improved irrigation practices.

Special short courses have been given in:

1. Farm drainage for drainage engineer—20
2. Land levelling—advanced course for 13 irrigation engineers
3. Small irrigation developments.
   (*a*) Basic course—20 engineers
   (*b*) Advanced course—12 engineers.
4. Equipment.
   (*a*) Mechanics—8
   (*b*) Operations—20
5. Research. Eleven research workers received training on methods of analysis of fertilizer trials for application to irrigation and soil conservation.

Of special interest is the new National Soil Conservation and Farm Irrigation Training Center now under construction at Tarsus. It is expected that the first training will be held at this new Training Center (engineers, sub-professionals, and skilled workmen), at three different levels, beginning in May 1960.

Demonstrations—Demonstrations have been held as follows:

1. *Land levelling demonstrations:* From September 1956 to May 1958 forty land levelling demonstrations have been held on 625 hectares of land in central Anatolia and southern and western Turkey. These demonstrations have been so effective that we have passed this stage using heavy equipment, and now have a big demand for doing land levelling on a reimbursable basis.

We still are demonstrating the use of small, locally made equipment such as fresnos, buck scrapers, etc. for the smaller jobs.

2. *Modern irrigation methods demonstrations:* Irrigation methods demonstrations have been set up in 38 locations on 570 hectares of land. Furrow irrigation methods have been demonstrated on cotton, peanuts, sugar-beets, citrus orchards and vegetables. Border methods have been demonstrated on alfalfa and other forage crops. The basin method has been used in rice production.

To illustrate how these practices have been accepted, we are glad to report that 15,000 hectares of cotton alone were irrigated the modern way in 1959. We know that this is a direct result of the demonstrations.

3. *Farm irrigation system demonstrations*—Attempts have been made to include farm irrigation system demonstrations wherever irrigation methods demonstrations have been held. Approximately 5,000 farmers have attended these demonstrations. As a result of this work, 500 farmers have applied modern irrigation methods on their farms.

Land Preparation Work—Following is a summary of types and amounts of land preparation which have been carried out.

Land levelling	6,600	hectares
Layout system—Farm irrigation and farm drainage	9,200	,,
Irrigation methods	25,000	,,
Farm planning	2,500	,,
Total:	43,300	,,

Beginning in 1959 high priority was given to land preparation for irrigation in the large government irrigation projects. Major water supply and the canal systems were completed, but the job of making best use of the water on the farms remains to be done. We are concentrating on this so the big investments can produce the main objective of increasing the crop production throughout the area. For example, in the Seyhan project alone there are 20,000 hectares for which the water supply is now available but cannot actually be utilized until the proper land preparation has been done.

Land Classification and Soil Survey for Irrigation Projects—Semi-detailed land classifications for irrigation suitability have been carried out on 190,000 hectares of land in two main areas where the State Hydraulic Works Directorate has irrigation projects planned.

Farm Irrigation Equipment—Work on farm irrigation equipment falls into two categories, land preparation and water control.

The following kinds of equipment are being used in Turkey for land preparation:

Scrapers
Land planes
Eversman land levellers

In addition to the above equipment, some locally made types are being used; such as floats, fresnos and buck scrapers.

Several kinds of equipment have been used for establishing efficient water control systems on the farms. These include: (1) ditchers, (2) locally made V-drag, (3) locally made border maker, (4) spiles, (5) siphons, (6) flumes.

Irrigation Research

Research Program—Five irrigation research stations or institutes are engaged in carrying out

research activities on the relationships of soils, crops, moisture and climate. Two main objectives are being stressed by these organizations. One is the cooperative work with the Ministry of Public Works for the purpose of providing the required data for sound irrigation project development. The other is gathering the necessary research information required to help the farmers use their land to the best advantage. The main phases of the irrigation research being investigated are:

1. Soil-water relationships
2. Soil-water-crop relationships
3. Climate-soil-moisture relationships

Use of Results of Irrigation Research—When dependable, useful data have been obtained, the Soil Conservation and Farm Irrigation Division and its regional and work unit offices and the Extension Service have been carrying the data to the farmers by extension and demonstration methods, publishing the experimental results and by providing direct technical assistance on the land to farmers in planning and applying improved irrigation practices.

Progress Made on Recommendations of the Previous Seminar

Although we are not satisfied with what has been done since the last seminar, we feel that good progress has been madein many aspects of our work.

We will summarize the progress under three broad categories as follows:

1. *Administration:* As stated in the report, legislation is now pending in the Parliament which, if passed, will create a General Directorate of Conservation and Farm Irrigation. There will need to be a reorganization to carry out the greatly expanded program made possible by the authorizations and new responsibilities under this act.

We are planning now on the additional regional and work unit offices to administer the program. We need to accelerate the training program to provide the many new technical and administrative people required.

Recently, substantial amounts of credit have become available which will certainly speed up the application of practices both in Conservation and in Farm Irrigation.

Steps have been taken to have a Central Cartographic Laboratory to facilitate map making, drafting and similar services to work unit offices.

2. *Research:* Five new sub-stations have been established to extend the research of the four principal institutes or stations.

The Soils and Fertilizer Research Institute at Ankara is conducting many investigations of direct value to farm irrigation problems.

All of the recommendations of the Committee on Research Needs in Irrigation of the 1958 Seminar, are being carried out at the Tarsus Irrigation Research Institute and are discussed in detail in the technical paper on that subject.

3. *Operations:* We have made substantial progress in practically every item listed under the recommendations of the previous seminar. We are using or have adopted:

(*a*) Permanent type structures for water control.
(*b*) Lining canals where required.
(*c*) Provisions for maintenance.
(*d*) Provisions for water control and use.
(*e*) Considerable stress is given to advance planning and timely construction of drainage facilities.
(*f*) As pointed out in the report, demonstrations have been used widely in Turkey. Their success is reflected in the great demand which has developed for improved irrigation practices.
(*g*) Several short courses have been given to train extension workers and others in the improved practices and methods of demonstrating them to the farmers.

Discussion

In reply to a question by Mr. Vernon, Mr. Kaleli stated that the number of drainage engineers (20) for example, quoted in the paper, referred to the total, rather than the annual number. This course was of 40 days duration and was held in the Tarsus Institute and in the Southern Regional office. It was a basic course so next year Turkey expects to offer another course on the advanced level.

In response to a question by Mr. Young about the cost of land preparation including leveling and irrigation and drainage, Mr. Kaleli stated that this was about 2,000 lira. (approximately $200.00) per acre. Costs for farm planning is about 30 lira per hectare. There is no limit on the size of farms which can be served. Cost for a government-owned scraper is approximately 400 liras per hectare. If needed, the farmer may obtain credit from the bank, but must show the plans made by the work unit to the banker.

Dr. Peterson asked if there were any farm organizations which worked directly with the regional and work unit offices of the Soil Conservation and farm irrigation service. Mr. Kaleli replied that they are just now trying to set up new farmer organizations called "Irrigator" or "Water User" associations. This summer an attempt will be made to set up some of these organizations in the irrigation project areas. Such organizations are not presently in existence. Later an attempt will be made to extend this type of organization to the privately irrigated areas.

CHAPTER IV

OPPORTUNITIES FOR EDUCATION AND TRAINING IN IRRIGATION

CEYLON

University Courses

The University of Ceylon offers the usual courses in Agriculture and Engineering but in neither Faculty (Department or College) are courses in Irrigation offered. In the Faculty of Agriculture, Irrigation is covered in lectures in Agricultural Engineering; in the Faculty of Engineering, there are no special courses in Irrigation, the subject is touched upon as a part of the course in Civil Engineering. The Faculty of Agriculture is located at Peradeniya on the new University Campus, the Faculty of Engineering is in Colombo but will be moved to Peradeniya when the buildings have been completed.

Two Year Courses

There are two schools of Agriculture; one at Peradeniya and one at Kundasale which offer two-year courses and grant School Certificates. Admission requires a Senior School Certificate with Chemistry as a subject. All subjects are taught in the Sinhalese or Tamil language.

The first year covers:

1. Principles of Agriculture
2. Crops
3. Agricultural Engineering
4. Horticulture
5. Animal Husbandry
6. Veterinary Science
7. Agricultural Chemistry
8. Agricultural Botany
9. Entomology
10. Plant Pathology

The course in Principles of Agriculture includes field work in:

(*a*) Soils
(*b*) Soils Moisture
(*c*) Drainage
(*d*) Irrigation
(*e*) Conservation of Soil Moisture
(*f*) Soil Organic Matter
(*g*) Soil Organisms
(*h*) Soil Structure

The second year covers theoretical and classroom work in:

1. Principles of Agriculture
2. Crops
3. Agricultural Engineering
4. Horticulture
5. Animal Husbandry
6. Veterinary Science
7. Agricultural Chemistry
8. Agricultural Botany
9. Entomology
10. Plant Pathology

The course in Agricultural Engineering includes:

(*a*) Elementary Hydraulics
(*b*) Irrigation
(*c*) Sources of Irrigation Water
(*d*) Tanks, Wells and Anicuts
(*e*) Pumps
(*f*) The Hydraulic Ram
(*g*) Water Lifts

Students from these schools who show special aptitude may be sent to work with commercial companies for two or three weeks to get further training in operation, repair and maintenance of tractors, pumps and farm machinery.

Practical Farm Schools

There are 21 Practical Farm Schools established throughout the country, admission to which requires a School Certificate. These schools offer a one year course of study, covering Elementary Principles of Agriculture, General Crops, Horticulture and related subjects. The work is mostly practical field training which covers the actual growing of crops, from preparation of land through harvesting. The schools are still in the development stage and technical assistance from USOM has been initiated.

Technical Training Institute

A Technical Training Institute has been established at Amparai on the Gal Oya Project offering a two-year course of training in Mechanical, Irrigation, Electrical, Roads and Survey Engineering for students from South and South East Asian countries as well as from Ceylon. The teaching medium is English. Entrance requirements are Matriculation, Senior School Certificate with English, Mathematics and Physics. Screening of applicants by the home country is required before entrance. A Diploma indicating training and competence is offered. This school is not recognized as a part of the educational system of Ceylon. Among the subjects offered under Irrigation Engineering are:

1. Planning and Job Analysis
2. Internal Combustion Engines
3. Driver Training
4. Science
5. Field Work (Land Development, Earth Moving, Rock Excavation)
6. Irrigation Engineering and Science

Well equipped shops and laboratories have been provided and hostels are being expanded.

INDIA

A short statement on education and training is included in the Country Report Chapter III.

IRAN

By DR. Gh. TAMADDONI*

Introduction

Iran, also called Persia, is one of the oldest civilizations of the world. It lies in the area of the Middle East usually referred to as the "Cradle of Civilization". From a period dating to approximately the fifth millennium B.C. we can follow almost without interruption the progress made in material civilization by the inhabitants of the Iranian Plateau. This civilization was subject to the many varying influences within this area, such as topography, climate, contacts with neighboring countries, invasion, and migrations.

Ancient Iran was a great empire. It had wonderful irrigation systems, well-built cities, and magnificant palaces.

Present-day Iran seeks to become a modern independent country. Its people are proud of their past, but eager to build a great future.

Some Geographic, Physiographic and Climatic Features of Iran—Iran lies east of the Arabian Penninsula in South-west Asia. It comprises the western and larger part of the Iranian Plateau, extending from the Persian Gulf to the Caspian Sea, and from the Indus River to the Tigris Valley For most part Iran is desert but irrigation would make a part of it bloom and prosper. It is an area in size of 1,645,000 square kilometers (63,5000 square miles) with a population of about 20,000,000. There is a population density of 12.2 persons per square kilometer (approximately 32 per square mile).

Present Status of Water and Irrigation in Iran—The two major mountain ranges form, more or less, a V-shape pattern with the bottom of the V in north-western Iran and the sides extending along the northern and western sides of the country. This mountain barrier blocks off the rain clouds and makes a desert largely of the interior. There is considerable snow in the mountains and when it melts in the spring the rivers and streams are full, and the underground water supply is recharged.

The annual precipitation is more than 600 millimeters in some parts of Iran. In other sections the rainfall ranges between 600 and 300 millimeters. In these regions, except on rice plantations, it is possible to carry on very good dry-farming operations. Some irrigation farming is also practiced.

Irrigation farming must be carried on in the areas where water is available and the yearly precipitation is less than 300 millimeters (12 inches). The present sources of water for irrigation are rivers, streams, and the underground water supply. The underground water supply has been used for many generations through the use of the "Kanat"

*Associate Professor, Agricultural Engineering, Karadj Agricultural College, University of Tehran.

system. This practice dates back many centuries. Some water is also brought to the surface by hand and animal operated wells. Part of the underground water remains in the water-bearing formations and much of it is presently being utilized through the use of deep-well pumps. The main limitation in this operation is the lack of a cheap source of power.

Due to the lack of dams much of the water from many rivers and streams is lost into the Persian Gulf or enters into the marshes, bogs, and salt lands of Central Iran.

Some lands are saline in parts of Iran and the irrigation with saline water, from some sources, greatly aggravate this condition.

Much of the land is badly eroded due largely to the misuse of water, or the use of enormous quantities of water when it is available.

It is estimated that the present utilization efficiency of water resources in Iran is about 35 percent.

What needs to be done—Studies have been made throughout Iran by different agencies with respect to geography, topography, climate, geology, vegetation, and soil and water resources. It is estimated, according to these studies, that it would be possible to bring into cultivation about 20% of the presently uncultivated lands, (about 327,000 square kilometers or 126,000 square miles). This could be accomplished through the use of better management practices, changes in cultural methods of crop and livestock production and efficient utilization of present water supplies.

It has been further estimated that production on presently cultivated lands could be increased to provide more food stuffs than would be needed in Iran even with a marked increase in population. This could be brought about by a program of proper land management, better land use, the use of animal and green manure crops, commercial fertilizer, the more efficient use of the present water supply, and the control of plant diseases and pests.

Erosion problems should be studied intensively and programs developed to prevent the loss of soil.

Fertility studies should be made to determine the productive capacity of the soils.

Irrigation systems and methods of application should be improved to increase the efficiency in the use of water. Much of the land could be levelled. This would allow for ease in furrow irrigation and reduce erosion.

Lands should be drained in many areas to relieve and correct saline conditions.

In order to achieve these goals it will require the coordinated and cooperative programs of many groups of well-trained men. These groups of technicians should be experts in the fields of crops, soils, irrigation, engineering, disease and pest control, and livestock production.

To help develop this program the colleges could train engineers and require a well balanced program in the biological and physical sciences with a strong supporting program in agriculture. This should particularly include areas of soil-plant-water relationship, land use, and agricultural engineering, especially water engineering or agricultural hydraulics.

Many countries of the world now achieve a similar program by training their students in two colleges, (1) College of Agriculture and (2) a hydraulic branch of the Engineering College.

History of Irrigation Training in Iran

It can be seen from a study of ancient dams, Kanats, (underground systems), canals and the irrigation methods, which were used in Iran over 3,000 years ago the people of that day were well-trained in principles of irrigation. In many respects they approach the scientific methods and principles of today.

To show the interest and concern of our ancestors in the problems of irrigation agriculture a statement from the Iranian prophet Zoroaster would be most helpful.[1]

"Earth itself is surrounded by special sanctity and is almost personified in the ZENDAVESTA in which AHURA MAZDA recounts the five places in which the earth feels most happy.

1. .....
2. .....

3. The earth's greatest happiness is "where one of the faithful sows most corn, grass and fruit, where he waters ground that is dry, or drains ground that is too wet".

It is evident that the ancient peoples of Iran paid much attention to irrigation and drainage, and taught their sons to follow these methods efficiently.

We have failed now to do this for many generations. If we are to achieve a secure life in agriculture for our present and future generations we must follow the example of our ancestors. We must use all the new ideas about irrigation now

1. The Pocket World Bible edited by Robert O. Ballow Routledge and Kegan, Paul Ltd., London, P. 159—160.

found in the world, and continue to improve through application of these ideas, and carry on research to gain new and helpful information.

Present Status of Irrigation Training in Iran

A rather extensive training program is presently being developed in Iran to help improve irrigation and agricultural practices. This training program can be divided into three parts as follows:

(*a*) *Training qualified engineers.* These engineers will be graduated from the Colleges of Agriculture with major training in Irrigation.
(*b*) *Training technicians.* The technicians will be the graduates trained in the agricultural secondary schools.
(*c*) *Operators or laborers in Irrigation (Irrigators).* These men will be those trained in the agricultural primary schools in the villages.

(*a*) Training Irrigation Engineers in Agricultural Colleges

These college trained engineers will be those from the Agricultural College at Karadj and from the Provincial Colleges of Agriculture.

1. *College of Agriculture at Karadj*

The College located at Karadj is the College of Agriculture of the University of Tehran.

(*a*) *Historical Background*—The Karadj campus has been used for nearly 60 years as a place of training for students in Agriculture. It has, however, been a four-year College for only the last five years.

From 1900-1906 it was a primary school of agriculture with a three year program. From 1918-1922 it was used only as a primary agricultural school with a one year training course.

From 1922-1927 it was a secondary agricultural school with three years of training. (Two years of theoretical course work and one year of practical training). From 1927-1940 it was a three-year vocational or technical agricultural school for students who had completed six years of secondary school.

In 1940 it became a three-year College of Agriculture in the Ministry of Agriculture. In 1945 the College was transferred to the University of Tehran. Ten years later, in 1955, the present four-year training program was adopted by the College.

(*b*) *Present Status of the College and Admission Policy*—The physical plant and the faculty of the college is being enlarged. Several new buildings with many new laboratories and class-rooms are being constructed. The curriculum is being revised and improved.

It is the policy to accept the applications to take the admissions examinations from boys and girls who have completed their secondary (high school) training. An entrance examination is given in mathematics, physics, chemistry, zoology, botany, foreign languages (English, French, German) and Farsi.

There are about 18 times more applications for admission than the College can presently accommodate. Therefore, only about 5% or 6% can be allowed to enter College. For example, this year, 1,960 students took the entrance examination for admission but only 110 could be accepted.

(*c*) *Areas for Major Fields of Study and Factors Associated with the Student Selecting a Major Course of Study Leading Toward a Degree*—The College now offers a four-year program leading to a degree. The first two years of the program are primarily one of general Education. The next two years are designed to train the student on a professional field.

A degree can presently be obtained with a major in any of the following areas. (1) Agricultural Engineering, (2) Agronomy, (3) Forestry, (4) Horticulture, (5) Mechanics and Agricultural Machinery, (6) Pest Control. It is anticipated that a major will be offered in the near future in the fields of Agricultural Industry, and Animal Husbandry.

A student is allowed to select his major field primarily on the basis of his professional interest. His acceptance into that area is largely determined by the number of students applying for that major, and the grades he has obtained in his basic courses.

In order to major in Agricultural Engineering a student must have very good marks in Mathematics and Physics. In case there are more applicants than can be accommodated by staff and facilities the professors of Agricultural Engineering can select the major students through a qualifying examination.

(*d*) *The Program for Majors in Agricultural Engineering*—During the past few months a study has been made of the curriculum in Agricultural Engineering at Karadj and some changes have been made to strengthen the program of study. An eight semester program adopted as the course of study for majors in Agricultural Engineering beginning next year. Each semester is four months long beginning September 20. There are usually 10 days between semesters. Laboratory periods are three hours. Detailed curriculum may be obtained from Karadj College.

In addition to the class work the freshmen, sophomores and juniors are required to enroll in a six-week summer program of applied training. The applied training for freshmen and sophomores is mostly in an overall program of field work in general agriculture. Juniors are introduced to industrial firms or have special workshops for special training in their major field.

(*e*) *Training Personnel*—The training program, as a whole, is somewhat restricted due to the lack of qualified teachers and instructors. One big problem is to find enough scientifically trained persons who can accept the responsibility of teaching and carrying on a research program.

It will be quite sometime before we are able to train enough students to meet our needs; either by training them in Iran or sending them to foreign countries for post-graduate study. We have recently sent three of our students to the United States and one to France. It is planned to continue this program in the future.

(*f*) *Laboratory Facilities*—For the past ten years the College has been working on the construction of new buildings and trying to properly equip them. The College has benefited greatly by the help received from the United States ICA and our own seven-year Plan Organization. Construction has just been completed on the new building for hydraulics and irrigation. Equipment has been purchased from the United States, France, Holland and Germany. We hope to be able to have all of this equipment installed and in use within the next two years.

(*g*) *Experimental Farm for Applied Training*—In addition to the laboratories on the campus the College owns a large tract of land which is being developed as an area for training the students in Applied Agriculture. The farm consists of more than 200 hectares (about 500 acres) situated about four kilometers from the campus. We are now in the second year of the program for preparing and developing this area. All of the land can be cultivated. About 100 acres were levelled this fall, planted to wheat and barley, and set up for furrow irrigation. We are now in the process of levelling another 100-acre section.

The program is being developed to give the students practical training in irrigation methods, how to develop crop rotation, the use of fertilizers and green manures, land levelling, land classification, and improved cultural methods of crop and livestock production. We are growing crops of alfalfa, clover, wheat, barley, beets, vegetables and fruits. This coming year there will be 100 acres of alfalfa for hay, and 30 acres of clover for green manure. This alone is a new and a fine program for Iran.

Two deep wells have been drilled and we plan to drill two more in the near future.

The farm will be an excellent place for the practical training of students. Also, by carrying on research work and demonstration activities, such as land levelling, proper methods of irrigation, and the use of fertilizers and green manures our farmers will be able to see the results of these activities and learn to improve their own farms.

(*h*) *Scholarships, fellowships, and other funds for student support*—Our College is located 40 kilometers from Tehran. Facilities for board and room in the city of Karadj are very limited. It is necessary, therefore, that these facilities be developed and provided on the campus for the students. Prior to six years ago, the College paid all of the expenses of the students who came to school. This policy has now been changed. We are encouraging the students to work and learn to be self-supporting.

A cooperative restaurant has been established. Most of the work in operating this facility is done by the students. The College has built a new dining hall and a well-equipped kitchen. The College pays the wages for the cooks, pays the fuel costs, and wages for some of the labor. Through their own activities and the help given by the College the students are able to save 40% of their food costs.

Some of the students admitted to the College receive scholarships from the school depending upon the marks they obtained in the entrance examinations. The 10 students receiving the highest grades receive a monthly allowance of 1000 rials (76.5 rials equal one U.S. dollar). The next 25 students with respect to having the highest grades, receive a monthly allowance of 800 rials. The other newly entering students do not receive any financial help.

There are scholarships available for students coming to College from the different Ostans (States) in Iran. The students with the highest grade from each Ostan receives a monthly allowance of 2,500 rials from the Royal Court.

Some assistance is available to students who are not as well off financially as others and have difficulty in coming to school because of the lack of funds. A loan fund has been set up through collections from the Professors and Assistant Professors. The poorer students are able to get a loan of 300 rials per month while attending school. This is to be repaid after they complete their course of study and begin working.

A scholarship is given by the Government of Iran to the student completing his course of study in the College with the highest grades. This

scholarship is sufficient to send him to a foreign country for study to obtain a post-graduate degree.

Other scholarships are available to students and members of the College staff through international organizations such as UNESCO, FAO and some foreign countries. These scholarships enable us to send students and laboratory assistants to other countries for post-graduate training.

Post-Graduate Studies--At the present time the College does not offer a program for graduate study. Therefore, until such time that a program is developed, it is necessary to send students abroad for additional training and post-graduate work.

It is anticipated that in the future the department of irrigation and hydraulics will be combined with the program in farm machinery, mechanics, and surveying into a College of Agricultural Engineering. The curriculum will be modified and improved. It may then be necessary to change from a four to a five year program.

2. *Agricultural Colleges in the Provinces of Iran*

During recent years great strides have been made in establishing agricultural colleges in some of the major cities in Iran.

There are now agricultural colleges at Ahwaz, Shiraz, and Tabriz. These are new colleges and facilities are not yet such that training can be offered in specific major fields. Courses in irrigation and drainage, however, are an important part of the curriculum.

3. *Short Courses in Training in Colleges and Ministries*

The College has, in the past, arranged and offered short courses in training in hydraulics and irrigation. These courses were conducted for graduate students during 1942-1944, and again in 1956-1958. It is planned to have additional courses in the future. The completion of our new building, the laboratories, and the addition of new staff members should help very much in improving the quality of these courses.

The College has assisted other agencies in conducting short courses. In this group has been the Independent Department of Irrigation, Department of Agricultural Engineering and Plan Organization. The Independent Department of Irrigation has trained 15 persons in Aerial Photography. They have been instrumental in completing a Generalized Soils Map of Iran. The reports on this project will be published very soon.

4. *Iranian Students in Foreign Countries*

At the present time there are about 14,000 students attending the University of Tehran and other Colleges and Universities of Iran. There are about 10,000 Iranian College students abroad studying in America and Europe. Many of these students are majoring in Agriculture and Irrigation. When they return they will be able to greatly assist in the improvement and development of our agricultural program.

5. *Research Program*

The new laboratories and college farm at Karadj now provide very good facilities for developing a research program; especially in the areas of hydraulics, drainage, irrigation; and soil physics. Not only is the professional staff encouraged to carry on research work but the best students are invited to assist. They will become acquainted with the methods and procedures of research programs and will be able to make many investigations. Other agencies are invited by the College to use these facilities as much as possible.

(*b*) Agricultural High Schools

It has been only within the last decade that agricultural high schools have been established by the Ministry of Education. These have been located in most of the major cities in Iran. These schools are able to accept from 20 to 100 students. The number admitted to each is determined by the size of the building, the staff facilities, and entrance examinations.

The course of study is for two years. The students are taught how to apply irrigation water, how to measure the amount of water applied, when to water crops, and about soil-plant-water relationships.

(*c*) Agricultural Primary Schools

During the last 20 years the Ministry of Education has established agricultural schools in most of the villages. This has been done in order to assist the peasants in making water measurements, and water distribution and application. The graduates from these schools have proved very helpful to the villagers.

Present and Future Needs of the Country for Irrigation Engineers and some Recommendations to Help with the Problem

The number of engineers, technicians, and irrigators presently being trained does not begin to meet the present or future needs of the country. The following recommendations may be helpful in planning to solve the problem:

Irrigation Engineers—In the last few years the College has been able to increase its enrolment from 60 to over 400 students. We now have from this group about 20-25 students who are graduated with a major in Agricultural Engineering with training particularly in irrigation.

If we add to this figure the number of students being graduated from foreign universities we are still far short of the number needed for the program in Iran. Provisions should, therefore, be made to (1) increase the facilities, dormitories, laboratories, and technical staff, at the College so that we could train at least 50 qualified students each year as irrigation engineers; (2) to support and help the Agricultural Colleges in the provinces to develop laboratories, staff, and adequate facilities to train qualified engineers.

Technicians—The Ministries of Education, Agriculture, and Plan Organization could work cooperatively together to develop a program for training technicians. This might be done through financial and professional support to the agricultural high schools and colleges.

By technicians are meant those men who are able to help develop and maintain the irrigation and drainage projects. The minimum number of such technicians should not be less than 250 each year. They should be taught the fundamentals of topography and surveying, soil analysis, erosion control, irrigation structures, methods of water conveyance, irrigation methods, and how to repair and maintain irrigation pumps and equipment.

Training Irrigators—There are many weaknesses in the present methods which are being used in Iran in agricultural production and irrigation. Farmers are familiar with the methods used by their ancestors and it is not easy for them to make changes and accept new ideas. It is, therefore, necessary to teach the young men the new ways of land preparation, new ways of irrigation, distribution of water, soil properties and new cultural practices. This means that irrigators must be trained in the agricultural schools from among the young men in the villages.

Importance of Training Engineers and Technicians—The training of skilled and professional men in agriculture and irrigation is as important to the welfare of our country as any program now in progress.

It is well to make studies know what needs to be done, but it is urgent that trained men who know how to get the job done must be provided.

It is very necessary to extend help and information to all sections of our area on irrigation methods, the use of deep wells, cooperatives, farm machinery, fertilizers, new seeds, and many more new and helpful agricultural practices. When this is done it will help to improve the irrigation practices in Iran, but most important it will help to raise the general standards of living in our country.

The author wishes to express his appreciation to Dr. Raymond B. Farnsworth, Advisor in Soil Science, with the Utah State University-ICA Contract at the College of Agriculture, Tehran University, for his many helpful suggestions in the preparation of this manuscript.

JORDAN

Statement by S. TOUFAHA

We have not prepared a written report, but we would just like to say a few words about the opportunities which we have for education in irrigation in Jordan. Although Jordan is a small country with limited resources, we have done a great deal to raise the standard of education and training in irrigation practices.

In Jordan there are only high schools—not up to the university standard, but we have agricultural schools, three in number which train students for agriculture and many aspects of elementary engineering. We have also research institute or "Institute of Scientific Research" as it is called, but this is only a two-year course. This institute has many highly qualified Jordanians working in it; and its purpose is to work on scientific research and special problems of the country. What those research specialists achieve is given to extension agents of the Ministry of Agriculture and those extension agents pass the information to the farmer. Those farmers apply, as much as they can, of the principles and technical information which the extension agents pass to them. Agriculture in Jordan has taken a new effort. We have started the soil analysis of the land which belongs to farmers and also to the government.

All our students who finish the primary education or the secondary education can only finish their education abroad. They go around the world into the neighboring Arab countries like

Lebanon and Egypt and Syria, to America and England and other countries. There are also training programs by the government and the U.S. Operations Missions in Jordan. We send students for training in America or somewhere else for a few months or a year or two years at most to get agricultural training. When they come back, they have to work in the country in the certain specialities they have achieved.

Jordan's resources are very small compared with other countries. We have shortage of water. The only water we have is from the Jordan River and its tributaries and underground water and rain water, which is uncertain, and in many years we have drought season.

The students also take graduate studies abroad and come back with high degrees to work with the government.

I think this is all we can say about training in Jordan, but we are going ahead quite fast.

Statement by F. NATOUR

As far as our technical schools are concerned, there is a plan to change one into an agricultural junior college according to an agreement with American University of Beirut. I think Mr. Macksoud knows more about that than I.

About training, we have certain training in the East Ghor Canal Authority. We are trying to select some few agricultural graduates with a B.S. degree in agriculture and give them an intensive training course in the problems of irrigation for the East Ghor. The Authority has irrigation training advisors and we hope that they will set up enough training.

I might ask Mr. Macksoud to tell us about the arrangements with A.U.B.

LEBANON

By SALIM W. MACKSOUD*

Summary

Lebanon embarked on an educational rennaissance in the latter part of the nineteenth century. Schools and universities were established and a general interest in education and science was spurred. Though mainly an agricultural country, agricultural education took a later start than the other sciences. Those interested in studying agriculture at the professional level had to go to Europe or the U.S. Local vocational schools were started around 1930, and since that date instruction at the three levels—elementary, secondary and college—has been in progress. Presently there are several government elementary schools giving an agricultural program, and one giving a secondary education in agriculture. There are very few private schools giving secondary or vocational programs in agriculture.

Instruction and training in irrigation are incorporated into the general agricultural education programs. These programs are relatively recent and are continuously undergoing considerable change and development. The programs of instruction in the governmental elementary and secondary agricultural schools include some course work on irrigation, but no practical training in water handling.

The American University of Beirut has initiated and supported an educational program which includes technical and vocational training, regular under-graduate and graduate college level course work and research in water management and irrigation science, as well as in agriculture and related fields.

The Government Elementary Schools of Agriculture

These are primarily for the village boys of the area in which the school is located. The program has a very limited amount of course work in irrigation, but facilities for practical training in water handling are not available.

These schools should include more work on water management. Graduates of such schools generally go back to their farms and any training they are given falls on fruitful grounds. More land and facilities are needed by such schools before they can embark on a program stressing irrigation practices from a practical point of view.

The Government Secondary School of Agriculture

This is located in Beirut, with very little land for practical training. Its program includes some

*Associate Professor of Irrigation, Interim Dean, Faculty of Agricultural Sciences, American University of Beirut, Lebanon.

course work in irrigation but no practical work whatsoever. Graduates of this school, generally, seek junior government jobs, and a much smaller number than one would hope, go into agricultural production or farm life. An adequate program at the present location of the school is impossible and it is hoped that when the school is transferred to a more suitable locality its program will be revamped so that it includes some practical training in water management.

Private Agricultural Schools

American University of Beirut—the only institution that is seriously concerned with problems of irrigation at the farmer's level is the American University of Beirut.

In 1952 the Faculty of Agricultural Sciences was initiated through a grant from the Ford Foundation. Its operating expenses have been met mainly from "actual cost" scholarships supported by the International Cooperation Administration. Students from all over the Near East and South Asia are enrolled in its various programs. The institution has a regional character and is engaged in programs and projects that are of interest to all the area served. There are three main types of educational programs presently in progress:

(1) The Undergraduate Program in the School of Agriculture.
(2) The Graduate Program in the School of Agriculture.
(3) The Technical and Vocational Program in the Technical Training Section.

1. *The Undergraduate Program*—The Undergraduate Program in the School of Agriculture leads to the Degree of Bachelor of Science in Agriculture and the Diploma of Ingenieur Agricole. Included in this program, are the following courses dealing with Irrigation:

Surveying. 1.5; 2 credits. (10 week summer session)

A study of the use and care of tapes, levels and transits, with special emphasis on their application to agricultural problems. Required course.

Principles of Irrigation. 2.3* 3 credits.

A study of the basic principles of the quality, movement, storage, availability of water in soils, the relation of soil moisture to growth leading to proper management or irrigation water and irrigated soils. Required course.

Pumps and Pumping. 1.3; 2 credits.

A detailed study of the principles, construction and operation of centrifugal pumps and deep well turbines. Elective course.

*2.3 means 2 hours of lecture and 3 hours of laboratory work per week for 16 weeks.

Water Management. 3.5; 3 credits. (10 week summer session)

Irrigation water-sources, development, measurement and methods of distribution, irrigation methods and land preparation. Required course.

Irrigation Systems. 1.3; 2 credits.

Basic hydraulics of flow leading to the principles underlying the design of farm irrigation systems together with an economic evaluation of such systems. Elective course.

Field Irrigation Practices. 1.3; 2 credits.

A course in applied irrigation—covering land preparation, water application methods and techniques and the procedures for their evaluation for commonly irrigated crops of Syria, Lebanon and Jordan. Elective course.

Drainage in Relation to Irrigation. 2.0; 2 credits.

Basic principles of drainage: location of drains and drainage networks with relation to irrigated lands. Elective course.

Basic Irrigation Hydraulics. 2.3; 3 credits.

Principles of fluid mechanics as applied to irrigation. Elective course.

Applied Irrigation Hydraulics. 2.3; 3 credits.

The Application of the basic hydraulics principles to the design of water conveying, measuring and controlling structures. Elective course.

Applied Hydrology. 2.0; 2 credits.

The basic principles of hydrology and methods for the practical application of hydrologic data to such problems as, mass diagram and duration curves, estimating stream flow and irrigation water supplies. Elective course.

2. *The Graduate Program*—The Graduate Program leads to the Degree of Master of Science in Agriculture with a split major which may include Irrigation.

In such a program the student will take some advanced work in (*a*) Soil-Water-Plant Relations, (*b*) Design of small irrigation systems with specification and cost studies, (*c*) Studies of drainage problems, including construction and maintenance of open and tile drains and (*d*) Water quality studies with special reference to irrigation use.

3. *The Technical Training Section*—This section, organized for persons not interested in a college degree, offers two types of programs: A—Short Technical Courses and B—One-Year Vocational Courses.

(*a*) *Short Courses*—These are 2-weeks, one-month or 2-month courses giving training in a specialized narrow field of interest. Generally students who take this course already possess a college degree and are only interested in acquiring more specific techniques in a narrow field of activity. However the course is not limited to such degree holders, and any mature person may pursue such courses. The courses are usually

patterned to fit the demands of the applicant taking into consideration his previous training and interest.

(*b*) *Vocational Training Program*—This is a one-year course organized to cover the needs for various types of special training and instruction. It is of particular interest to operators of farming enterprises and to government employees engaged in extension or extension type activities. Applicants are usually literate, mature persons engaged in agriculture and preferably having a position to which they intend to return after completing their training. Included in this program are three courses that deal with irrigation: Agricultural Engineering, Irrigation, and Soil Salinity and Irrigation.

The Agricultural Engineering course deals in a general manner with water management and land preparation, while the Irrigation course which is generally selected by those interested in this subject, includes more detailed study of soil-plant-water relations. The third course, Soil Salinity and Irrigation, is a summer practical course, given in conjunction with the Soils Department, dealing with field irrigation techniques.

Persons taking one-year course in Irrigation receive very good training in irrigation practices including some land preparation and surveying work.

For each of the above programs, the University in general, and the Division of Agricultural Engineering in particular has well equipped laboratories with ample and generous supplies, extensive field trial and demonstration plots and an abundant water supply for student use. Limited research in irrigation is concurrently carried out by the staff and students may share in such experiences. Continuous addition of equipment and supplies both by purchases, and from donations manufacturers keeps the laboratories well stocked with all types of devises necessary for a sound training program.

Throughout their training students become familiar with all the different pieces of equipment found on the market and are taught how to use their judgement in choosing the most suitable. Above all they are given a broad basic understanding of the sciences underlying proper irrigation practices.

APPENDIX

A.

AMERICAN UNIVERSITY OF BEIRUT CURRICULUM SCHOOL OF AGRICULTURE

Detailed curriculum may be obtained from the University.

B.

AMERICAN UNIVERSITY OF BEIRUT. SPECIAL TRAINING COURSE IN IRRIGATION PRACTICES

Land preparation for irrigation and the proper handling of irrigation waters are receiving increased attention from farmers and farm operators throughout the Middle East. Many are beginning to realize that through proper irrigation practices they are able to use their limited sources of water to irrigate larger areas, their yields are higher, the quality of their produce is better and more uniform and they are able to reduce their drainage and salt accumulation hazards. With this realization has come a definite demand for information and advice on land and water problems and for men who have some qualifications to go out to the fields and offer practical advice and who, if the problems is beyond the scope of their personal ability, know where to go for further help. The Irrigation Practices course is given to help answer this demand. It is a 4-week course offered by the Division of Agricultural Engineering of the Faculty of Agricultural Sciences during the month of June of each year.

Applicants should have had some field experience in irrigated agriculture and at least a secondary school education. Knowledge of English is desirable but not necessary for Arabic speaking persons as the course can be conducted both in English and Arabic.

The course consists of 40 Lectures—2 hours daily, 5 days a week for 4 weeks—and of 8 Field Sessions.

The lectures are presented and discussed at a level commensurate with the background and training of the applicants. Persons with different backgrounds and educational levels are handled separately. The lectures cover the following subjects:

(1) Land Grading—
Benefits, Methods, Economical Aspects.
(2) Measuring Irrigation Waters—
Methods and Techniques.
(3) Farm Conveyance and Regulatory Structures—
Ditches, Canals, Pipes, Gates, and Risers.
(4) Irrigation Methods—
Conditions under which each is used.
Flows recommended for each method.
Field techniques
(5) Irrigation Intervals or Timing of Irrigation—
How to determine when one should irrigate.

The field sessions cover:

(1) Staking and surveying a field for determining the proper irrigation method and/or the need for land grading.
(2) Measuring irrigation water in canals, pipes and reservoirs.
(3) Field Testing of surface irrigation methods.
(4) Setting up and calibrating a Sprinkler System.

C.

AMERICAN UNIVERSITY OF BEIRUT ONE-YEAR TECHNICAL VOCATIONAL TRAINING COURSE

The Technical Vocational Training Course was organized to answer the need for various types of special training and instruction not leading to degree in agriculture. It is of particular benefit to operators of farming enterprises and to government employees engaged in extension or extension-type activities. The training program is for two semesters and one summer session.

The requirements for entrance are:

1. The applicant must be in some way engaged in the field of agriculture.
2. The applicant should have assurance that he can return to his position or another position in agriculture.
3. The applicant must be able to read, write and speak English.

Classes for the First Semester, starting in early October, are at the University Farm in the Bekaa Valley. There are classrooms, laboratories, a dormitory and dining room as well as good recreational facilities and entertainment features on the farm, which is 80 kilometers from Beirut. Several breeds of cattle, sheep and poultry are maintained with good equipment and housing which provide excellent opportunities to obtain practical experience in animal production. A large portion of this 250-acre farm is devoted to research and demonstration on the production of fruits, vegetables, cereals, forage and various other field crops. A small scale village improvement program is in operation amongst the villages in the vicinity of the University Farm.

The Second Semester (Spring) starts in the latter part of February and all classes for the students who attend will be on the Beirut Campus in the Agriculture Building. The semester will close in mid June. The 10-week Summer Session begins in later June and ends the last week in August, and is usually organized on the University Farm.

CURRICULUM

First Semester—(Fall) University Farm

Animal Science	.. 2	Lectures	& 3	Laboratory	hrs.	per	week
Agronomy	.. 2	,,	& 3	,,	,,	,,	,,
Agricultural Engineering	.. 2	,,	& 3	,,	,,	,,	,,
Horticulture	.. 1	,,	& 3	,,	,,	,,	,,
Extension Methods & Workshop	.. 2	,,	& 3	,,	,,	,,	,,

Second Semester (Spring) Beirut Campus

Animal Hygiene	.. 2	Lectures	per	week			
Agricultural Economics	.. 2	,,	per	week			
Plant Protection	.. 2	,,	& 3	Laboratory	hrs.	per	week
Soils	.. 2	,,	& 3	,,	,,	,,	,,
Visual Aids in Extension	.. —	—	3	,,	,,	,,	,,
Option I							
Food Preservation	.. 2	Lectures	per	week			
Rural Sanitation	.. 2	,,	,,	,,			
Rural Sociology	.. 2	,,	,,	,,			
Option II							
Subtropical Horticulture	.. 2	Lectures	& 3	Laboratory	hrs.	per	week
Seed Technology	.. 1	,,	& 2	,,	,,	,,	,,
Irrigation	.. 1	,,	& 3	,,	,,	,,	,,

During the Summer Session each student is given the opportunity to choose a particular field of concentration. The fields of concentration that are offered are:

Animal Husbandry
Agronomy and Weed Control
Agricultural Economics
Horticulture (Fruits and Vegetables)
Soil Salinity and Irrigation
Plant Protection
Farm Machinery and Power

The work in these fields for the summer session will be essentially applied rather than theoretical and much of the time will be spent on field trips and laboratory exercises.

EXPENSES AND REGISTRATION

Please apply to the Director of Bursary Students Office for all particulars of expenses and tuition fees and to the Registrar for application forms for registration.

Additional information concerning the course work and facilities may be secured from the:

Dean's Office
Faculty of Agricultural Sciences
American University of Beirut
Beirut, Lebanon.

D.

AMERICAN UNIVERSITY OF BEIRUT TECHNICAL TRAINING COURSE

This course includes an Introduction to Elementary Surveying; Soil, Water, Plant Relations; Water Management; and Farm Machinery. The laboratory work will include work in Surveying, Water Handling and Farm Machinery. Tractor driving will also be taught within the limitations of the farm set up.

Lecture Sessions

I. Source of Irrigation Waters
   (1) Hydrologic Cycle
   (2) Surface and Underground Storage of Water
   (3) Water Quality
   (4) Water Measurement
   (5) Development of Irrigation Wells.

II. Soil Moisture and Plant Growth
   (1) Basic Concepts of Soil Moisture
   (2) Extraction of Soil Moisture by Plants
   (3) Moisture Availability
   (4) Water Use and Irrigation Requirements.

III. Irrigation Methods and Farm Irrigation Layouts
   (1) Principles and Factors Determining Choice of method
   (2) Water Application Efficiencies
   (3) Methods and Layouts.

IV. Farm Machinery
   (1) Principles
   (2) Soil Preparation Machinery
   (3) Seeding Machinery
   (4) Cultivating Machinery
   (5) Harvesting Machinery
   (6) Miscellaneous Farm Machinery.

Laboratory Sessions

(1) Levels and Levelling Rods
(2) Areas and Contours—(Tape and Stadia)
(3) Irrigation Layouts
(4) Water Measuring
(5) Plows
(6) Drills and Planters
(7) Combines and Mowers
(8) Pumps and Turbines
(9) Tractor Maintenance

PAKISTAN

WEST PAKISTAN

The colonizers of the canal colonies, who came mostly from the eastern districts now in India, had developed and practised irrigation from shallow wells worked by some indigenous devices or by Persian wheel. Although they had no previous experience of large stream irrigation from canals, they had the background for handling and efficient use of irrigation water. For colonization of new canal project areas basin irrigation was considered most efficient and effort was made to have it adopted by the farmers. With the completion of colonization, emphasis on basin irrigation was not maintained and now we find irrigation practised as it suits the farmers. The progressive farmers generally practice basin irrigation, border irrigation and furrow irrigation, the backward farmer takes to flood irrigation. In general it can be said that sufficient attention to education and training in irrigation has not been given in this country. The Agricultural Colleges at Lyallpur, Peshawar and Tandojam in West Pakistan provide basic knowledge in agricultural sciences up to graduate level. Irrigation as a science and as an art is a very important part of scienctific agriculture. Some knowledge about water requirements of crops is imparted at these institutions but not much about irrigation practice. It is felt that irrigation science and irrigation practice should be given much more importance in the academic and practical curriculum of studies at the agricultural colleges.

The Irrigation Department in this country has considered itself relieved of its responsibilities at the point of delivery of water from the irrigation channel and has not concerned itself with the use of water by the farmer. One branch of the staff of the Irrigation Department goes actually into the field for keeping record of the area which receives canal water for purposes of assessment of government revenue on crop rate basis. But this staff does not interest itself much with irrigation practice except to the extent that for accurate measurement of area demarcation of field boundary is considered necessary.

The Irrigation engineer is a civil engineer whose background of engineering education does not include any water use aspect of irrigation. Only the engineering side of irrigation water diversion and delivery forms part of his education and training.

It is with the cropping up of soil problems in irrigated areas that attention has been given to irrigation practices and soil science by a branch of the Irrigation Department—the Directorate of Land Reclamation. The field workers in this Directorate get some experience and training in water use and irrigation practices. The experimental and demonstration farms maintained by the Directorate of Land Reclamation provide opportunity for demonstration of irrigation practices emerged out of research to be necessary for soil and water management. At these farms work has recently been taken up on irrigation practices which had not been used in this country; like syphon irrigation, sub-irrigation and furrow irrigation for cotton. Due to saline characteristics of the soil material the Land Reclamation Department are not thinking in terms of sprinkler irrigation or any other costly methods which are conducive to thin spreading of water.

For reclamation of land affected by salinity, very efficient grading and division of an acre field into four basins for irrigation has been considered essential for uniform application of water for leaching. Basin irrigation layout has, therefore, been imposed as a necessary condition for the provision of extra water supply for reclamation.

While temporary reclamation is carried out in scattered fields and managed by the Irrigation Department the projects of the Soil Reclamation Board for permanent reclamation and developments are for large contiguous areas. There is statutory provision in the Soil Reclamation Act, under which the Soil Reclamation Board will have irrigation practices recommended by research and adopted by the cultivator.

It is felt that the educational institutions as well as the Government Departments of Irrigation and Agriculture should interest themselves in education and training in irrigation. The curricula of the agricultural colleges and for civil engineering in the engineering colleges should provide educational background in irrigation practice. At the Agricultural College for the First Examination the merits of different irrigation practices and practical training must be included in Item VI in the syllabus pertaining to irrigation and drainage. A more detailed study of consumptive use of water by crops, efficiency of irrigation and irrigation practices for different crops should be included in Part II Item I under a new sub-head 'Irrigation'.

In the College of Engineering in the syllabus for the final examination Item 9 (Irrigation) should include water application appliances, land grading for irrigation and irrigation practices.

The Department of Irrigation should cater for field demonstration of efficient irrigation practices. With the help of an extension service the

Directorate of Land Reclamation as well as the Soil Reclamation Board can do effective work in this direction. The Government farms run by the Directorate of Land Reclamation and those run by the Department of Agriculture can provide additional facilities in this connection.

EAST PAKISTAN

Statement by M. S. MINHAS*

Reference was made to the extension and demonstration aspects of farmer irrigation. This is included under "Experimental and Demonstration Farms in East Pakistan" in Chapter VIII.

University education may be divided in two parts—engineering and agriculture. There are two colleges in East Pakistan, both at Dacca. These are Ahsan Engineering College and the Agricultural College. About 100 engineering students graduate each year. These are mainly civil engineers; and irrigation engineering, as understood today, has been taught to them, including hydraulics, water requirements of crops, application of water, construction of hydraulic structures and distribution of water. Because of the desirability for training and education in agriculture when the irrigation projects were started in the Ganges-Kobidak Project, an agricultural wing was set up which was effectively co-ordinated with the irrigation engineers.

*This statement is abstracted from the verbatum presentation of Mr. Minhas.

SUDAN

Introductory

Before explaining the opportunities for training, we would like to give you a brief description of the organization of the irrigation schemes in the Sudan.

The major irrigation schemes are operated on a basis of partnership between the Government and the farmers (tenants). The main crops are cotton, food crops and fodder. The government provides the land, constructs the canals, provides the water and the social services. The Government also forms administrative boards to control the agricultural side of the schemes through a staff of resident inspectors; whose main job is to supervise the work of the tenant in watering, growing the crops, picking, clearing and preparing the land. The Government also undertakes the marketing of the cotton crop. Food crops and fodder are kept by the farmer. The tenant is responsible for the whole of the agricultural work in his holding including the upkeep of the water courses and the laterals. Supplies made to him in kind such as seeds, and work done on his behalf such as ploughing, etc. are charged to his account. Advances of cash are made to him at suitable periods by the Government to meet his expenditure in sowing, weeding, picking, etc.

The private pump schemes run by individuals or companies under licences are also operated on the same basis.

Irrigation water is indented by the inspectors from the Ministry of Irrigation who controls the water up to the minor canals. The tenant conducts the watering of his plot under very strict supervision by the inspector.

Training of Tenants

Tenants in irrigation schemes are trained by field inspectors and scheme managers who are often trained agriculturists. Tenants are trained in the field on ploughing, levelling, ridging, digging water courses, methods of sowing, spacing of plants, thinning, weeding, harvesting and, most important of all, watering. Legislation is provided for punishment of tenants who fail to follow proper agricultural practices. Punishment may start by fine and may extend to eviction from the tenancy.

The Gezira Scheme with an area of 1,800,000 acres is operated by the Government through the agency of the Gezira Board. The scheme is divided into blocks of an average area of 20,000 acres each. Each block is under a block inspector assisted by one or more field inspectors. Tenants receive their instructions from the field inspectors who are assisted by some appointed tenants called "Samad". Each samad is responsible for a number of tenants and reports all their faults to the inspectors. Defaulting tenants are brought before the block council for punishment. The members of

the block council are appointed from among the tenants of a block.

The Government provides the tenants with facilities for adult education, health services, agricultural shows, cinema shows of agricultural interest by mobile cinema units and radio broadcasts on subjects of interest to the tenants. Tenants are also taken for visiting countries to learn new methods of cultivation. Such visits were made by some of the Gezira tenants to Egypt and United Kingdom.

Tenants Training Centers

There are two training centers in the Gezira scheme in which sons of tenants are trained for two years after completing the elementary education. Training includes all the agricultural operation in the field. These boys, after the completion of their training, assist their fathers on their tenancies or they may be allotted separate tenancies when vacancies occur.

Training of Agricultural Staff

In relation to the expansion in irrigated agriculture there is a severe shortage in trained agricultural staff in the country. Graduates in Agriculture from the University of Khartoum are few in number and provide advisory and extension services to the tenants in a very limited scale as they are often engaged in other administrative jobs. Field inspectors and scheme managers received little regular agricultural training in the past. Recently an Institute of Agriculture has been established in which boys are taken after completion of their seconday education and are trained for two years in all agricultural practices. On completion of their training, they are appointed as field inspectors or scheme managers.

Outstanding graduates of both categories of the agricultural staff mentioned above, after gaining experience of field work in the Sudan, are sent abroad for higher education and training.

Training of Irrigation Staff

Boys, after the completion of their intermediate school education, are appointed by the Ministry of Irrigation as technical subordinate trainees and are given training in the drawing office and the field in the following :

1. Levelling and simple survey work in the field to enable them to make preliminary canal investigations.
2. Drawing office training to become tracers, draftsmen or gauge recorders.

Technical examinations are usually held twice a year and those who pass are promoted to engineering assistant posts or given a job in the drawing office. Engineering assistants are sent to the field to work with the civil engineers in maintenance work and in water control. When they gain more experience they are posted in a sub-station to look after work in a more independent manner under the supervision of the Irrigation Engineers.

This class of technicians proved to be useful in carrying out the minor work in the field efficiently.

Civil engineers graduated from the University of Khartoum or from Khartoum Technical Institute are sent abroad for further education and training. Graduates from the University are usually sent to work with consulting firms in irrigation work for a period of two to three years. Graduates of Khartoum Technical Institute are usually sent for a short practical course of one year.

Civil Engineering syllabus in the University or in the Khartoum Technical Institute does not normally include much in the field of irrigation engineering. It is hoped that such a branch will be included in the future.

TURKEY

Present Educational Opportunities

University-College Level—There are three Agricultural colleges at the university-college level, University of Ankara (28 years old), Ataturk University at Erzurum (2 years), Ege University at Izmir (4 years). The courses dealing with irrigation and drainage are given in the school of Farm Machinery and Irrigation at each agricultural college.

In the Soils Department some lectures are also given in Irrigation.

There are also the Technical University at Istanbul and Robert's College, Istanbul. Although there is no irrigation course as such, the basic training in mathematics, hydraulics and the sciences (for Engineers) gives a good background for "In-Service" training conducted by the Soil Conservation and Farm Irrigation Division, within the Ministry of Agriculture.

Agricultural High Schools—There are three Agricultural High Schools at Adana, Busrsa, and at Istanbul. Among the several agricultural subjects, there are some lectures on Irrigation and Drainage. However, these do not provide enough knowledge for the purposes of the requirements.

Agricultural Grade Schools for Village Children.—These are government schools covering grades 6 to 8. The basic purpose is to train boys and girls to become leaders in the village in improved farm practices and home-making. The students learn something about how to irrigate, how to operate, equipment, farm crops, tillage practices, planting and pruning trees, beekeeping, livestock feeding, etc.

Short Courses and Workshops—The Soil Conservation and Farm Irrigation Division has conducted several short courses at Tarsus, Menemen, Cumra and Ankara, in connection with the Research Institutes and Stations. There are three levels (1) Agricultural Engineers, (2) County Agents and Village Agricultural Teachers, and (3) Ditch Riders and Skilled Workers.

Projected Plans for More Intensive Education in Irrigation and Drainage

Universities and Colleges—At each of the Universities listed above there is a strong interest in establishing more complete education in Irrigation, Drainage and Soil Conservation. The Soil Conservation and Farm Irrigation Division has been working closely with these institutions on requirements for accomplishing the degree of training needed so that the graduates can readily qualify for the work to be done in these fields in Turkey. Projected plans are well enough along so that the improved departments are expected to be functioning by 1961.

Agricultural High Schools—In 1960, for the first time, there will be courses especially designated as Farm Irrigation, Drainage and Soil Conservation in all three of the Agricultural High Schools. The Soil Conservation and Farm Irrigation Division has been requested and is giving direct assistance in subject matter to be included, how extensive the lectures should be, and suggestions on practical training desired.

Agricultural Grade Schools—It is well recognized that there is an increasing demand for trained irrigationists. The farmers are willing to pay them well for helping them to irrigate their fields more efficiently. So, there will be more complete and practical training given to the boys attending the agricultural grade schools. The personnel of the Soil Convservation and Farm Irrigation Division are often called upon to help in the training desired.

Short Courses and Work Shops—The new National Training Center for Soil Conservation and Farm Irrigation is now under construction at Tarsus. It is expected to be ready for starting the new training program by May 1, 1960. The Center has sufficient space for 60 trainees so that three separate courses can be underway at the same time. It is equipped with the latest visual aids.

In addition to the classroom lectures and discussions, practical training will be stressed utilizing adjacent fields which have many of the different problems encountered in irrigation practice in Turkey.

Basic and advanced training will be conducted in three categories :

1. Agricultural engineers.
2. County agents, village agricultural teachers.
3. Skilled workers, equipment operators.

All universities and schools mentioned in this report conduct their classes entirely in the Turkish language. However the newly-established "Middle East Technical University" carries out its curricula in the English language. This University was founded by the Government of Turkey in co-operation with F.A.O. of United Nations. Courses dealing with irrigation and drainage will be offered in a special school of the university which will be called the school of Land Utilization.

Discussion

Dr. Asghar remarked that in one of the colleges in Pakistan they formerly gave a two-year course leading to a diploma. This was an extension type of training with the idea that the graduates would get into the country and become the leaders and teach the farmers by demonstration. That diploma and course has been stopped. This course included basic science at the elementary level, plus general agriculture.

At the degree level irrigation is not included in the curriculum in agriculture. He stressed the necessity for including such courses.

Pakistan has both government demonstration farms and demonstrations on the farmers' land. There is a question about how much can be taught the farmer. Some little gains have been made on the agronomy side, but none in irrigation practices.

Some instruction is given by showing films and discussion, but this work has just started. Dr. Asghar stated that Pakistan is very hopeful about the new approach through the Basic Democracy and the Union Councils; however,

until the Union Council members are trained, they cannot become leaders. The Indian delegates have given a good account of the progress made through Village AID; but Dr. Asghar stated his experience in Pakistan through Village AID had not been very encouraging.

Dr. Asghar questioned the limited amount of practical training in the irrigation courses in the curriculum of Karadj Agricultural College; and felt that in general, in most institutions in the region in the agricultural engineering curricula, agronomy as related to engineering is stressed, rather than irrigation as related to agriculture. He emphasized the desirability of Extension and Demonstration centers located at various points throughout the countries in addition to the agricultural colleges.

Dr. Asghar mentioned that one of Pakistani Trainees had been sent for undergraduate training at American University of Beirut, with the expectation that he would work at the farm level. However, he was unhappy there and required a position in the Land Reclamation Directorate after two or three months. He stated that he did not yet know what impact A.U.B. had made with regard to one of the postgraduate trainees of his department since he had only recently returned. He stressed that unless those people stay in their field, their training is not useful to Pakistan.

CHAPTER V

CLEARING HOUSE FOR COUNTRY PROBLEMS

AFGHANISTAN

Question

Mr. Begley mentioned that in Afghanistan water supplies are ample. However, it is difficult to practice night irrigation. He further stated that there was no means of measuring the water. Afghanistan does not have the trained personnel to measure the water to the farm units, which range from 7½ to 15 acres. Some measurements indicate that from six to twelve times the amount of water actually needed is being applied. *The problem is basically one of making water measurements to small areas.*

Discussion

With regard to measuring devices, Dr. Qureshi mentioned that there are two types of measuring devices called "modules" used on the government canals in Pakistan. One type depends only on the water level upstream, while the other type is independent of both upstream and downstream conditions, and draws a fixed quantity of flow. Tables are published which give the necessary upstream and downstream heads and widths for the desired quantity. Below the module the ditch may serve from one to fifty landholders. The quantity delivered to the landholder depends upon the time under a rotation system.

Dr. Qureshi referred to a publication *Irrigation Outlets* by Mahbub and Gulhaty.

Mr. Rejali stated that on new projects in Iran water was measured to the laterals using weirs. The users on the laterals appoint their own ditch rider and distribute the water among themselves according to their own desires.

In regard to water control in Sudan, Mr. Abdul Mageed stated that farmers are placed under very strict supervision by the Engineering and Agricultural departments. Block supervisors with four or five assistants are provided for each block of land. Through information gathered, daily requests are made for the water needed. These are consolidated by the engineers. Measurements are made in both major and minor canals utilizing measuring devices or current meters. The difficulty arises at the farm outlet. Experiments are being tried utilizing meters placed on the downstream end of the outlet pipes. The accuracy of the meters is being checked against the measured amount flowing into the lateral. Mr. DeFalla stated that these experiments had been successful in verifying the conclusion of the Research Department relative to the water meter.

Mr. Sawaya state that because water is so precious in Lebanon all canals; primary, secondary and tertiary will be concrete lined. Since the water supply varies, measuring devices are being installed, which will automatically record the amount of water diverted to the various laterals. The water will be divided in accordance with the proper percentage. Cultivators will be informed of the expected discharges so that they may arrange their crops accordingly. The operation of the main canals and secondaries will be supervised by the Litani Authority; the tertiary canals by the cooperatives. The cooperatives will be supervised by the Authority.

Mr. Vernon stated that the measurement problem was one of the most difficult of those faced by the project design and management. There are two approaches to this problem, one is to actually measure the water to the farm; the other is to provide a fixed stream for a measured time. The nature of the system used will depend upon the availability of trained personnel and the value of the water. The *time* system is the simplest to administer. Mr. Vernon pointed out that systems should not divide the stream into flows which are too small for economic irrigation on a particular farm. He stated that the ideal system would be to actually deliver the best size stream at the required time, fully measured, and that this is a great challenge to the managements of irrigation projects.

CEYLON

Question

Mr. Rajaratnam mentioned that Ceylon does not have big problems like drainage and salinity. Irrigation means rice irrigation, cultivated by flooding the land. For this, ample water must be issued to the cultivator who continually asks for more and more water. Advances can only be made in the control and issue of the water if the cultivator can learn to appreciate the benefits of using optimum crop requirements.

Mr. Rajaratnam stated that an effective distribution system must be provided in combination with drainage and accessibility to serve the small 3 and 4-acre holdings. Each has independent distribution and drainage.

Land must be rehabilitated under people moved from industrial areas to areas where land is available. This land is primarily available in the dry zone. In terms of total rain, the dry area is not so dry; however, the rain occurs only during the winter and averages about 16 inches. New lands must be taken from the jungle and placed under irrigation. The cultivator is not brought out on the land until after the system has been made and the allotments blocked out. He is not used to this type of work, and wants more water.

Water is carried to the allotment where it is placed in bays and is successively run through each bay until it reaches the lowest, from which it may pass through artificial drainage to natural drainage channels.

The problems are: (1) Levelling must be such as to provide a uniform depth, otherwise germination is poor. (2) When there is insufficient water to cover the ground, unsatisfactory weed growth occurs. (3) If levies are not properly built they breach and much water is lost, especially at night.

Mr. Rajaratnam stated that drainage was adequate and that problems of distribution system operation were remedied as they arose.

Discussion

Mr. Ismail mentioned that, where underground water supplies are available, irrigation of tobacco, chillies, onions and vegetables may be undertaken. This is true on about 20,000 acres of land where allotments are usually ¼ to ½ acre. Three crops are taken.

Dr. Asghar suggested reference to the Australian literature relative to weed control. In Pakistan hand labor is used to remove the weeds from paddy; the feasibility of this would depend on the cost of labor. Dr. Asghar suggested that groundwater might be used when other water is not available.

Dr. Peterson suggested that rice was raised in Japan without keeping it entirely flooded. He referred to the Aichi Corporation in Japan; and mentioned that rice was used for leaching salinity, in rotation with other crops, in experiments in south-eastern Turkey.

Mr. Rejali stated that experiments in northern Iran showed that good results could be obtained with rice either by continuous flooding or by intermittant irrigation.

Mr. Phillippi pointed out the great need for increased rice production in Ceylon. However, in the dry zone, farmers will not cultivate or plant until the tanks are filled; being unwilling to take the risk. As a result the use of the 12 to 15 inches of rainfall on the fields during this period is lost.

IRAN

Question

Dr. Ahi stated that their problems could be classified into four types: *psychological, educational, technical* and *economical.* He stated that *psychological* problems are of two types (1) problems with the government—neither they understand us nor we understand them. This is the main problem to tackle in the various changes which are happening in Iran. We expect too much but they don't give enough help. They don't understand our language. The second phase is with the farmers. Farmers are uneducated, they don't know how to operate their farm. Very soon they are going to be the owners. Previously they have been dependent on their landlord and what problems they had were referred to them.

In the *educational* problem we are very handicapped by the lack of trained personnel. We don't have enough men to handle our problems and it is hard for us to train enough in our insti-

tutions. We need men at the University level, the vocational level, and the under vocational level. There is a great gap between the University graduates and our under-graduate level. Probably we have enough irrigation or agricultural engineers, but we do not have enough men who are under-graduate to help them out. Dr. Ahi stated that Mr. Ayazi would discuss the technical problem, but commented that, while technicians could agree on solutions, the problem was to put this in a common language that could be passed on to the farmer.

Our *economic* problem depends on the other three. So far the landlords runs the villages and our national income depends upon what they get from their villages. Now these lands are going to be divided among peasants. It is a question whether or not agricultural production will be maintained on the same level as now. I am afraid that lack of education, lack of trained men, and not being able to hand the information to them will be a handicap for several years.

Mr. Ayazi stated that water supplies are insufficient in Iran and that the farmer is not acquainted with irrigation agriculture. According to available information, if we could control the water we have, we could increase our irrigation by about double. The second problem is drainage and salinity. About one-half of our irrigated area is a problem. The picture circulated shows a farmer from the south of Iran who has spent one year's time and a lot of money to crop wheat. You will see he has got about nothing.

In Ghulistan (?) area farmers have formed a cooperative organization to obtain irrigation water from the river by pumping. They proceeded without technical assistance and invested about $30,000 for 600 hectares. They have built the dams, dug the canals; and after one or two years operation, they have proved that it is not possible to continue farming. They need to drain and reclaim the land. They now believe that agriculture is not a good business. They are selling their farms to each other and the government has come in to help them establish drainage and reclamation.

Attempt to Cultivate Saline Lands without Proper Reclamation Led to Failure.

A board is elected for each river. This board controls the distribution of water in the rivers and the main canals—but not in the distributaries. The farmers use the water by rotation under a self-control arrangement. Actually water measurement is not the big problem, the problem is that the farmer does not know how to use the water. We have tried to introduce crop rotation into rice cultivation. Because of the difficulties in getting the farmer to do this, a demonstration farm has been established.

In some areas deep furrow irrigation has been successful; flooding and border irrigation has been a lot of work. It will be hard to introduce water measurement at the farm level. However, if we will introduce irrigation agriculture to the farmer, we will benefit.

Discussion

Mr. Ismail stated that there was a tendency for educated young men to not wish to get out into the field and do hard work. Dr. Peterson commented that there is a tendency for technically-trained people to wish to spend their efforts on the exciting technical problems rather than to concern

themselves with the great and more difficult social and economical problems and urged that scientifically trained men and engineers as they mature, should become more concerned with these latter problems.

Mr. Rajali stated that in Iran the people have the right to use the water of the river for irrigation, but that if the government constructs the project, the extra water belongs to the government. The revenue from this water is for amortization of the project. There is some trouble collecting the money and a good contract with the land owners is needed. The water rights and distribution of water is based on ancient tradition and is difficult to change. Another problem is land tenure. There are three kinds of land tenure in Iran. Public domain is to be divided among the farmers. On land held by landlords the land owners changed the land assignments each year. This discouraged fertilization and development of the land by the tenant.

LEBANON

Question

Mr. Sawaya stated that in Lebanon the government builds the secondary canals into the villages and the tertiary canals are to be built by the cultivators. The problem is how to allocate the cost of the tertiary canals, since the cultivators living near the secondary canals felt that they should not pay for downstream tertiaries which did not serve them.

Discussion

Dr. Qureshi stated that in Pakistan the practice was for the government to build primary, secondary and tertiary canals; but they felt field water courses were the responsibility of the farmers. In new projects even the field water courses are excavated by the government and the amount subsequently recovered, mostly in proportion to holdings. In some of the new projects government is actually bearing part of the cost of even field water courses in that they have provided a lead water course of small cross section but of the full length to guide the land owner to the alignment and section that he ultimately should have. The Thal Authority provided everything including the house and wiring and subsequently recovered everything from the farmer in the shape of sale of land.

Professor Macksoud reiterated that the problem was one of distributing the costs; and Dr. Qureshi stated that this is done by *area* in Pakistan. Professor Macksoud wondered how this could be accepted; to which Dr. Qureshi replied that the matter was based on legislation.

PAKISTAN

Question

Dr. Asghar felt that Pakistan's problems could, like Iran's, be classified into psychological, educational, technical and economic. He presented a written statement of the technical problems of Pakistan and requested assistance from delegates of the other nations in solving them. Following is his statement:

We have four problems on which we would like to seek the advice and assistance of other country delegations.

1. The first one concerns distribution of irrigation water. The average size of holding in the canal irrigated areas of West Pakistan is very small. The size of holdings may vary from one acre or even less to 900 acres. The upper limit has been fixed by the very recent agrarian reforms in the country before which there was no upper limit. The area irrigated from an off-take from the canal does not comprise of complete holdings and most land holders have land on more than one off-take. The duty of canal water supply is much higher than in most other arid countries where irrigation is practised and generally ranges from 300 to 350 acres or more per cusec. The quantity of water provided for irrigation has to be divided over the area of the holdings on the off-take. Even on the same off-take, the holdings are not all consolidated and some may be scattered in more than one part.

The topography of the Indus plains is generally very flat and does not provide gravity facilities for storage of irrigation water. The majority of cultivators is financially at a very low level and cannot afford to provide means of water storage by power lift.

Considering the given conditions, the turn system is the only known and practised system of distribution of water considered practicable in this country. The turn of a holding or for a consolidated piece of a holding is arrived at by multiplying the turn per unit area by the number of units of area. The turn begins with the holding at the head of the water-course and ends at the tail end of the water-course. The length of turn generally varies between one week and two weeks.

It is evident that the turn system cannot provide water on demand and therefore, the irrigation practice does not follow the crop requirements. The crop has to wait for the turn, which affects outturn. This question has not yet received the attention that it should have received. We will be very glad to receive any suggestions on the possibility of providing water on demand under the economic, land tenure and other conditions explained.

2. The second problem concerns the most productive use of limited water supply. As long as the problems of salinity and waterlogging had not become serious, additional sources of irrigation water were tackled for providing irrigation supply to undeveloped areas and this outlook has persisted up to this time. However, with salinity and waterlogging problems and with the development in the understandings on soil science it has come to be realized that the water requirements for soil protection from salinity and sustained agriculture are much more than the allowance of water that has been provided. The water requirements for reclamation of land already affected by salinity are over and above the soil protection requirements for the land not yet affected. With the position as it is, the question of priority of different categories of land for the utilization of any additional source of irrigation water is very pertinent. The culturable land in the country can be split up into:—

(*i*) Land already receiving irrigation water and not yet affected by salinity.
(*ii*) Irrigated land affected by salinity:
(*a*) Still under cultivation.
(*b*) Gone out of cultivation.
(*iii*) Undeveloped land which can be classified according to soil profile characteristics and topography on the basis of potential productivity and development cost.
(*iv*) Land irrigated from other sources which can be benefitted by supplementing the available irrigation source with canal water.

What should be the order of priority between these land categories for the utilization of any additional water resources? We tentatively consider the order of priority to be the same in which these categories have been mentioned. In the third category the upper classes of undeveloped land will have priority over inferior classes. The inferior class of undeveloped land will compete with the fourth land category, viz. land to be benefitted by supplemental irrigation. If the latter is potentially better land and is threatened with deterioration due to inadequate irrigation it should have priority over undeveloped land of lower class. If the order of priority suggested is sound, then the development and irrigation policy in this country will have to be reorientated to it without losing any more time. It is possible that there may be some very useful suggestions from other delegations on this question.

3. The third point is a follow up program for areas in which the salinity and waterlogging problems have been tackled. The areas being taken up in the reclamation projects of the Soil Reclamation Board are the ones specifically in mind. Reclamation and soil management measures are being adopted according to our existing understanding of soil science. No one can say what further problem or situation will arise in future. Research as a continuous process is the only way of keeping abreast of all problems following the present reclamation and development program. It, therefore, seems absolutely essential that we should have a sound follow-up program. Members of other delegations may have some helpful suggestions to make with regard to such a follow-up program.

4. The last question on which the views of other delegations would be very welcome for us concerns organization of soil research and actual reclamation and development work in the field for reclamation of saline and waterlogged lands and protection of areas not yet affected from deterioration. We have at present a number of Government agencies connected with different parts of this work. The Directorate of Land Reclamation which is a part of the Irrigation Department is a research and advisory organization.

The Superintending Engineers of Canal Circles are responsible for making extra supply of water available for three years for temporary reclamation of saline fields and for administrative control of these operations. The Soil Reclamation Board is a semi-autonomous body of representative of Government Departments of Irrigation, Revenue, Agriculture, Forestry and Co-operative Credit and is responsible for permanent reclamation and development projects for seriously affected tracts of land.

The Water and Power Development Authority is another semi-autonomous Government body which is responsible for installation and working of tubewells in the project areas of the Soil Reclamation Board. The four different agencies have got to co-ordinate their work in order that the problems of soil and water management may be efficiently

tackled. Our present thinking suggests that for effective co-ordination there should be an overall set up under one organization.

Delegations from other countries may have experience of organization of work on soil problems from which we could benefit.

SUDAN

Question

Mr. Dufalla stated that Sudan has no major problems like drainage and salinity, but has problems of other kinds. These are problems of siltation and weed control in canals and rivers. The siltation problem in the Gezira scheme prevails in canals at all levels. This system was originally designed for continuous operation. However, because of the difficulty of getting farmers to irrigate at night, the minor canals are used for night storage. This greatly accelerates the deposition of silt in the minor canals. Removal of this silt is costing a lot of money. It has been proposed that continuous operation be reinstated. However, it has been impractical to break the tradition which has been established. The costs of removing the silt is becoming a problem.

A more difficult problem is the acquetic weed problem. This is a very serious problem especially in the Gezira scheme. They are trying methods of control involving (1) manual methods, (2) mechanical means, (3) chemical means. Mechanical means are limited to deep canals; manual methods have been successful only in the minor canals, but they are trying chemicals. They are finding chemicals effective. Fortunately the copper sulphate used for weed control also kills the snails which carry bilharzia; but this treatment is expensive.

A problem which is now causing great concern is the discovery of the water hyacinth in the White Nile. In two years time this has spread from Giselle as far as Khartoum. The hyacinth has interfered with pumping from the Nile. They have appealed for outside help and ICA is furnishing an expert and machines are being brought from the Congo and from America.

CHAPTER VI

PRACTICAL PROBLEMS OF IRRIGATION FARMING

(This Chapter contains the results of several panel discussions held on the subject of the title.)

WHEN AND HOW TO APPLY WATER TO CROPS

Led by H. S. ZAIDI, PAKISTAN

When to Apply Water

Research work on this subject has advanced much during the last 20 years. We know in terms of soil moisture tension the status of soil moisture availability for plants at different moisture levels. Viehmeyer and his co-workers in California had brought out from their work that soil moisture between the field capacity and the permanent wilting percentage is equally available to plants but workers elsewhere have established that water is not equally available in this entire range and crop yields are raised by maintaining the soil moisture content near 50% of field capacity and above. The plant does not give indication of moisture requirements for maximum yield and only shows signs of wilting when the moisture content goes down to permanent wilting percentage and at that stage the damage has already been done. A number of methods for field determination of soil moisture have been evolved which can indicate when to apply water for maintaining the soil moisture content for the highest cropping out-turns. In more advanced countries like United States farmers are actually making use of field moisture determining devices.

For maintaining the optimum soil moisture content, it is necessary that water should be available on demand; but under the turn system of distribution of irrigation water, supply of water on demand is not available. The turn system of water distribution has been imposed by the small size and fragmentation of holdings. In the turn system the only choice that the farmer has is between a crop field showing signs of wilting and another crop field not showing such signs on the day the farmer gets his turn. In the Canal colonies of West Pakistan the length of turn generally ranges between one week and two weeks. In winter the farmer is not faced with serious trouble in giving the different crops. The field that cannot get water in one turn has to wait for the next turn and by that time it may have seriously suffered on account of soil moisture deficiency. The summer crops stand in the following order according to their total irrigation requirements:—

(1) Sugarcane;
(2) Cotton;
(3) Food and fodder crops.

The position could be improved if the farmer did not aim at putting the maximum area under cash crops of sugarcane and cotton under the misconception that more area cropped will give more gross out-turns. With revenue to Government as the objective, the Irrigation Department is also very much interested in the maximum area being cropped. This outlook of the farmer as well as the Government has done inestimable damage to crop outturns and crop productivity of the soil. It is a major cause of the salinity problem with which we are faced.

To protect soil from salinity it is necessary to apply enough water to maintain a net downward balance of movement of moisture and salts in the profile. It is also necessary to provide crop cover on the land throughout the year as far as practicable to check the rate of upward movement of moisture and salts under evaporation. For this about two to three times the delta of water we have provided are needed. We have developed crop rotations which can provide for these soil moisture requirements.

In areas affected by salinity at the surface or having accumulation of salts at variable depth within the root zone of the crop we need preliminary leaching to the field before sowing any crop. For fields affected by salinity at the surface a heavy delta crop like rice is sown after the preliminary leaching. In a field in which the salinity zone is below the surface we can grow low delta crops after the preliminary leaching. Where water

application is required for leaching, therefore, when to apply water is indicated by the salinity content and not by a growing crop. In experiments at Ballahwala, cotton and sugarcane crops have been successfully raised by providing preliminary leaching in soil having the salt zone at variable depths.

Apart from the effect of salinity on water requirements there are some other problems which have to be met under Pakistan conditions.

(1) In area which receive non-perennial canal water supply, water is available from April to September. In the case of Sutlej Valley canals in many years the summer supply is received very late. In these areas growing of cotton and sugarcane raises the problem of water requirements before and after the canal supply is available. Both these crops need irrigation after September and the sowing time of sugarcane is late February and March when the summer supply is not available. In the absence of irrigation water in winter, growing of winter crops is also very limited. Where sweet water is available at shallow depth supplemental source of irrigation is provided by installing irrigation wells. However, only very limited area can be irrigated by wells as the labour requirements of well irrigation are very high and the discharge very small. Not more than 12 to 15 acres can be irrigated from a well.

We have been carrying on experiments at Haveli and Rangpur Experimental farms to determine if the water requirements of crops like cotton and sugarcane after September can be met by applying heavy irrigation delta in the later part of summer, i.e.; August and September and by mulching. The results have shown that by applying a heavier delta than usual to cotton during the time water supply is available and by applying mulches like rice husk and dry grass a reasonable amount of moisture can be stored and conserved for raising an average crop of cotton.

The results of an experiment conducted at 7/3L Experimental Farm on Rangpur Canal showed that sowing of sugarcane could not be delayed till middle of April without loss in yield. The crop has, therefore, to be sown with the help of well water up to the end of March. However heavy and more frequent irrigations in September could cause enough moisture to be conserved in the soil to meet the water requirements after September.

(2) The weather conditions in Thal in summer have a very marked effect on water requirements of crops. The summer temperatures go up to 123°F and there are frequent sand storms. The frequency of irrigation has to be increased under these conditions. The results of experiments on frequency and depth of irrigation for cotton and sugarcane are being reported in a technical paper in this seminar. Apart from this, work was carried out on sowing cotton earlier than the usual sowing time in other colonies and it was determined that cotton sown in the month of April (instead of May and June—the normal sowing time in other colonies) makes sufficient growth to withstand the effect of severe sand storms and high temperatures.

How to Apply Water

Flow irrigation from canal is the only method we have. In rare cases, in high water-table areas, sub-irrigation is practised by blocking an open drain, provided the drainage water is of good quality. The practices used for different crops and by different types of cultivators are basin, border, furrow and flood irrigation. Irrigation with syphons is being adopted at some of our experimental and demonstration farms. Sprinkler irrigation has not been practised in this country for irrigation farming.

In general we can say that with the salinity hazard and the leaching requirements of the Indus Valley soils on the one hand and the turn system of water distribution we can neither benefit from the use of the devices for field determination of soil moisture nor from farm irrigation equipment like sprinkler. We may possibly get some help from field moisture determination for winter crops when there is shortage of supply in canals due to low river supplies. Countries which are more fortunately placed than use with reference to the salinity problem can make more extensive use of these devices and irrigation equipment.

Discussion

In response to a question by Mr. Ayazi, Mr. Zaidi said that, while one tubewell would serve 250 acres, a shallow well pumped by a Persian wheel would serve only about 15 acres.

Mr. Ismail noted that large groundwater supplies are available in the areas visited during the field trips. He stated that where power is available an effort should be made to develop deep wells to provide water to meet crop requirements and that where power is not available, shallow wells with Persian wheels might be used. He inquired regarding Pakistan's plans for such a program. He stated that a shallow well yields about one-fourth cusec and serves 12 to 15 acres; does this imply a duty of 50 to 60 acres per cusec?

Mr. Zaidi replied that all of the surface water supplies were utilized and that nevertheless the salt problem increased. This water supply problem led to a groundwater investigation in cooperation with ICA. Whether the groundwater can be utilized depends on its quality. The investigation revealed that good quality of water exists in some places, poor quality in others. The question

of the use of Persian wheels depends in part upon economics. If the holding is too small, a pair of bullocks exclusively for this purpose may not be justified. If the Persian wheel may be operated using the spare energy of bullocks needed any way, this may be advantageous. In large areas where power is available, the tubewell may be most favourable. Each area must be studied on its own merits. No general statement can be made. Where the land holdings are fragmented, cooperatives or consolidation of holdings is hoped for. While a Persian wheel may be favourable today, by next year it may not be so favourable.

Mr. Phillippi of Ceylon asked if the Government of Pakistan had experimented with the use of small gasoline-powered pumps for pumping from shallow wells and, if so, what was the economic comparison between them and bullock power. Mr. Zaidi replied that this had not been done for shallow wells but that gasoline-powered units had been used for wells prior to electrification.

Mr. Vernon wondered if Pakistan is not facing a revolution in regard to irrigation practices on the farm. Even though water is short, it is spread on more land in order to produce more revenue. On the other hand the best information is that utilizing the water for more intensive irrigation might be more financially beneficial to the cultivator. Are these two points in conflict or complimentary? Given a particular increment of water, is more crop produced by using it on land already under irrigation or by putting it on a new piece of land? Mr. Zaidi replied that, if the history of irrigation is studied, great emphasis has been placed on the revenue side and that is the cause of Pakistan's entire problem; that is the cause of the trouble of irrigation and the problem of salinity that is faced. Fortunately there is a change in this philosophy. It is now realized that irrigation water should be used consistent with obtaining maximum yield and long range fertility. Some people have gotten more returns at first by spreading their water thinner on virgin land; however, ultimately this has led to deterioration of the land.

Dr. Carl Larsen, Advisor, Lyallpur College of Agriculture, stated that under continuous flow delivery, when the stream is insufficient to meet all of the crop requirements, the cultivator must decide on which crop to apply the water. Under a rotation scheme of delivery it may not be possible to obtain the water at the time the crops need it. Thus, although research may show when to apply water, this may not be possible under many systems of delivery. Results that can be achieved are thus limited by the delivery system. The problem of distributing water in accordance with the needs of the crops is an age old one. Because of the extremely sandy soil and low water-holding capacity on the Umatilla project in Oregon, U.S.A., an attempt is being made to make water available on demand with 25 hours notice. Demands will be based on the use of irrigation meters and tensiometers by the farmers. It may be necessary to re-design some of the ditches and canals to meet the resulting peak demands. It is very difficult to reconstruct the system. The farmer should be taught so that he can tell when his crop needs water, although the system may not be capable of always furnishing it. A demand system requires much larger canals and ditches. The solution to the problem requires the full cooperation of the engineers, the operators of the system, the agricultural extension workers and the farmers.

Mr. Vernon stated that he certainly had no objection to educating the farmer and that he was in favor of this. On the other hand he wondered if one phase of the education is not being neglected —that is, the education of the government to the profitability of improved irrigation practices.

CROP ROTATIONS FOR IRRIGATION AND SALINITY CONTROL

Led by MANZOOR AHMED, PAKISTAN

The requirements for sustained crop production from soil form the scientific basis for determining the cropping patterns suitable for any area. The type of soil and sub-soil, depth of the sub-soil water-table, salinity and alkalinity status of the soil and plant nutrient status and requirement of the soil have to be taken into consideration. The economic and social factors have also their bearing on the adoption of cropping patterns in an area. The projects of the Soil Reclamation Board cover that part of Rechna Doab which is severely affected by salinity and high water-table hazards and therefore it is all the more important that no cropping pattern should be adopted which cannot set right these maladies and which is unscientific.

As salinity is the foremost problem of the Indus Valley soils, the water requirements for cropping have to include the quantum of water required for the highest crop yields as well as to check the concentration of harmful salts in the surface layers of the soil. In order to maintain an over all downward balance of movement of moisture and dissolved salts the cropping pattern should be

such that it gives at least 20% drainage of water delta in high sub-soil water-table areas and at least 10% drainage in deep water-table areas. This makes it necessary to include high water delta crops like rice, sugarcane and berseem in the rotations or to apply more than generally practised delta to the common crops. Field studies for prevention of salinization carried out at Ballahwala Experimental Farm showed that rise of salts to the surface can be kept under check by practising crop rotations which include rice after different intervals according to the depth in the soil profile at which salts occur. It is also necessary to keep the intensity of cropping as near 200% as possible so that the land does not remain fallow which promotes quick salt rise to the soil surface under our meteorological conditions. To meet these requirements the existing duty of irrigation supply on the Indus Valley Canals, which is about 1000 acres per three cusecs, has to be reduced to 150 acres per cusec at this stage, which may require revision at a later stage on further experience. Actually the duty per cusec under arid conditions in advanced countries like U.S.A. is only 100 acres per cusec or even less.

The following crop rotations are considered suitable for high water-table areas:

(*i*) Rice-Berseem-Chari/Guara-Wheat-Maize-Senji,
(*ii*) Rice-Berseem-Sugarcane-Sugarcane,
(*iii*) Rice-Lentil-Chari/Guara-Wheat-Bajra-Senji,
(*iv*) Rice-Shaftal-Chari/Guara-Wheat.

For areas with water-table deeper than 6 feet the rotations suggested are:

(*i*) Rice-Berseem-Sugarcane,
(*ii*) Sugarcane-Sugarcane,
(*iii*) Guara (Green manured)-Wheat-Maize-Senji-Sugarcane,
(*iv*) Maize-Senji-Sugarcane,
(*v*) Cotton-Berseem-Chari-Guara-Fodder Peas,
(*vi*) Sugarcane-Cotton-Maize-Senji.

In well aerated light soils which are not very well suited for rice or surgarcane the following rotations may be employed with advantage where salts are quite deep:

(*i*) Chari-Guara-Wheat-Maize-Wheat,
(*ii*) Maize-Wheat-Bajra-Turnips,
(*iii*) Maize-Wheat-Chari-Berseem,
(*iv*) Mash-Wheat-Maize-Wheat,
(*v*) Mash-Wheat-Chari-Berseem.

More than practised delta should be applied to the above rotations. Lysimeter studies have shown that crops like wheat, maize, bajra, chari and guara draw upon the sub-soil moisture storage and therefore cause depletion in water-table under existing irrigation practices. There is, therefore, every possibility of rise of salts if these crops are grown under prevalent irrigation delta. Although the intended constant crop cover will keep the upward salt movement restricted, yet to ensure a check even on the small rise of salts, application of higher delta for each crop is suggested.

For already deteriorated soils, the cropping program has to include the initial reclamation operations. The cropping scheme shown in Tables I and II is suggested for different soils and stages of deterioration for an eight years period:

Table 1—Rotations for Reclaiming Uncultivated Waste Land

Year	Harvest	UNCULTIVATED WASTE LAND	
		Alkaline stiff clay with salt content (Rakkar)	Alkaline stiff clay with high salt content.
1st.	Summer	Jantar	Jantar
,,	Winter		
2nd.	Summer	(*) J.G.M. Rice	Rice
,,	Winter	Berseem	Berseem
3rd.	Summer	Rice	Rice
,,	Winter	Berseem	Berseem
4th.	Summer	Rice	Rice
,,	Winter	Berseem	Berseem
5th.	Summer	Rice	Rice
,,	Winter	Berseem	Berseem
6th.	Summer	Rice	J.G.M. Rice
,,	Winter	Gram	Senji
7th.	Summer	Sugarcane	Sugarcane**(R)
,,	Winter	Sugarcane	
8th.	Summer	Sugarcane (R)	Cotton
,,	Winter	Methra	Senji

(*) J.G.M.: Jantar Green-manuring.
** (R): Ratoon.

Table 2—Rotations for Reclaiming Cultivated Land

Year	Harvest	CULTIVATED THUR LANDS			
		Saline loamy soil with low P.H.	Stiff clay	Clay loam	Light loam and sandy
1st.	Summer	Rice	Rice	Rice	Rice
,,	Winter	Berseem	Berseem	Gram	Berseem
2nd.	Summer	Rice	Rice	Rice	Rice
,,	Winter	Gram	Berseem	Gram	Gram
3rd.	Summer	Rice	Rice	J.G.M. Rice	Guara
,,	Winter	Gram	Gram	Fodder peas	Wheat
4th.	Summer	Rice	J.G.M. Rice	Sugarcane	Jawar Mash
,,	Winter	Senji	Barley	Sugarcane	Gram
5th.	Summer	Sugarcane	Jawar Mash	Sugarcane (R)	Guara
,,	Winter	Sugarcane	Wheat	Methra	Wheat
6th.	Summer	Sugarcane (R)	Guara G.M.*	Jawar Mash	Jawar Bajra
,,	Winter	Methra	Wheat	Wheat	Berseem
7th.	Summer	Cotton	Jawar	Guara G.M.	Maize
,,	Winter	Senji	Berseem	Wheat	Senji
8th.	Summer	Jawar Mash	Cotton	Cotton	Bajra Moth
,,	Winter	Senji	Senji	Gram	

* G.M.: Green-manured.

For working out the general cropping patterns for an area it can be divided into categories like the following:—

(*a*) Heavy soils with less than 20% salt patches.
(*b*) Heavy soils with more than 20% salt patches.
(*c*) Light soils with less than 20% salt patches.
(*d*) Light soils with more than 20% salt patches.

The following cropping patterns are suggested for these main types of soil for a unit holding of 12.5 acres.

Cropping Pattern for Type (a)

Summer		Winter	
Rice	4.0 acres	Wheat	5.0 acres
Cotton	2.0 ,,	Gram	2.0 ,,
Sugarcane	1.0 ,,	Lentil and Barley	0.5 ,,
Maize	1.0 ,,	Senji in cotton	2.0 ,,
Fodder	2.0 ,,	Fodder	1.0 ,,

Cropping Pattern for Type (b)

Summer		Winter	
Rice	6.0 acres	Wheat	4.0 acres
Fodder	1.5 ,,	Gram	2.0 ,,
Maize	1.0 ,,	Berseem	2.0 ,,
Sugracane	1.0 ,,	Senji in cotton	1.0 ,,
Cotton	2.0 ,,	Taramira	0.2 ,,

Cropping Pattern for Type (c)

Summer		Winter	
Mash	4.0 acres	Wheat	6.0 acres
Bajra	3.0 ,,	Gram	3.0 ,,
Jawar	1.0 ,,	Godder	2.0 ,,
Fodder	2.0 ,,	Lentil and Barley	1.0 ,,

Cropping Pattern for Type (d)

Same as for Type (*c*) with preliminary leaching.

The rotations and cropping patterns suggested are not the final word on the subject. Soil conditions differ greatly from field to field and it is for the agronomist to interpret the results of soil tests in detail and make suitable changes wherever necessary.

Control of the rising water-table and dewatering of the waterlogged areas is a basic requirement for sustained crop production under our existing conditions. Drainage, therefore, should be considered the starting point of all development projects. Surface drainage is necessary to cope with the precipitation which sometimes is very heavy. The lowering of sub-soil water level can be achieved only through deep seepage drains and pumping by tube-wells. The choice of a drainage system rests on the type of soil profile, general slope and other hydrologic features of the area. In each of the projects provision has been made for effective drainage by the most suitable methods.

Discussion

Dr. Peterson mentioned that he was greatly impressed with the work of the Tarsus Experiment Station on the Adana plain in the south-eastern part of Turkey, where rice is used in rotation for the purpose of leaching lands which have become heavily salinized. He stated that he was very much impressed with the work of the Land Reclamation Directorate in West Pakistan where crop rotation patterns are used as an aid to reducing salts. Here it has been demonstrated that good irrigation practices with scientific cropping can be very effectively used to mitigate the problem arising from salinization and poor drainage.

Dr. Peterson stated that crop rotation schemes can help in at least three ways: (1) by reduction of the salt or sodium condition near the surface, (2) by improving infiltration characteristics, and (3) by helping to break up hard pans. A successful crop rotation plan depends both upon an adequate water supply and the availability of economic conditions favourable for the various crops in the rotation.

Mr. Ismail inquired as to the delta (water application) used in connection with rice. Mr. Ahmed replied that for lands affected by salt, 1 cusec for 45 acres is provided. This is an increase of about seven times the normal allowance and is provided for a period of about three months. The volume consumed is about 60 inches.

Professor Macksoud pointed out that the purpose of the rotation was to apply more water than the crop needed so that (1) there would be downward movement of the soil water and (2) capillary rise would be prevented. Professor Macksoud wondered why a crop rotation is necessary since it would be possible to simply furnish the required additional leaching water under single-crop operation. He wondered why it would not be possible to simply decide upon the most economic rotation and then furnish in addition the water necessary to leach the salts.

Mr. Ahmed felt that some crops requiring high water delta should be included. For reclamation it is desirable that a crop cover be provided continuously. Another purpose of the rotation is to restore and preserve the fertility.

Mr. Abdul Mageed inquired if it had been found that the crop rotations were sufficient to provide adequate nitrogen. Mr. Ahmed stated that commercial fertilizers were not available in Pakistan; and that, even in areas where they are available, rotation is still desirable in order to maintain an adequate fertility level.

In reply it was stated that leaching was possible under grass or other crops; however, it was best to adopt rice for economic reasons. Since rice is a one season crop, then some consideration has to be given to the crop to be grown during the winter.

Mr. Anderson stated that the general impression of the Seminar has been that the use of commercial fertilizers in the NESA Region does not pay economically. He wondered if actual data were available. He stated that the use of 200 kilos of ammonium sulphate on irrigated wheat at the experimental farm near Tehran gave an increase of 7 to 1 in the yield and a net return of roughly $100.00. Although the fertilizer was very expensive to apply, it still paid.

Mr. Abdul Hafiz stated that there are two problems: (1) the fertilizer is not available and (2) the farmer does not have the money to invest in it if it were. The situation with regard to commercial fertilizer is improving. Pakistan government is giving 50% subsidy on fertilizer and the progressive farmers are taking up the use to a considerable extent.

There is also major question of the effectiveness of the fertilizer on saline soils. On alkaline soils the fertilizer has the effect of adding additional salt. This is another factor which must be considered in West Pakistan. In the rotations developed by the W. Pakistan Land Reclamation Directorate, they tried to find out the crops that would give the best economic returns to the cultivator.

Mr. Ayazi stated that reclamation of soil involved the following four steps: (1) increasing the infiltration rate, (2) lowering the ground water-table by installation of drainage, (3) leaching, and (4) establishing cropping patterns. In West Pakistan all of the steps are being combined. Wells have been installed, infiltration has been improved by cropping and water has been made available for leaching.

Is it possible to solve the salinity problem simply by a cropping pattern without improving infiltration, providing drainage, or leaching? In reply it was stated that the crops used in the rotation were for different benefits. Some were deep-rooted, some were shallow-rooted, some were nitrogen fixing and some removed nitrogen. The consumptive use is fully matured in the rotation presented, and the additional leaching water is provided. The classification mentioned by Mr. Manzoor Ahmed takes into account that the rotation practice at the time of reclamation and the water made available depend both on the type of soil and the level of the salts.

Mr. Ayazi pointed out that the definition for saline soils were unique as used by the Land Reclamation Directorate. It was stated that these were practical, based on the experience at the various reclamation farms.

FARM DRAINAGE

Led by ENG. A. AYAZI, IRAN.

I believe it would be most effective to show emphatically, the importance of farm drainage in the Middle East countries. I have accordingly taken some notes on this subject from the various Country Reports presented here.

Starting with West Pakistan:

> "In the Indus Basin the irrigation practice has resulted in the creation of a zone of accumulation of salt and has turned once fertile land into saline land unfit for crop production. In sixteen central districts which comprise the former Punjab Province, more than 3 million acres out of 12 million acres irrigated by channels are seriously affected by salinity which includes 1.3 million acres completely gone out of cultivation. In the whole of West Pakistan 7 million acres are estimated to be seriously affected. *Each year at least 100,000 acres are adding to this seriously affected area.*"

India:

> "In the introduction of every irrigation project in India the problem of waterlogging and the consequent alkalization of the soil have confronted the irrigation engineers. The worst affected states are Punjab and Uttar Pradesh. An area of as much as 3,000,000 acres have sub-soil water level within five feet from the ground level. A considerable proportion of this area grows either no crop or very poor crops. *Now the question assumes fundamental importance in the present context of food shortage in the country.*"

USOM Afghanistan:

> "In Helmand Valley Project area, 320,000 acres are now being irrigated. The problem of drainage in the Helmand Valley are problems that are faced at one time or another by projects the world over. During the time of development only the minimum amount of drains were installed. Consequently many areas have been waterlogged and salts brought to the surface. Work is now progressing with the installation of additional drainage and considerable work is needed in leaching and water control methods, both by the farmers and the Irrigation Department."

Iran:

> "Several of the large, modern irrigation projects in Iran are confronted with the problems of soil waterlogging and the resulting salinity and alkalinity. For example, in Shabakenkara Project 300,000 date-palms were planted, 15,000 are dead; and about 120,000 are adversely affected and in real danger under present conditions. The total loss of crop, including date-palms, due to waterlogging and salinity are approximately one-half million dollars."

Briefly I should explain the water-table has come from 14 feet to 6 feet within two years irrigation. In Garmsar area the yield of crops is decreasing year by year; and within four years the yields are reduced to about 1/3 of the average yield.

Now, if we want to have a conclusion from the different reports which have been presented to this Seminar, we should say it is necessary for all Near East countries to find easy ways to solve the farm drainage problem. One way which looks important is to have an exchange of ideas and research results not only during the Seminar, but also between the Seminar periods, to encourage the farmers to start drainage and land reclamation work in their farm. The main drain and laterals must be done by government; and governmental service must be available to assist to provide the farmer with: (1) plan of work for field drainage, (2) provision of execution, (3) in some cases assist the farmer by execution of work with government equipment on a contract basis, (4) very efficient way is the establishment of drainage and land reclamation demonstration farms to show the farmers the methods which must be used, (5) also, supervision for maintenance of the existing drain is very helpful.

As we have seen at the experiment stations at Chuharkana and Chekanwali, Dr. Asghar mentioned they have installed the drain and after four or five years, when the income and expense was equalled, they leave it to the farmer to run it. But after two years they understood this was not a good way and the farmer needs to have some supervision of the work.

Finally I wanted to say here this very helpful sentence—Irrigation and drainage are married and they cannot be divorced.

CHAPTER VII

FIELD TRIPS

Dr. Asghar Explaining Reclamation Experiments at Chuharkana Farm.

Group at Risalewala Farm.

Hydraulic Model at Irrigation Research Laboratories.

Visit to Balloki Headworks.

Inspecting Large Lysimeter Tanks at Land Reclamation Laboratories.

CHUHARKANA AND CHUKANWALI RECLAMATION FARMS

19 February, 1960

The first field trip of the delegates was to observe two types of land reclamation demonstrations: (*a*) reclamation of heavily salinized soils and (*b*) reclamation of an area having high water-table and high salinity. These farms are operated by the Directorate of Land Reclamation of West Pakistan.

The Chuharkana Farm, approximately 30 miles from Lahore, is located in the service area of the Upper Gugera Branch of the Lower Chenab canal system. An open drainage ditch passes not far from the farm, however the soils had become heavily salinized and before reclamation operations began the land was out of production. Various types of crops were being grown and it was apparent that removal of salinity through appropriate rates of water application and installation of field drains was meeting with success. The farm suffered from the widespread flooding during the last monsoon season, consequently some loss of progress in reclamation operations was evident. This pointed to the necessity for protection from widespread flooding to insure stable reclamation development.

While in the area of the Chuharkana Reclamation Farm the delegates inspected a tubewell installation.

The tour then travelled along the Upper Gugera Branch Canal to the Chukanwali Reclamation Farm. While travelling along the canal, two general locations of tubewell installations for drainage purposes were observed. For a portion of the canal reach, tubewells were located at approximately the intersection of the canal bank and the land. The other location of the wells was approximately 600 feet away from the canal bank. In both types of locations heavily seeped areas were noted beyond the canal banks, but the latter described location seemed to be more effective in cutting off the seepage flow.

Considerable time was spent observing results at the Chukanwali Farm. The group was informed that prior to the start of reclamation operations the land was heavily seeped and suffered from high salinity concentrations. Considerable experimentation had been carried out on spacing of drains with a view to lowering and controlling the ground water surface. Several types of drains were in use, such as open drains, tile drains and mole drains.

Following leaching operations, the ground water had approximately the same quality as canal water. Therefore, in some areas, sub-irrigation was being practised by blocking the drains and raising the general water-table to the desired elevation. In general, the unblocked drains maintained the water-table at approximately three feet.

One of the problems at the Chukanwali Farm is that canal water is supplied for only six months of the year. The group was informed that because of the seasonal water supply considerable attention had to be given to preventing increase in salinization of the soil in the off-season because of the relatively high water-table. Consequently, considerable attention is given to determining the types of crops which may be grown. Experimentation showed that rice was the best summer crop because of its heavier water requirement which coincides with the availability of water. Soil-building crops such as legumes were best grown in the winter season.

The delegates were served a luncheon while at the Chukanwali Farm and were given the opportunity to discuss practical farming questions with some of the local farmers.

The tour then resumed, returning to Lahore by a different route than that followed in the morning. On the way, the tomb of Shah Jehangir, a Moghul Emperor, was visited. All were impressed by the beauty of the well kept grounds and the intricate and delicate artisanry decorating the Mausoleum. While at Jehangir's Tomb, the delegates were served with refreshments by the Mir Rifat Pasha Sheikh, Administrator of the Lahore Corporation.

Summary of observations during the trip:

(*a*) Large areas of the countryside are suffering from high water-table and/or salinization and thus have no, or greatly reduced, crop production.

(*b*) In areas where high water-table and/or salinization are not observed the inherent fertility of the soil is apparent.

(*c*) Good agricultural production is obtainable

in areas presently suffering from high water-table and/or salinization by:

1. Introduction of suitable drainage facilities to lower the ground water-table;
2. Application of adequate amounts of water to leach out the salts and thereafter to maintain a downward movement of the subsoil waters; and,
3. Selection of suitable crop rotations to build up soil fertility and improve soil textures.

LYALLPUR

23 February, 1960

Forty delegates to the NESA Irrigation Seminar visited the Lyallpur area on February 23, 1960.

The field trip required a full day as Lyallpur is located about 90 miles west and slightly south of Lahore. The group visited the Moharanwala Experimental Station, 15 miles east of Lyallpur; Risalewala Research Station near Lyallpur; Saigols' farm near Lyallpur and the Punjab Agricultural College at Lyallpur.

Travel by bus and cars afforded the delegates an opportunity to observe the serious effects of salinity and waterlogging in the area. In addition, several irrigation canals and drainage channels were observed.

The first stop was at Moharanwala Experimental Station which was established about 1937 and is operated by the Directorate of Land Reclamation to verify tentative conclusions previously obtained from results of laboratory and field determinations. These tentative conclusions were:

(*a*) That under the existing system of perennial irrigation canals the salts in the soil had formed a zone of accumulation in the soil profile some distance below the natural surface.
(*b*) That the rising water-table was unable to pierce through a soil crust more than 10 feet in thickness.
(*c*) That under normal water allowance and normal crop rotation the sub-soil was not the main source of salt at the soil surface.

The criteria used for selection of this farm area were as follows:

(1) The area had not been previously cultivated.
(2) The soil surface was free from salt.
(3) The water-table was rising rapidly.
(4) The land had a soil crust of varying thickness.
(5) An independent supply of canal water was available.

Originally the farm comprised 15 acres in area but this was subsequently increased to 49 acres out of which 36 acres are under experimental cultivation, 11 acres are in reserve for future experiments and 2 acres have been used for buildings and roads.

Dr. Asghar and the Land Reclamation staff explained to the group the various experiments with crop rotation, green manuring and irrigation practices being conducted with the objective of developing a cultural practice which would aid in depressing salts of the root zone.

Next the delegates visited the Risalewala Research Station (Punjab Agricultural College) which was established to conduct water use studies. Facilities of this research station include a water measuring tank and distribution flumes to accurately measure the volume of water delivered to each experimental plot. The delegates were welcomed by Professor M. S. Gill and Dr. Carl Larson. Refreshments were served while Professor Gill discussed: *Water Requirements for Crops under Lyallpur Conditions* and Dr. Larson discussed: *Soil Moisture Plant Relationship Experiments*. The group then inspected the farm area and observed the use of "Iro-meters" (Tensiometers) for determining soil moisture conditions.

Saigols' farm was then visited. The host, Mr. Rafique Saigol, gave an excellent lunch for the group following which, Mr. A. Wahab, Lecturer, Punjab Agricultural College, discussed *Water Requirements for Cotton*. The delegates then inspected the irrigation system used on this farm. Mr. Saigol described the system, discussed its merits and pointed out that the capital investment was more than offset by savings in labor, water and improved irrigation efficiency.

The Punjab Agricultural College at Lyallpur, established in 1909, was the final place visited. Dr. A. Sattar, Principal, introduced the delegates to the College staff and then conducted the group on a tour of the college. Several sections were visited and the delegates showed considerable interest in the work of the college. The college stresses the importance of the practical application of Agricultural Technology through demonstration and with student participation. Upon completion of this tour, tea was served and the delegates then departed for Lahore.

BALLOKI HEADWORKS

20 February, 1960

On Saturday, February 20, a trip to the Balloki Headworks on the Ravi River, was sponsored by the Pakistan hosts.

The Balloki Headworks as constructed in 1912, consisted of a weir across the Ravi River, with 35 bays 40 feet wide between 7.25 feet wide masonry piers, for diversion of 6,300 cusecs into the 120-mile long Lower Bari Doab Canal. Originally an outfall for the Upper Chenab Canal, a link from the Chenab across Rechna Doab entered the river immediately above the weir on the right bank. This has been abandoned and the outfall moved 20 miles upstream.

The Lower Bari Doab Canal, designed for 6,300 cusecs, carries 8,300 cusecs during the summer months and irrigates about 2 million acres in Lahore, Montgomery and Multan Districts. The water allowance for the canal is 3.23 cusecs per 1,000 acres with an irrigation intensity of 66.6%.

In 1952-54 an additional headworks was constructed upstream adjacent to the Lower Bari Doab Canal intake, for diversion of 15,000 cusecs from the Ravi River to the Sutlej River through the 54-mile long Balloki-Sulemanki Lieeh Canal. The first 40 miles of the canal are brick lined. The outlet of the canal is above the Sulemanki Headworks and the water diverted from the Ravi River is diverted by these headworks into the Sutlej Canal systems.

The maintenance of the Balloki Headworks structures was notable. Gates and hoists were in good condition and metal work has been kept painted. The apron-down stream from the weir appears to have required considerable maintenance and will probably require much more until the apron is extended and provision is made to dissipate the energy of flood waters.

Although the Ravi carries a heavy load of silt during flood season, it appears that little silt is diverted into the canals. The location of the intake structures on the outside of a curve in the river and the elevations of the sills of the diversion structures with relation to the sill of the diversion weir create a favourable condition for minimum diversion of bed load into the canals.

The delegates were served tea in the park at the headworks, after which they returned to Lahore.

CHAPTER VIII

TECHNICAL PAPERS

A

WATER REQUIREMENTS AND CONSUMPTIVE USE

USE OF ELECTRICAL RESISTANCE UNITS TO DETERMINE CONSUMPTIVE USE BY CORN IN LEBANON[1]

By
SALIM W. MACKSOUD[2]

Summary

Previously calibrated electric resistance units were embedded at varying depths in a field just planted with corn. The resistance of each block was read just before and 24 hours after every irrigation. The amount of moisture that was depleted from the soil between consecutive irrigations was calculated and the total consumptive use of the crop was determined.

Introduction

The consumptive use of water for various crops has been determined by intensive soil moisture studies. This has been satisfactory in areas of uniform deep soil with a very deep water-table. Using this method, soil samples are usually taken by means of an auger or soil tube before and after each irrigation. The moisture content of each soil sample is determined using the standard oven drying method. The variation in moisture content between irrigations is used to determine the quantity of water removed from the soil per unit depth. If a large number of such samples are taken, at varying depths and throughout the growing season of the crop, its monthly and total consumptive use could be determined. This method has been used successfully, but generally requires much time and effort in getting the samples and determining their moisture content. Furthermore the excessive sampling, if used on a small plot, may influence the growing pattern of the crop under study.

The use of electrical resistance units for measuring the soil moisture content was envisaged as one way of reducing the amount of time required for determining the moisture content of many samples and for overcoming the damage that may result from excessive sampling in a small plot. Electrical resistance units have long been used for determining soil moisture. Various kinds exist on the market, but all are similar in principle. Two electrodes are surrounded by matrix material which is placed in contact with the soil. Water moves from the soil into the matrix material. The resistance between the electrodes depends upon the amount of water present in the matrix material which in turn depends upon the moisture content of the soil and a few other generally fixed factors for each specific case. Resistance units are sensitive to salt, with plaster units being less than others. Time, temperature and the interval between successive dryings influence the readings of most units. Units should be calibrated to get a relation between resistance readings and actual soil moisture content.

Procedure

1. 40 Resistance Units (CEL-WWD Plaster Soil Blocks, impregnated with plastic, obtained from Industrial Instruments Inc., 89 Commerce Road, Cedar Grove, New Jersey, U.S.A.) were calibrated to read moisture content. A set of eight units was placed in a soil sample taken from the field under consideration and containing a certain moisture content. Both soil and units

1. The work described herein was performed at the Terbol Experiment Station, Lebanon, and was undertaken as a special research project by the Division of Agricultural Engineering of the Faculty of Agricultural Sciences at the American University of Beirut.

2. Titles of delegates are given in the official delegate list, p. (iii).

were then placed in a glass jar with an air-tight cover. The leads of the eight units were brought out through a hole in the cover of the jar which was then sealed with Fairprene cement. Five moisture contents were chosen to represent the range of available moisture. Readings of the units were read at intervals with a BN1 Bouyoucos Moisture Meter until no change was observed. No serious change in temperature was experienced and no condensations were observed on the inside walls of the jars. The jars were opened and the soil moisture content determined. Table I gives the individual and average readings of the units in every jar and the determined moisture content of the particular soil sample.

2. The Volume, Weight and Moisture Equivalent of the soil were determined, as well as its Permanent Wilting Percentage using sunflower plants. These averaged as follows:

Moisture Equivalent =29.4%± .6%
Permanent Wilting Percentage =15.2%±1.1%
Volume Weight =1.08gms. per c.c.

3. From the calibration data determined in (1) and the basic data determined in (2) the figures in Table II were calculated to indicate the amount of moisture that would have been removed from the soil at the indicated readings of the units assuming the soil was at Field Capacity to begin with. The formula D=PVd, was used, where

D= depth of moisture removed from soil in mm.

P= Percent change in moisture content, with Field Capacity, as reference.

V= Volume weight in grams per cubic centimeter, or Apparent Specific Gravity.

d= Depth of soil under question in mm.

4. Eight locations were chosen in a newly planted corn field and 4 units were embedded in each location, at 10, 30, 50 and 70 cms depths. The leads were so marked and attached to stakes.

5. All the units were read just before each irrigation and 24 hours after the actual water application had stopped.

TABLE I.—Calibration of Plaster Units.

Unit Nos.	Average Meter Reading. Percent Moisture	Soil Moisture Determined by Oven Drying	Remarks
1—8	100	28.1%	Unit No. 3 read 60% Discarded.
9—16	75	25.0%	—
17—24	50	21.4%	Unit No. 24 read 80%. Discarded
25—32	25	18.2%	Units 27+28 read 0% Discarded.
33—40	10	16.5%	Units 38 & 39 read 0% Discarded.

TABLE II.—Extracted Water and Meter Readings.

Meter Reading in Percentage	100	90	80	70	60	50	40	30	20	10
Moisture removed from 20 cm soil layer, mm of water.	0	2.7	5.3	8.0	11.3	14.3	17.0	19.5	22.3	25.1

Data, Results and Discussion

Table III, on the following page gives the average readings of units placed at the same depth for each date. Also is gives the calculated depth of water in millimeters removed from each 20 cm soil layer during the interval between irrigations. The last irrigation was completed on September 17, and on September 25 the corn crop was topped and finally it was harvested on October 29, 1956. The total Evapo-transpiration or Consumptive use of the corn crop for the 113 days beginning with planting was found to be 310.3 mm or approximately 12 inches. The figure seems reasonable and the amount of work involved was considerably less than that usually required in an intensive soil moisture study by actual soil sampling. An interesting side light on this trial was supplied by comparing this Consumptive use figure, with that obtained using the Blaney Criddle formula, U=kF=sum of kf. The field in question falls on the 34th Latitude North and the Mean Monthly Temperature in degrees Fahrenheit was as follows:

June	71.5°F
July	75.5°F
August	79.5°F
September	74.5°F

TABLE III.—Readings of Units & Consumptive Use By Depths & During Given Intervals.

Date	Interval Days	For Units Placed at 10 cms. depth.		For Units Placed at 30 cms. depth		For Units Placed at 50 sms. depth		For Units Placed at 70 cms. depth		Total for Period in mm.
		Meter Reading	Water Removed in mm.	Meter Reading	Water Removed in mm.	Meter Reading	Water Removed in mm.	Meter Reading	Water Removed in mm.	
June 4	16	100%	25.1	100%	5.3	100%	0	100%	0	30.4
June 20		10%		80%		100%		100%		
June 21	12	100%	17.0	100%	5.3	100%	0	100%	0	22.3
July 2		40%		80%		100%		100%		
July 3	16	100%	19.5	100%	14.5	100%	5.3	100%	0	39.3
July 18		30%		50%		80%		100%		
July 19	15	100%	19.5	100%	17.0	100%	11.3	100%	0	47.8
Aug. 2		30%		40%		60%		100%		
Aug. 3	15	100%	17.0	100%	19.5	100%	8.0	100%	2.7	47.2
Aug. 17		40%		30%		70%		90%		
Aug. 18	15	100%	19.5	100%	19.5	100%	8.0	100%	0	47.0
Sept. 1		30%		30%		70%		100%		
Sept. 2	15	100%	17.0	100%	17.0	100%	8.0	100%	0	42.0
Sept. 16		40%		40%		70%		100%		
Sept. 17	9	100%	14.5	100%	14.5	100%	5.3	100%	0	34.3
Sept. 25		50%		50%		80%		100%		
Totals		113	149.1		112.6		45.9		2.7	310.3

The calculated monthly consumptive use, using for k=0.75, as suggested by the authors, is as follows:

June	5.20 inches or	132 mm
July	5.40 inches or	137 mm
August	5.50 inches or	140 mm
September	4.65 inches or	118 mm
	Total	527 mm

The monthly consumptive use, as determined by using the resistance units was as follows: (From Table III)

June (26 days)	49 mm
July	85 mm
August	100 mm
September (25 days)	76 mm
Total	310 mm

This shows a large difference between observed and predicted values, and it is unfortunate that actual consumptive use figures based on direct soil moisture measurements are not available to check both of these figures.

This trial was an attempt on the part of the author to reduce the amount of work involved in water requirement studies, fully realizing the risks and dangers of using a large number of resistance units for such work. The use of this method for measuring actual water consumptive use is limited by the accuracy with which soil moisture can be measured using resistance units. As such units are refined and improved. This method may gain considerable popularity.

Discussion

Dr. Nazir Ahmed mentioned that he has developed a device whereby a large, known, quantum of heat energy is released within 1 millionth of a second to a coil. The rate of dissipation of that energy is measured using the temperature-resistance characteristic of the coil as one leg of a Wheatstone bridge and is a measure of the moisture content.

This method is independent of salt in the soil water.

Mr. Ayazi mentioned that salt in the soil made a difference in the block readings and that the blocks should be calibrated for each soil. Professor Macksoud replied that it is true that salt influences the block reading. He stated that the particular experiment was based on using only a general calibration of the block in terms of percentage of soil water holding capacity, not on specific calibration for each soil. Dr. Asghar felt that these blocks would not be useful in most of the region due to the low educational level of the farmers.

PAKISTAN REPORT ON WATER REQUIREMENTS FOR CROPS

Presented by ABDUL HAFIZ[1]

Emphasis placed by Dr. Asghar in the country report for the last Seminar and also yesterday that *consumptive use* or *evapo-transpiration* is not in itself the correct basis for determining the actual water requirements for crop production. The magnitude of the salinity problem as it is in the Indus Valley is a glaring illustration of the point at issue. Not only the quantum of evapo-transpiration by the crop but the water requirement of the soil for sustained crop production have to be met if permanent agriculture is the objective. We must consider the total amount of water required for evapo-transpiration as well as for maintaining the productivity of the soil by protection from accumulation of harmful salts. This involves more than the existing concept of consumptive use. We must find a more composite name for the actual water requirements for crop production. Water requirements itself is a rather loose term as it can even cover other components like the conveyance loss, etc.

The irrigation system of West Pakistan, since the earliest irrigation project was brought into existance, has been designed on more or less an arbitrary water allowance for the land to be irrigated. The water requirements of soil were never considered. Although the water allowance was not fixed on the basis of any consumptive use studies, even if we assume that it was based on the consumptive use for the normal crop outturn obtained in this country, we have to remember that the average yields of our major crops are from one-third to one-seventh of the highest average yields obtained in other countries of the world. Consumptive use of water increases with the stand of the crop and therefore, consumptive use determined for a low crop outturn cannot be correct for higher crop outturns. Satisfaction was drawn from higher crop outturns obtained with irrigation than without irrigation and no more attention was given to the question.

Instead of charging for the canal-water delivered to the farmer on the volumetric basis, the crop rate basis was adopted and this led the Government into being interested in the maximum area being cropped by the farmer with minimum quantity of water. The limit is 25% of the normal crop outturn for the tract; below this the Government remits the crop rate. The farmer himself has laboured under the misconception that with a given quantity of water the gross outturn could be increased by cropping more area.

The Department of Agriculture also, in their work on water requirements of crops, confined its attention to economy of water and not to the actual requirement of crop production. But even the number of irrigations considered to be required for the maximum yield of a crop cannot be applied by the farmer with his misguided objective and that of the Government.

Work on water requirements of sustained crop production has been carried on for some years by the Directorate of Land Reclamation. For temporary reclamation of saline areas not yet completely gone out of cultivation, one cusec of water is generally required for 45 acres for three consecutive summer seasons. On some non-perennial canals where additional water is not available for the full summer season, one cusec is provided for 35 or 40 acres. For saline areas gone out of cultivation additional water is required for more than three years.

Lysimeter studies have given very useful information regarding the moisture movement pattern for the irrigation deltas applied to different crops. Rice, berseem and sugarcane crops were found to cause accretion to the water-table of 29% to 48%, 28% and 12% of the irrigation delta applied. Wheat, cotton, maize were found to cause depletion of water-table and therefore, upward movement of salts in the soil. For permanent reclamation and protection of soil from deterioration it is necessary to adopt crop rotations which give a downward balance of movement of moisture and salts in the soil. According to our findings to-date it is considered that the water allowance of canal irrigated areas has to be increa-

1. Asstt. Land Reclamation Officer, Land Reclamation Directorate, West Pakistan.

sed to one cusec for 150 acres from the existing allowance of one cusec from three hundred acres and above.

It is necessary to determine the evapo-transpiration requirements of different crops for maximum crop production and the soil requirements for protection from salinity and to add the two to get the total water requirements for crop production.

Work on consumptive use, as understood by Western scientists has lately been taken up at Jagattan Reclamation Farm in Lyallpur District and Bhallewala Reclamation Farm in Montgomery District. Part of the work done at Jagattan Reclamation Farm has been mentioned in the technical paper on *Distribution system in Irrigation Projects of Pakistan* to be presented in this Seminar. The table below is from that paper and is of interest. The reader should also refer to Fig. 2 of the referenced paper. The results show that the consumptive use as well as the consumptive use efficiency is different for different irrigation practices:

TABLE I.—Consumptive use efficiency and yield with different irrigation practices.

	Irrigation (Inches)	Rain (Inches)	Total (Inches)	Consumptive use (Inches)	Consumptive use efficiency.
Syphon	14.05	12.05	26.10	19.93	76.36%
Furrow	13.52	12.05	25.57	18.84	73.68%
Flat	15.30	12.05	27.35	20.50	74.99%

Discussion

Dr. Nazir Ahmed called attention to the fact that the position of the water-table, if within the capillary zone, influences the water requirement. Dr. Qureshi agreed that water allowances in the neighbourhood of 150 acres or lower per cusec are desirable under certain conditions of cropping and cropping intensity, but felt that this could not be done at first under new projects. Dr. A.G. Asghar agreed that the water allowance needed to be changed as the cropping pattern developes and that excess water during early years, if misused, can add to the problem of waterlogging.

CONSUMPTIVE USE OF WATER INVESTIGATIONS IN IRAN

By

ENG. M. REJALI and ENG. F. RAJI, IRAN

Introduction

The importance of water and irrigation in Iran is indicated by the fact that in most parts of the country, the only good and dependable farm production is by means of irrigation. Over these parts of the country, the normal annual percipitation is only about 20 centimeters.

Among the many reasons for the very low proportion of the land that is being cultivated, limitations having to do with water are most important. To overcome some of these limitations the Irrigation Cooperation has been undertaking many irrigation development schemes throughout the country during recent years. One of the most beneficial ones is the establishment of an Agricultural and Irrigation Investigation Section within the Cooperation. This section consist of a number of agriculture engineers, irrigation technicians and economists. Study groups from this section are sent to different parts of the country for making thorough investigations with regard to the farming patterns of those particular areas. These study groups gather accurate and definite information as to the method of irrigation, amount of the water available and sources of water; appraise the economical situation of the area; and finally submit comprehensive reports as regards the future improvements to be made in the area. Twenty-six of these studies have been made in the various parts of the country.

One of the major parts of the studies being undertaken by this section is the complete irrigation investigation. The field group, by use of a current meters, claculate the total amount of water which is available in any area, and by means of parshall flumes measure the amount of water used for irrigating various crops grown in the region and tabulate the date as is shown in Table No. I. In row-type irrigation two measuring flumes are used, one for intake and one for outflow. In flood-type irrigation only one at intake is used.

Technicians calculate the quantity of water used for irrigation in liters of water per second and in cubic meters volume and compare it with the quantity of water which is available in the river, canal or any other source of water. In this comparison adjustments are made for both proposals of changes in cropping pattern and in irrigation practices. This comparison shows how many hectares can be served by the total amounts of water to be made available in the proposed development.

In addition to the studies of irrigation practices, the groups study the methods of cultivation pre-

valent in the area and make recommendations as how to improve production methods and adopt suitable modern methods.

The Table No. II shows amounts of water being used per hectare for various crops in different parts of the country, as determined in these field studies of present irrigation practices.

Experimental work in determining consumptive use of water was begun in 1955 in the Division of Agricultural Engineering in the Ministry of Agriculture with the cooperation of American Experts. Since that time the work has continued with three crops, cotton, rice and sugar-beets, at Varamin and Karadj in the central plateau area near Tehran. In general, optimum use of water as found in these experiments are in reasonably close agreement the result obtained by the field investigations groups in studies of amounts of water being used by farmers who have adequate supplies.

Reference to the experiments made on cotton, and results concluded from experiments on sugar-beet will indicate the nature of these experiments and the factors being investigated.

COTTON

Objectives

This project was designed and executed in order to:

1. Determine the optimum amount of irrigation water at VARAMIN area on the cotton.
2. Determine distribution of irrigation water during the growing season (time between irrigations).
3. Determine the amount of water for each irrigation.

Principles of the Experiments, 1335 Agricultural Year

This experiment considers texture and its effects on the availability of water to the plant. The field capacity and wilting point of the soil at the location were not determined in advance, therefore a close estimate was made. By use of soil tube, the average moisture equivalent for the upper 3 feet at 24 hours after irrigation was determined as the starting point. The soil moisture at permanent wilting point was estimated by field test methods under several trials. The field capacity for the upper 3 feet was 19.5 percent of dry weight.

$$WP = \frac{F.C.}{1.84} \qquad WP = \frac{19.5}{1.84} = 10.5$$

19.5—10.5=9 Available Field Capacity.
10.5+1.8=12.3=20% Available Field Capacity.
10.5+3.6=14.1=40% Available Field Capacity.

Design of plots

As per Fig. 1 the land on which this experiment took place before preliminary agricultural seed bed preparation such as plowing, disking harrowing.

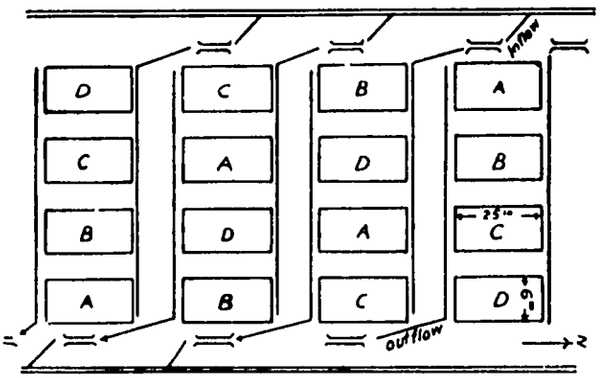


Fig. 1. Location of Plots Irrigation Experiments on Cotton

distributing fertilizers etc. was divided into 16 plots of equal size (25 mts. length and 6.4 mts. width) designated as follows:

A and C
Plots receiving 30 inches of irrigation water during the growing season.

B and D
Plots receiving 36 inches of irrigation water during the growing season.

A and B
Plots irrigated when the test moisture showed 40/100 Available Field Capacity.

C and D
Plots irrigated when the test moisture showed 20/100 Available Field Capacity.

Seeding

The seeding in all plots was in rows and distance between plants in row was 25 centimeters while spacing between two rows is 80 centimeters. Each plot was formed of 8 rows.

Method of Irrigation

The method of irrigation selected for this experiment is shallow furrow method and in order to distribute the amount of water equally among furrows concrete pipes of 20 centimeters length and 5 centimeters inside diameter were used. They were placed at the same level at entrance of furrows for each plot thus resulting of equal distribution of water. The excess at the end of furrow is drained away.

Water Measurement

During entire period of the experiment the inflow and outflow water of each of the 16 plots was

carefully measured using 3-inch parshall flumes and full data were recorded carefully in special forms prepared for the purpose.

Every effort was made to maintain precision, to reduce the time between measurements and to maintain uniform inflow to the plot.

Soil Sampling Procedure

Soil samples were taken every day but sometimes not until 48 hours after irrigation because of high moisture in the soil. Samples were taken from two different points in the root zone to determine the moisture from different depths. To avoid evaporation the samples were taken to the laboratory immediately.

TABLE I.—Estimated use of Zarinehrud water for one Hectare of each of Various crops, 1956.

Kind of Crop	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Total
Wheat	1680	840	..	..	..	..	..	1000	1200	..	..	280	5000
Cotton	..	..	..	..	..	..	..	120	..	810	810	1200	4020
Sugar-beets	1500	..	..	..	..	..	..	..	1200	2200	2050	1600	8550
Other summer crops	600	1200	..	..	1000	..	..	800	1300	700	1200	600	7400
Alfalfa	..	..	..	..	1000	..	750	1500	1550	2400	2750	1550	11500
Tobacco	..	1200	..	..	..	..	..	..	..	1500	1400	..	4100
Garden	600	..	..	..	800	..	..	..	1000	1000	1000	600	5000

NOTE:—Measurements of water were made only in the months of September and October. They are subject to a wider range of error than when made over a longer period of time.

At the laboratory the moisture content was determined by weight difference due to drying at 105°C in an oven for 24 hours. This was converted to depth of water equivalent.

To determine whether or not 24 hours of drying was adequate some samples were dried for a longer period, however, no additional loss of weight occurred.

Consumptive use of water

The theoretical consumptive use of water by cotton at VARAMIN was computed as follows:

U = KF=sum of Kf

U = consumptive use of crop

K = monthly coefficient = $\frac{U}{f}$ = 0.62 for cotton

f = monthly consumptive use factor = $\frac{t \cdot p}{100}$

t = mean monthly temperature in degrees Fahrenheit

p = monthly percent of daytime hours of the year.

Months				Temperature mean monthly	Hours % (p) day time	Consumptive use factor(f)	Coefficient	Consumptive use in. (u)
Mar. 22—Apr. 22	..	..	..	56.6	8.86	5.01	0.62	3.01
Apr. 22—May 23	..	..	..	66.9	9.59	6.41	0.62	3.97
May 23—Jun. 23	..	..	..	75.7	10.08	7.63	0.62	4.57
Jun. 23—July 24	..	..	..	83.4	10.03	8.36	0.62	5.01
July 24—Aug. 24	..	..	..	84.3	9.59	8.08	0.62	4.85
Aug. 24—Sept. 24	..	..	..	75.7	8.87	6.71	0.62	4.02
Sept. 24—Oct. 24	..	..	..	64.2	7.83	5.02	0.62	3.01
Oct. 24—Nov. 23	..	..	..	55.0	7.14	3.92	0.62	2.35
Nov. 23—Dec. 23	..	..	..	44.6	6.68	2.97	0.62	1.78

TABLE II.—Quantity of water used for irrigating one hectare of different crops, cubic-meters

Kind of Crops	Colpa-vegan	Sistan	Esfa-han	Shush-tar	Mian-doab	Behbe-han	Marve-Dasht	Bam-pur	Garm-sar	Nesh-bur	Meh-ran	Sari-su	Sara-ks	Bijar	Vara-min	Hami-dich
1 Wheat	7200	5000	7600	2200	5000	25000	3600	3500	5200	6750	4700	7500	5500	3300	5600	3600
No. of Irrg.	6	4	7	4	3	3	4	5	6	7	5	10	5	4	8	4
2 Rice	..	..	52100	32000	..	..	39500	..	..	..	..	..	..	..	..	..
No. of Irrg.	..	..	..	4	..	..	6	..	..	..	..	..	..	..	..	..
3 Potatoes	..	..	8400	..	7400	..	..	..	..	..	..	..	..	..	..	..
No. of Irrg.	..	..	9	..	8	..	..	..	..	..	..	..	..	..	..	..
4 Sugar-beet	..	..	..	..	8550	..	12000	..	..	..	..	..	..	..	..	..
No. of Irrg.	..	..	..	..	8	..	15	..	..	..	..	..	..	..	..	..
5 Cotton	7300	8900	9000	17000	4500	9200	8200	..	7500	7500	..	7500	7500	..	8000	..
No. of Irrg.	5	9	10	8	4	13	4	..	10	8	..	10	6	..	8	..
6 Tobacco	..	..	..	..	4100	..	..	..	..	..	..	..	..	..	..	..
No. of Irrg.	..	..	..	..	6	..	..	..	..	..	..	..	..	..	..	..
7 Alfalfa	18000	32000	..	28500	11500	..	..	..	..	..	..	..	12750	9000	..	..
No. of Irrg.	19	32	..	31	14	..	..	..	..	..	..	..	15	13	..	..
8 Melon	9300	6000	8000	7000	..	..	..	6200	7200	..	..	..	7500	..	..	..
No. of Irrg.	14	..	13	5	..	..	..	8	..	..	..	..	6	..	..	..
9 Orchards	10000	..	..	14000	..	13500	7000	10500	9500	..	17200	11000	5000	..	..	..
No. of Irrg.	10	..	..	11	..	19	11	16	11	..	24	20	4	..	..	..
10 Palm	..	..	..	..	..	10500	..	..	..	..	..	..	..	..	..	..
No. of Irrg.	..	..	..	..	..	8	..	..	..	..	..	..	..	..	..	..

TABLE III.—Date, Amount of Irrigation and Yields Cotton Plots

Irrigation No.	PLOTS A	B	C	D
1	June 21 3.32	June 27 3.47	June 30 3.00	June 28 3.51
2	July 1 3.00	July 8 2.62	July 17 3.67	July 11 2.98
3	July 15 2.24	July 15 1.63	July 26 1.91	July 18 1.69
4	July 22 1.76	July 22 2.07	Aug. 1 1.30	July 24 1.32
5	July 29 1.77	July 29 2.10	Aug. 7 1.64	July 30 1.56
6	Aug. 6 2.04	Aug. 5 2.42	Aug. 14 3.04	Aug. 7 1.82
7	Aug. 13 2.99	Aug. 13 3.00	Aug. 22 3.69	Aug. 14 3.04
8	Aug. 19 3.00	Aug. 19 3.09	Aug. 29 3.07	Aug. 22 3.57
9	Aug. 25 3.02	Aug. 26 2.96	Sept. 8 4.35	Aug. 29 2.98
10	Sept. 4 3.39	Sept. 5 4.09	Sept. 19 4.29	Sept. 9 4.48
11	Sept. 13 3.45	Sept. 14 4.16	— —	Sept. 19 4.54
12	—	Sept. 25 4.09	—	Oct. 3 4.51
Total Irrigation in Inches	30	36	30	36
Yield, Tons per hectare	2.13	1.97	2.08	1.85

The yield

To determine the yield of any given plot, to prevent border effect and other plot effect, only the middle 4 rows out of each 8 rows of a plot were selected also the yield of one meter in length from the ends of each row was eliminated. The area thus left was measured carefully. The yields are reported in Table III. It can be seen that plots receiving 30 inches of irrigation water during the growing season gave the best results.

SUGAR-BEETS

This reports results obtained from the experiments made on sugar-beets at Karay in 1957-58.

The objective of this study was the same as for above experiment. Some fertilizers were used in this experiment to be concise. We are forced to indicate the pattern of plots.

1957 *Experiments*—In 1957 the lands were divided into 8 sections which had the same length and width. To identify plots and to distinguish the treatment following symbols were used:

First time of irrigation	T1
Second time of irrigation	T2
Fertilized sections	F
Unfertilized section	O
Indicating the replications	BCD

Leading to sections as follows:
T1 F, O (A.B.C.D.)
T2 F, O (A.B.C.D.)

Research plan is split plot. The main plots were formed by the percentage of moisture at the irrigation time.

1958 *Experiments*—The number of sections in 1958 was twice that for 1957. The land was divided into 16 equal (25×10) sections. The research factors were:

First time of irrigation	T1
Second time of irrigation	T2
Fertilized section	F
Non-fertilized sections	O

Leading to sections:
T1 F (A.B.C.D.)
T2 F (A.B.C.D.)
T1 O (A.B.C.D.)
T2 O (A.B.C.D.)

Type of Irrigation

The type of irrigation was furrow irrigation. To divide the water equally in all the furrows, wooden pipes 25 centimeters long and a having diameter of 5 centimeters were used. After passing through the furrows the surplus entered the main drain.

Quantity of the crops

For sugar-beets, two things are very important, amount of crop and the amount of the sugar which can be gotten from the crop.

Farmers try to increase their crop to get more income from sale but the sugar factories want to buy the beets which have the most sugar. Farmers must learn to consider also sugar content and the condition of the root.

Results for 1957

In an area of 250 square meters twenty rows of beets were planted. Ten of them had chemical fertilizer and ten had none.

In harvesting, to prevent side effects, two furrows were chosen from each ten furrows, and, one meter was cut from the beginning and end of each kart. The harvesting was done therefore in an area of 23 square meters.

TABLE IV.—Results of 1957 Experiments on Sugar-beets

Name of Section	First Replication	Second Replication	Third Replication	Fourth Replication	Average
		YIELD IN KG/HECTARE			
T1 F	42304.34	35652.17	35434.78	29130.43	35630.43
T1 O	39000.	33478.28	29565.21	25218.39	31815.22
T2 F	36456.52	39130.43	39130.43	46304.34	42255.22
T2 O	23456.52	44782.60	33913.04	38695.65	35211.95
		PERCENT SUGAR			
T1 F	19.4	19.	19.2	19.8	19.35
T1 O	20.4	20.2	20.	20.	20.15
T2 F	19.4	19.2	19.6	19.4	19.40
T2 O	20	19.4	19.9	19.6	19.72
		TOTAL SUGAR YIELD IN KG/HECTARE			
T1 F	8207.04	6773.91	6803.47	5767.82	6888.06
T1 O	7956.	6762.61	5913.04	5043.47	6418.78
T2 F	7072.56	7513.04	7669.56	8983.04	7809.55
T2 O	4691.30	8687.82	6748.69	7584.34	6928.03

Table IV shows the crops harvested in each section.

The best crops occured in sections which had chemical fertilizer and irrigation was done when 75% of the available moisture was used.

Percentage of Sugar

To ascertain sugar content; from each of the sixteen sections 50 hects were sent to the laboratory. The percentage is shown in table IV.

As may be inferred from the above table, the sections which did not have chemical fertilizer and the irrigation was done when the available moisture was reduced to 50% have the best percentage results. Table IV also shows the amount of sugar yield in kilograms per hectare.

The best results are given by the sections which have chemical fertilizer and were irrigated when the available moisture was 75%.

Results for 1958

In harvesting, to prevent side effects, six furrows from every section were chosen and one meter was discarded at the end of each furrow. Thus the harvesting was done on an area of 23 meters long and 3 meters wide. The results are shown in Table V.

TABLE V.—Results of 1958 Experimeats on Sugar-beets

Name of Section	First Replication	Second Replication	Third Replication	Fourth Replication	Average
		YEIELD IN KG/HECTARE			
T1 F	52333.3	43942.	49956.5	44682.6	47728.2
T1 O	55043.4	31753.6	47855.	36695.6	42836.9
T2 F	50811.5	45376.8	48347.8	44347.8	47220.9
T2 O	38362.3	37971.	31623.1	46550.7	38626.7
		PERCENT SUGAR			
T1 F	21.6	21.6	21.4	21.8	21.6
T1 O	21.6	22.	21.4	20.4	21.45
T2 F	22.	21.6	21.	21.8	21.6
T2 O	21.4	21.8	21.8	21.2	21.55
		SUGAR YIELD IN KG/HECTARE			
T1 F	11304.	9491.5	10690.7	9740.8	10309.3
T1 O	11889.4	6985.8	10432.4	7485.9	9188.5
T2 F	11178.5	9801.4	10153.	9667.8	10199.7
T2 O	8209.5	8277.7	6893.8	9867.7	8324.1

In Summary for 1958

1. Maximum amount total crop was given by the sections which had chemical fertilizer and available moisture was 50% (this is contrary to 1957).

2. The maximum percentage of sugar was in the section that had chemical fertilizer (contrary to 1957).

3. Maximum amount of sugar came from sections that had chemical fertilizer and the irrigation was done when the percentage of available moisture was 50% (there was a slight difference in 1959).

Amount of Water

Table VI shows the amount and replications of irrigation.

TABLE VI.—Application of Water

Name of Section	Replication of Irrigation				Inches of Water		Water Cubic Meters Per Hectare	
	1	2	3	4	1957	1958	1957	1958
T1 F	20	23	24	22	46.8	53.2	11887	13512
T1 O	20	23	24	22	46.8	55.1	11887	13995
T2 F	18	21	21	22	49.6	55	12598	13970
T2 O	18	21	21	22	49.6	53.1	12598	13487

CONCLUSIONS

As reported earlier in this report, optimum amounts of water for similar plots C (fertilized and unfertilized) were found to be similar to amounts being used by farmers. One important suggestion come from the experiments for improving farm production. Yields were significantly higher on the experimental plots. This suggests possibilities for improving farm production through developing correct irrigation practices (minimizing water losses), land levelling, better plowing and use of crop rotations, manure, chemical fertilizer and other means not involved in the present comparison of results. Much further work in consumptive use will be needed as these and other improved production practices come into common use.

Discussion

Dr. Qureshi noted that the consumptive use coefficient had been uniformly applied for each month and stated that this varies from a minimum value of about 0.5 to a maximum of about 0.9 under conditions occurring in south-western U.S.A., Pakistan and Iran. Values of "k" in Pakistan are April, 0.5; May 0.6; June, 0.75; October, 0.55; and November, 0.5. There are also areas in the north where the season starts later in May and crops take water in December. In this case, the December coefficient is again 0.5. The average is 0.7. Mr. Raji stated that they found the average for cotton to be 0.65; they have not computed the values by months, but could do so from the data available.

B

LAND DRAINAGE AND RECLAMATION

INVESTIGATION AND PLANNING THREE PROJECTS

By

ENG. M. AYAZI, IRAN

GARMSAR AREA

Introduction

For some years the farmers of Garmsar district have strongly considered the development of improved lands. In order to increase the area of cultivated land they have reclaimed some saline and alkali soils. These development activities are made through local and non-local farmers sporadically. Most of these farmers and landowners do not succeed in the development work—either they quit or they dispose to others. Studies have been made to determine the reasons for this. First, the soil is saline and alkali, and the water-table is too high; second, the farmers and landowners do not know correct methods and procedures of drainage and land reclamation for the improvement of saline and alkali soils.

Considering the above difficulties, the Ministry of Agriculture has established a Research Station at Nooreddin with the cooperation of other interested organizations. This station is working for determination of practical and economical methods of reclaiming unproductive saline and alkali soils of the area. Furthermore the farmers and landowners are expected to take advantage of the methods used for drainage and land reclamation and correct procedures demonstrated through the station technicians.

Location and Agricultural Conditions of Nooreddin Village

Nooreddin Village has an elevation of 810 meters above sea-level, and this village has been developed during the last seven years. The land was part of a desert which has been developed by the local farmers during the last seven years. They have tried to reclaim and develop it, however, they have not used proper methods; therefore, satisfactory results have not been obtained. The fields are semi-cultivated or uncultivated, the water-table is high, and the soil is rather saline so the crop yield is low, and it is decreasing year by year as shown in the table below:

Year	Crop	Yield Kilos/ hectare
1954	.. Wheat	.. 900
1958	.. Wheat	.. 300
1954	.. Cotton	.. 1,050
1958	.. Cotton	.. 300—450

The inhabitants of the village, which consists of 40 homes, have adapted mostly ranching as their work.

Nooreddin has two ganats, one of which was excavated about 27 years ago. This ganat had been excavated originally to lower the underground water-table in upper areas, and the water comes to the surface of the land in Nooreddin fields. In years 1949—1956 this ganat was extended and the flow is 150 liters per sec. (April, 1958). The length of the ganat between the mother well and the place where the water flows onto the surface is about 1100 meters. The water is rather hard and its salt content is 2240 p.p.m. (third class water). Another ganat has been excavated in the years 1955-1957 to drain the area through which it passed. The flow of this ganat is 60 liters per sec. The water of this ganat is not utilized and flows into the desert. Salt content is about 2240 p.p.m.

It should be added that some development work was done in the years 1955-1956 by local farmers, but since then it has stopped and the area is semi-developed.

Selected Desert for Research Station

The selected desert is situated in the southern part of Nooreddin village and an experimental station has been established for drainage and land reclamation purposes. This area has a length of 6300 and a width of 1700 meters. As already mentioned Nooreddin village is in the north of this desert and the Dehnagsh village is in the west.

Weather Data

A weather station has been established at the Nooreddin village and weather data collected. The summary of results are as follows:

Max. temperature	..	44° centigrade
Min. ,,	..	—9° ,,
Max. daily evaporation	..	21 millimeters
Yearly evaporation	..	2600 millimeters
Max. wind velocity	..	28 kilometers per hour.
Annual precipitation	..	109 millimeters

Drainage Investigation

The investigation made for drainage consists of following steps:

1. *Topographic Surveys*:

As the availability of the grade of land, common features, and the outlet of drains were very important, a topographical map of 1100 hectares areas of selected desert was made. The map was made by gridding in two serials 1:3000 and 1:5000 with 50 centimeters contour interval.

As a whole, all of the 1100 hectares of land were stripped at distances of 300 meters and the appexes of all stripped land were marked by numbered stakes, thus making every kind of study easy and simple. The crews performing the studies can locate any point without any difficulty. This desert has steady and uniform grade averaging 3-4 meters per kilometer from north to south. The profiles of the four investigation lines show the grades are almost uniform and steady.

On the desert under study there are no gullies, hills, breaks in slope or eroded patches. One existing feature is a natural drain starting from about 2 kilometers down from the upper edge of the land and ending in the lower edge. The depth of this drain is40—80centimetes at different points and the width at the top is about one meter. This drain leads the surplus water of a few springs in its path, and also the drainage water of its surroundings, to the end of the selected desert path. In the summer season, as the water-table is low. this natural is dry. The other features of the patch are four other shallow drains in the northern edge, the length being around 400—500 meters with a depth of one meter. These drains were excavated in the years 1955-1956. As these drains do not have proper cross-section and are not maintained well, they are deteriorating. At present they are not efficient from a drainage point of view.

Four springs exist in the selected desert. These springs are located in the low lands of the desert and are forming marshy fields around them. The water of these springs runs out from a depth of about six meters. The water is rather soft and is used by local ranchers. Following are results of analyses of these waters:

Location of Water Sample	Date of Sampling	Total Salts
Rashmeh Guy Spring ..	May, 1958	1400 p.p.m.
Shurguy Spring ..	,, ,,	490 ,,
Kurkulan Spring ..	June, 1958	1856 ,,
Guyelar Spring ..	,, ,,	1856 ,,

2. *Soil investigation*:

(*a*) *Texture and Stratum Survey*:

Soil investigation has been made regarding the texture and stratum survey, and also for total salt content within a depth of 3 meters. This important information was needed for land reclamation purposes.

Three hundred samples of soil in the area of 1100 hectares, taken to a depth of 3 meters, show the salts content ranging between 0.45% and 3%. Tests show that the soil has less salt with depth. It even reaches to a percent whereby the soil is satisfactory for cultivation. In the most part the tests show the salt content to be 1.5% to 3%.

Probably the most important single technical phase of the drainage investigation is the soil-stratum survey, which gives the location and physical characteristics of the various under-lying soil layers.

Four investigation lines were established and piezometers installed to a depth of 2 meters, at intervals of 300 meters. Auger holes have been dug beside each piezometer to a depth of 3 meters for soil profiles.

The top soil changes between the ranges of 40—80 cmts, and is a permeable sandy loam layer at this depth. The interesting part is that we rate this soil as in *SL* category; but agricultural soils of *SL* type really do not exist. Perhaps in the years past, by evaporation and the accumulation of the salt at the surface, especially gypsum crystals ($CaSO4$, $2H_2O$), have formed a distinctive granulation. This layer, because of having a great quantity of soluble salts, has a brownish-white color. The chemical tests show that there is a great quantity of gypsum in this layer. Even in the testing procedure, flocculation takes place. The presence of exchangeablesodium is very noticeable, but lime content is very low or does not exist.

The study and chemical analysis of soil of this layer for the experimentation of land reclamation is very important and has been done carefully.

The pH of this layer has been indicated first by chemical indicator and later by pH meter, and ranges between 8 and 10, averaging 9. After this layer there is some silty clay. This layer is a rather medium-texture type. The layer that is lower than about meters is silty clay and clay which has a great influence in natural drainage. In some profiles in depths ranging between 1-3 meters these are some light layers such as sand, sandy loam and gravel.

The existing layers having olive and gray colors like the hills and cuts in the northern area of Garmsar plain, and show very clearly that they are of the same formation. The ramnents of vegetation and the roots in the layers which grow in the marshy areas; also the appearance of vegetation features, prove that this desert has been a marshy area for years in the past.

(*b*) *Soil Permeability* :

To determine the soil permeability the field measurement method of piezometers and auger hole methods have been used.

The results show the coefficient of permeability changes from 2"/hr. to 4"/hr in different places and with different stratum. In some places coefficient of permeability has even been measured from 8" to 10" per hour. With the above mentioned quantities it is obvious that permeability classes change from moderate to rapid within this area.

(*c*) *Soil Analysis* :

(1) Dissolved salts—The salt content is measured by using the conductivity bridge and is as reported above.

(2) pH of the Soil—The pH of soil is found using pH indicator and pH meter as follows : In the upper layers of the (from 0 up to 100 cms) down, because salt has been accumulated in the past years, the pH of soil is high ranging between 8 and 10 and as a whole it is about 9. Thus the quantity of exchangeable sodium is heavy in this sandy loam layer which is rated as saline-alkali. Luckily this layer holds a large quantity of gypsum crystals providing a suitable condition for land reclamation

(3) Soil that have been reclaimed in recent years : Samples taken of areas of Dehnagsh and Nooreddin villages that are reclaimed in recent years by non-technical procedures are very interesting. Samples were taken at two different places in Dehnagsh area and tests made. The results are :

Depth of Soil centimeters	Salt content percent	Depth of Soil	Salt content percent
0— 60	0.34	0— 20	0.25
60—100	0.31	20— 40	0.31
100—160	0.46	40— 80	0.19
160—240	0.49	80—160	0.18
240—260	0.53	160—300	0.38

As it is noticed these changes in the profile of the soil in the first year of reclamation are worth considering.

Samples taken at Dehnagsh from an alfalfa field which has been under reclamation and cultivation for 6 years and tests made show the following results :

Depth of soil centimeters	Texture	Salt content percent	Water-table depth m.
0— 20	SCL	0.39	1.6
20— 40	SCL	0.44	"
40— 80	L	0.39	"
80—100	SCL	0.52	"
140—160	CL	0.34	"

Results obtained from the soil of Nooreddin where wheat and alfalfa are cultivated were as follows :

Wheat Field		Alfalfa Field	
Salt content percent	Depth of soil centimeters	Salt content percent	Depth of soil centimeters
0.53	0— 20	0.22	0— 20
0.38	20— 60	0.21	0— 50
0.18	60—140	0.20	50—160
0.16	140—180	0.20	160—240
0.19	180—240	0.18	240—300
0.20	240—300		

The samples of the soil of Nooreddin in the orchard of Alimadad, reclamation of which was started about 20 years ago using non-technical

procedures, have been analysed and the results are as follows :

Salt Content	Depth of soil	Salt Content	Depth of soil
—	—	0.34	0— 20
0.17	20— 60	0.25	20—100
0.22	60—120	0.23	100—160
0.25	120—200	0.26	200—300

Alimadad has been able to develop some 30 hectares of desert land in Nooreddin area in a period of several years. He has established an orchard in this area. The feature that was considered interesting at Alimadad orchard was lack of deep and adequate drains.

He stated in the last 20 years, his trees, on account of raising of underground water-table to an unallowable limit, have perished twice. He then replanted the trees. The reason for this raising of the underground water-table is assumed to be heavy precipitation at Firouzkuh mountains, full flow of Hablehrud, heavy floods and surplus water of irrigated uplands. In ordinary years, as this area is slightly higher than neighbouring areas, the water-table is rather low. In May 1958 the underground water-table was checked to be 180 cms below the surface. If a few deep drains were excavated in this orchard good agricultural results could be obtained.

The crops raised in this area are some wheat, alfalfa, melons, and cotton, but not much. The trees planted in the last few years are : some fig trees, mulberry, pomegranate, apricots, apple and Hungarian olive trees. The orchard land is located in the north-west of the selected desert and for this reason its development is worth consideration.

Summarily the results obtained from investigation and examination of the soil samples of Dehnagsh and Nooreddin show that although the reclamation was done by primitive methods, and the work was handled by the old system; still looking to the aspect of development and economy, it is worthy of appreciation.

3. *Water-Table Investigation:*

To study the fluctuation of underground water-table, a grid pattern was established on entire selected area. Piezometers have been put across the grid which consists of 154 points at intervals of 300 meters. These piezometers are 2/5 meters long and the diameter is about 0.9 centimeters. The depth and fluctuation of underground water-table starting from March, 1958, in different months, were measured and recorded and graphically plotted. The depths of water on March 24, 1958 at different points ranged between 20—100 cms. In general, during March 1958, the underground water-table was less than 100 cms. in depth. The underground water-table and its fluctuation is clearly noticeable. In later months, up to August, the underground water level was receding to a maximum depth of 1.80 mts.

4. *Water Source Survey:*

During the study of underground water-table fluctuation, the sources of drainage water was carefully considered. According to the studies made, the sources of drainage water of Garmsar plain are influenced by the following factors :

(*a*) As the soil of the district is salty, in the period of time that Hablehrud is in flooding season, the farmers leach their land as much as possible. The surplus water penetrates to the lower areas thus raising the underground water level.

(*b*) In the distribution of Hablehrud, which is the only river of the area, the technical aspects are not considered. Neither water measurement is popular, nor the canals and ditches are lined. As it has been stated above the Northern area of the plain is very permeable, thus a great quantity of water in the canal and ditches is wasted, through seepage losses penetrating to lower areas of the plain and consequently raising the underground water-table tremendously.

(*c*) Since the water measurement is not properly handled and the farmers do not care for technical methods, they use excess irrigation water thus contributing to the underground water-table in the lower areas.

(*d*) In order to check probable artesian pressure in the Garmsar district, a piezometer cluster to a depth of 6 meters was set. The results show an artesian pressure does exist, but, the piezometers indicate a hydrostatic pressure in a stratum and four springs which are flowing in this area originate from this stratum.

5. *Ganats :*

Among the implementations of agriculture and irrigation in Iran, ganats are very important, and were popular with our ancestors. In the areas that proper grades exist, in order to take advantage of underground waters, the e ganats

are developed. In Garmsar district, in recent years, several ganats have been developed. Generally in most southern villages of Garmsar district there are ganats. The wells excavated and their numbers, depend on the grade and the depth of underground water. In the southern villages of Garmsar plain, as the underground water level is high, the length of the ganats are short, but the salt content is rather great and all ganat water is hard. The ganat waters are used to compensate for the shortages of the Hablehrud river. In recent years, because farming is increasing, water is not sufficient. Thus farmers and the Public Domain Department are considering the development of ganats. Through the development of more ganats the water shortage in the area has been adequately solved. Improved and existing ganats number 30 each and there are about 10 ruined ganats.

The results of the analysis of some ganat water at Garmsar are as follows :

Name of of Ganat	*Sampling Date*	*Salt Content p.p.m.*
Mohamedabad	May, 1958	2600
Adlabad	,, ,,	2100
Saidabad	,, ,,	2400
Nooreddin	,, ,,	2240

6. *Natural Vegetation* :

The natural vegetation of this area is divided into two parts :

(*a*) Plants which grow, generally, all over the area :

1. Salincornia herbiacea
2. Alhagi camelorum
3. Tamarix
4. Reaumuria cistodes
5. Statice spp.
6. Atriplex spp.

(*b*) Plants which grow only by the surroundings of desert springs :

1. Aelocepus litoralis
2. Cynanchum acutum
3. Frankenid aucheri
4. Setaria viridis
5. Kochia spp.
6. Cressa cretica
7. Asparagus officinalis
8. Spergulasia narginata
9. Taraxcum
10. Trogropogom
11. Scripus polochaemus

7. *Results of Drainage and Land Reclamation Investigation* :

The studies made in the Garmsar district and the results obtained are as follows :

(*a*) This district is the center for wheat, cotton, melon, pomegranates and figs. Because the area is close to Tehran these fruits sell the best.

(*b*) In this district the cost of lands which have formerly been reclaimed is about 5 to 8 times higher than those which have been reclaimed recently. As the cost of reclamation of this land is not large considering the availability of implementation, it is worthy of every consideration.

(*c*) The technical studies including meteorology, soil, water and feasibility of drainage and reclamation made in this area, and also activities achieved through public domain and landowners for drainage and land reclamation, although not completely correct or adequate, shows a good future and hopeful disposition.

(*d*) The drainage and land reclamation of this area is of utmost interest to both landowners and the Public Domain Department, and the results obtained are satisfactory. Therefore, it was justifiable to establish a drainage system for land reclamation to demonstrate the results of proper methods and procedures to the farmers and landowners.

Project Preparation

According to the results of investigation, a project was prepared for a drainage system to be executed and is now in action.

A brief description of the project and its design will be described below :

The project area is about 1100 hectares (3000 meters by 1700 meters), and is divided into two parts. First part, which is situated in the upper section, consists of 500 hectares. The drainage and land reclamation work will be executed in the first part and when it is finished, the results obtained will be used to plan, the operation to start in the lower part.

The design of the drainage system which is under execution consists of :

1. *Five Ganats* : These ganats are about 10 km total length. They will serve a double purpose, and will be used as an underground drainage system and at the same time as a water

supply. Three of these ganats are excavated at the Nooreddin newly reclaimed area to get water for irrigation of the upper part of the project area. At the same time they will drain a large section of the Nooreddin village lands. Two of them will be used now as a water ground drainage system and later, when the quality of water is suitable for irrigation, the water will be used for irrigation of the lower part of the project area.

The quality of the water of these ganats are as follows :

Description	Sampling Date	Salt Content p.p.m.
Nooreddin ganat	October, 1959	2240
Ganat No. 1	,, ,,	2730
,, ,, 3	,, ,,	1400
,, ,, 4	,, ,,	11200
,, ,, 5	,, ,,	2240

The excavation programs of the ganats are as follows :

Ganat No. 1	1400 meters
Ganat No. 2	800 ,,
Ganat No. 3	1200 ,,
Ganat No. 4	1200 ,,
Ganat No. 5	1500 ,,

2. *Main Open Drain* : This drain, which will be used as outlet of the underground drainage system, is situated in the middle of the project area and will be 6 km long at the final stage, but now only 3 km of it will be dug. About 2.2 km of this main open drain is finished, and has the following specifications :

(*a*) Depth	3m.
(*b*) Bottom width	1.2 m
(*c*) Side slope	$1\frac{1}{2}$:1
(*d*) Slope	0.12 %

This drain was excavated by dragline and bulldozer and its outlet is the desert.

3. *Underground Laterals* : To determine the depth and spacing of laterals some research work has been done. The effects of the ganat system, and open drains, on the water-table elevation have been studied and the results show that 250 meters spacing with 1.8 meters depth is a suitable design.

Fourteen laterals will be installed as underground drains.

A trench liner machine is available for trenching and Kaval will be used instead of tile, Fig. 1.

Land Reclamation

When the drainage system is installed the land reclamation work will start. According to the research made in the farmer's fields, as special program is prepared for reclamation of the saline and alkali soils of this area. The Hablehrud river water will be used for leaching and the cropping program will start with alfalfa and barley.

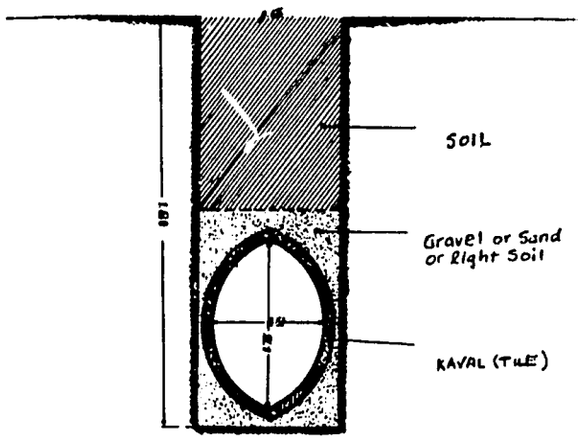


Fig. 1. Installation of Underground Drainage System by Kaval

Conclusion

The Garmsar drainage and land reclamation project includes all the problems existing in the arid regions. The research work for drainage and reclamation of saline and alkali soils, installation of different kinds of drains and other relative activities is worthwhile for training and demonstration purposes. This project is used as a training ground and also has grealy influenced the farmers and landowners to become acquainted with the technical rules of drainage and land reclamation.

TABLE 1.—**Water Quality for Garmsar Reclamation Project.**

No.	Sample Location	Total Soluble Salt p.p.m.	Date
1	Hablehrud river before the salt springs join it.	340	April, 1958
2	Hablehrud river at Sar rud (the distribution place).	2100	,, ,,

No.	Sample Location	Total Soluble Salt p.p.m.	Date
3	The reservoir of salt springs at Bon Kooh close to tunnel.	215000	April, 1958
4	Another reservoir of salt spring	12900	" "
5	Delichai River	240	" "
6	The ganat of Mohammadabad	2600	" "
7	" " " Adlabad	2100	" "
8	" " " Saidabad	2400	" "
9	" " " Nooreddin	490	" "
10	Shoor Ghovi Spring	1400	" "
11	Reshmeh Ghovi Spring	1856	July, 1958
12	Kor-koolan Spring	1856	" "

No.	Sample Location	Total Soluble Salt p.p.m.	Date
13	Quality of underground water of desert at Nooreddin		
	Points :		
	A9	28000	April, 1958
	A17	44100	" "
	C3	34300	" "
	C19	42000	" "
	E3	27000	" "
	E10	28000	" "
	E11	264600	" "
	G3	8400	" "

TABLE No. 2.—**Results of Soil Analyses, Garmsar Project.**

Lab. No.	Saturation percentage	ECX 103	Ph of saturation extract	Soluble Cation M.e/l Ca++ Mg++	Na+	Total	Soluble Anion. M.e/l CO3	HCO3	SO4	Cl	Total	Exchangeable CEC m.e/100 gr	E.S. m.e/100 gr		Alkaline Earth Carbonate m.e/100 gr.
3749	3	104	7.4	209	876.2	1085.2	..	2	284.4	855	1105.4	3.74	3.50	High	8.5
3750	36	53.7	7.3	156.8	398.3	555.1	..	1.8	141.2	428.1	571.1	3.07	1.90	"	13.6
3751	40	33.	7.5	84	236.2	320.2	..	1.5	82.2	250	333.7	5.47	.90	"	12.6
3752	44.8	190.	7.5	65	350	415	..	2	65.1	115	341.8	5.50	..	"	20.9
3753	40	54	7.4	144	349.2	493.2	..	2.5	82.6	419	504.7	14.75	..	"	16.7
3754	32.1	117.5	7.5	270.6	978.1	1248.7	..	1.8	173.5	1082.5	1257.8	6.70	5.30	"	13.3
3755	30	17.8	7.3	83	262.1	345.1	..	2	104.1	265	371.1	3.08	2.40	"	10.3
3756	33.2	25.3	7.6	78	180.2	258.2	..	2	83.2	180	265.2	2.85	2.51	"	17.7
3757	36	121.4	7.7	339	1040	1379	..	2	220	156	1432	7.77	..	"	19.7
3758	49.6	24.3	7.5	71	169	240	..	1.5	87.4	1210	244.9	9.75	4.22	5.50	39.9
3759	37.2	10.8	7.8	54	54.2	108.2	..	1.5	53.9	48.9	109	8.66	2.60	High	15.5
3760	29.6	57.5	7.5	112.5	426.8	539.3	..	2.5	107.8	436.1	546.4	5.24	3.07	"	14.5
3761	68.8	216.7	7.8	456	2593.2	3049.2	..	7	1291.2	1781.3	3080.5	4.94	4.80	"	10.3

GHEZELHESSAR AREA

Ghezelhessar is a public domain village. A large section of this area has had a high water-table for a long time.

The Livestock Department wanted to establish pastures on the area, but there were two factors which prevented this.

(1) High water-table.

(2) Concentration of the white and black alkali in the root zone.

This area, since it is close to Tehran, is a good place to undertake a drainage and land reclamation project for demonstration and training purposes. It forms a training field for students taking the Agricultural Engineering Training Course. They can work there and have practical experience in applying what they learn.

Progress of the Work

Weather Data : The temperature and rainfall data prepared by the Karadj Agricultural College weather station, about 15 kilometers away, are available and presented in Table 1.

Topographic Map : At the start a topographical map on a scale of 1/4,000 was prepared and later a map of a scale of 1/3,000 was prepared by the students of the Agricultural Engineering course making a survey for training as well as to provide more detailed information.

Soil Investigation :

Auger Holes : On 6 investigation lines and along alignments of three suggested main open drains, 120 auger holes were dug to determine the soil texture and for a stratum survey. In most of the area the soil is heavy with a low infiltration rate.

Permeability : The permeability of the soil was measured by disturbed soil samples in the laboratory, and also by the Piezeometer method in the field. The result of investigation shows that the permeability is moderately low to low.

Soil Analysis : To determine the kind of salted soil, soil samples have been sent to the soil laboratory for analysis. The results show there is non-saline-alkali and saline alkali soil besides the saline soil in the Ghezelhessar area, Table 2, and reclamation is necessary.

Water Quality :

The surface water (ganat water) and the underground water have been checked. The results show that the surface water is first class water, but the quality of the underground water is second and third class water, and contains high and very high soluble salts, Table 3.

Water Source Survey:

1. *Precipitation*—A large quantity of rain which drops on the upland drains into the Ghezelhessar area and because of the low infiltration, it stands on the land surface for a long period making surface drainage essential.

2. *Excess Irrigation Water*—Poor methods of water application and inefficient use of irrigation water, in other words faulty irrigation practices, cause drainage problems. Waste water reaching the low areas either by surface runoff or by running into the soil contributes to rise of water-table.

3. *Artesian Conditions*—To find out if there is any upward flow in the area the following steps have been taken :

(*a*) One tube-well with 33-meter depth and 10-centimeter diameter has been dug in the north part of the Ghezelhessar area. The log has been taken and the fluctuation of the water-table has been checked in the well. As the results show there is no underground water pressure, and the fluctuation of the water-table in the well is similar to the piezometers.

(*b*) Some piezometer clusters have been established with 2, 4, 6 and 8-meter depth and the fluctuation of the water-table has been measured. The investigation shows there is no upward flow in the area.

Water-table Observation:

To measure the fluctuation of the water-table, six investigations lines have been established and piezometers have been put on lines to depth of 2 meters at intervals of 100 meters. Auger holes have been dug beside each piezometer. The log of the auger holes and the results of the water-table measurements and the permeability classes are recorded on the maps. The investigation shows the area has a high water-table at least during 6 months of the year and the soil can be considered waterlogged.

In 1956 Dr. O. W. Israelsen, Professor, Utah State University, and well known drainage expert was invited by United States I.C.A. to come to Iran and has seen the area and has given his advise and guidance.

A brief summary of the investigations made includes :

1. Weather data
2. Topographic map with scale 1/4,000 with 0.2 meter contour lines.
3. Profile of soil and water-table of the investigation lines.
4. Annual fluctuation of the water-table.
5. Underground water contour and the direction of the underground flow.
6. Premeability measurement data.
7. Soil and water analysis data.
8. Log of the well which has 33-meter depth and 10-centimeter diameter.

On the basis of the above data it was concluded that drainage was necessary and essential

for this area, and the project preparation was started.

Outlet:

The old existing drain, the major part of which is situated in the low line, has been chosen as outlet of the drainage system. Of course, some parts of this outlet needed to be straightened, deepened and cleaned of silt and weeds. The profile of the outlet has been chosen as follows :

Bottom width	..	1.2 meters
Depth	..	2.5 meters
Side slopes	..	1½ to 1

The slope is 0.0012 and the velocity of the flow will be about 1 meter per second (roughness coefficient n=0.04). With this cross-section the outlet will be able to collect the water which will come from three main drains and their laterals, and at the same time it can act as the outlet of the underground drainage system.

Surface Runoff : Approximately the surface runoff from about 1,000 hectares of land surrounding Siah Jube outlet will be run into the drain. By using the existing data it is calculated the rainfall intensity will be about 12 millimeters per hour in this area. Therefore, the runoff is computed as 8 cu. meter per second, and with the large cross-section that the outlet has, it will be able to carry off this runoff. The following profile has been chosen for the three main drains :

Bottom width	..	1.2 meters
Average depth	..	2.5 meters
Side slope	..	1½ to 1

The slope is 0.0012 in some parts, and 0.0015 in the other parts.

Project Accomplishment

1. *Water Development* : There was a ganat system in the Ghezelhessar area which delivered 45 litres per second of water, however, this water was not enough for irrigation. There were two possibilities for water development :

(*a*) Digging a deep well and establishing a motor pump.
(*b*) Establishing a ganat system.

Because some part of Kamalabad area, which is nearby the Ghezelhessar area, needs to be drained, it was found after investigation that it was much better to establish a ganat system in Kamalabad area. This will serve as a double purpose system, to drain the upland and to irrigate the lowland. According to the prepared project a ganat system with 3 kilometers length was established. At present the water of this ganat is flowing and it is available for irrigation.

2. *Outlet* : The outlet of the drainage system has been cleaned and deepened by labourers.

3. *Main Drains* : The excavation of three main drains was accomplished by bulldozer to a depth of 0.5 m and deepened by labourers.

4. *Laterals* : Four laterals have been installed which drain into drain No. 1. The total length of these laterals is 1060 m.

5. *Existing Drains*: The effect of the existing drainage system on lowering the water-table has been studied and graphs prepared.

6. *Land Levelling* : Thirty hectares of land has been levelled by mechanical equipment, and twenty hectares of it is boarded for leaching.

The execution of the project will continue, and this area will be used for a training ground to acquaint the students of the Agricultural Engineering Training Course and Karadj Agricultural College with drainage and land reclamation procedures.

TABLE 3.—Climatalogical Data. Kanady Agricultural College Station.

Month	1330				1331				1332				Remarks
	Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		
	Min.	Max.	rain	snow	Min.	Max.	rain	snow	Min.	Max.	rain	snow	
Farvardin	0.4	25.8	23.1		0.4	28	31.30		—5.6	24.5	24.52	5	
Ordibehesht	5.4	30.3	15.1		—0.8	30	118.24		3	27.6	45.5		
Khordad	10	33			8.8	33			6.3	33	1.0		
Tir	10	37.4			11.5	37.17	6.75		12.5	36.5			
Mordad	13.9	37.9	6.25		12.2	34.2	+		12.2	35.5	2.3		
Shahrivar	10.2	34.6			10	32.9	2.50		8.8	34.6			
Mehr	3.2	30.5	34.75		7	30.9			7	29.6	19		
Aban	0.9	20.5			—7.3	23.4		21.1	—2	22.4	64.25		
Azar	—3.1	15.6	5.5	6.6	—4.4	16.5	8.87	7.15	—8.5	13.7		37.81	
Day	—8.6	9.5		12.0	—5.5	13.9	22.5	18.25	—9.8	13.7	14.75	19.0	
Bahman	—5.4	15.9	20.2	3.66	—5.5	15.2	7.75		6.5	13	24.40	10.35	
Esfand..	—6	20	39.74		—6	16.5	13.95		10.1	18	43.56	13.68	
Total			150.35	22.26			211.87	55.5			269.29	85.84	
Grand Total			172.66				267.27				355.13		

Month	1333				1334				1335				Remarks
	Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfail		
	Min.	Max.	rain	snow	Min.	Max.	rain	snow	Min.	Max.	rain	snow	
Farvardin	—3	23	78.5		—2.7	26.6	47		—7.5	18.4	76.5		
Ordibehesht	3.5	27	8.25		2.2	28.5	28.5		1.5	29.4	2.5		
Khordad	10.	32	3.75		5.4	32.5	9		6.4	30.5			
Tir	10.6	35.9	15.5		9	37.6			13	35.6	6.25		
Mordad	12	35.5	5.75		12	37.9			13.5	36			
Shahrivar	10	33			11.2	33	+		10	34			
Mehr	4.5	28.5			5.	30.6	22.1		37	27.5			
Aban	1	25	1.25		1.5	24.5			—2.8	—22.5			
Azar	—3.4	13.5	4.5	49.25	—7.5	18.5	19.35	20	—9	19.5	1.5	5.75	
Day	—4.5	14.5	19.5		—9.5	11.5	3.65	29.5	—9	7.5		16.29	This quantity of precipitation up to the morning of the date Day 16, 1335
Bahman	—3.7	18	2.25	13.5	—5.5	15.6	24.35						
Esfand	—5.5	21	35.75		6	18.6	70.82						
Total			175.0	62.75			263.77	49.5					
Grand Total			237.75				213.27						

TABLE 4—Soil Analysis. Ghezelhessar Reclamation Projects.

Lab. No.	Col. lector No.	pH of saturated extract	Saturation percentage	ECX 103	Soluble Cation & anion						Exchangeable				Alkalin earth carbonate M.e/100 gr.	S.A.R.
					Na m.e/l	Ca+ Mg. m.e/l	Total Cation	CORs m.e/l	HCRs	Cl m.e/l	CEC m.e/l 100 gr.	ESP	ES m.e 100 gr.	Gypsum m.e/ 100 gr.		
3409	I	8.4	79.3	3.05	24.8	6.5	31.3	1.0	16.0	5.0	33.3	28.9	9.63	3.78	30.75	13.76
3410	II	8.0	60.0	12.6	109.3	36.0	145.3	..	3.0	19.0	23.0	22.1	5.10	0.04	18.60	25.76
3411	III	8.5	54.7	25.6	439.6	6.0	445.6	1.5	24.5	86.5	26.7	91.9	24.55	2.96	25.90	253.78
3412	IV	9.2	76.7	3.05	61.6	..	61.6	1.5	8.0	7.0	18.5	89.2	16.50	..	27.85	..
3413	V	8.7	76.9	4.8	43.5	5.5	49.0	..	6.0	8.5	19.1	28.4	5.44	9.96	28.57	26.23
3414	VI	8.4	50.7	302.4	..	77.5	..	2.5	6.0	159.0	18.54	..	..	31.87	25.12	..
3415	VII	8.0	58.2	138.6	1442.4	29.9	1472.3	..	4.0	483.0	19.95	84.7	16.90	30.40	17.37	29.5
3416	VIII	8.7	89.4	15.1	129.4	8.0	137.4	1.0	5.0	20.0	24.30	62.2	15.13	..	20.75	64.20
3417	IX	8.1	60.1	15.1	179.5	69.0	248.5	..	22.0	52.0	15.87	38.3	6.08	0.96	35.35	30.5
3418	X	8.5	91.3	25.2	408.3	21.0	429.3	..	3.5	92.0	25.90	68.3	17.70	..	37.45	126.0

TABLE 5.—Water Quality. Ghezelhessar Reclamation Project.

(In Milli equivalents)

Coll. No.	Sources	T.S.S. P.P.M.	ECX10⁶	Ph	CO3	HCO3	Cl	SO4	Ca	Mg	Na	Sum Cation	S.A.R.	Residual Na2003	Class
I	Grd. Water at hole C5	1244	2000	..	x	9.10	2.75	7.96	0.85	5.15	15.40	21.40	8.6	3.10me/l	C3S2
II	Siah Joui water	1908	2685	..	x	12.102	0.75	15.76	2.15	10.55	19.10	31.80	7.6	..	C4S2
III	G. W. at the end of drain outlet No. 2 ..	46714	45291	..	x	20.75	134.85	532.7	65	.90	613.4	688.30	120.	..	over C4S4
IV	G. water at hole C9 ..	18654	19680	..	x	14.90	45.25	205.0	7.10	64.4	195.0	266.10	32.7	..	,,
V	Ganat water No. 1 ..	860	1392	..	0.90	3.60	1.15	2.38	3.65	3.10	1.28	8.03	0.70	..	C3S1
VI	Ganat water No. 2 ..	570	845	..	1.05	4.05	0.80	2.60	3.70	3.70	2.01	8.31	1.13	..	C3SI
VII	G. water at hole A 4 ..	578	867	..	x	12.45	3.30	5.74	1.05	2.15	19.10	22.30	15.50	9.25	,, C3S3
VIII	Well water 33 m. deep ..	1302	2006	..	x	16.70	4.25	9.42	0.80	1.40	22.20	24.49	21.10	14.5	,, C3S4

SHABANKAREH AREA

Introduction

The Shabankareh Irrigation Project Area is located in the south-west part of Iran about 240 kilometers south-west of Shiraz.

Background Information

According to the stories told by the old men of the area, there were, in former times, canals taking water from the river to irrigate the right side, which is a part of the area now under irrigation. These stories are confirmed by traces of three old canals which can be seen at their intake point along the Shapoor river. One of these canals, say the old men, went under the name of Nahr Khadjeh, and it brought water to irrigate lands of the village of Tchahar Bordj. In the village of Grogogazi Seconar, not far from Tchahar Bordj, there were then date-palms growing, it is said; but the water-table became high little by little, and the date-palms died. For a long time after that, the land went uncultivated.

When the lands were no longer irrigated, the water-table gradually went down, the condition of the soil became better, and it was again suitable for cultivation.

Project of Recent Years

The Shabankareh Dam was completed in 1319 (1940) to divert water from the Shapoor river to irrigate these lands. The canals were designed and located, as shown in Map 2, to provide water for the irrigation of an area of approximately 10,000 hectares, or 25,000 acres. Actual irrigation was begun in 1320 (1941); not over 5,000 hectares, however, have been irrigated each year.

During the first few years of irrigation, production of grain crops and of date-palms was fairly satisfactory. There was no regulation of the amount of water to be used by the farmers, however, and artificial drainage was not provided for the area. The water-table began to rise, some lands became waterlogged, and some parts became swampy. Portions of the waterlogged area have been abandoned.

It is estimated that about 2,500 hectares are waterlogged because of seepage losses from irrigation canals and excessive application of water to the lands. Of approximately 300,000 date-palms growing, 15,000 are dead, and about 120,000 are adversely affected and in real danger under present conditions. The total losses of crops including date-palms, due to waterlogging and salinity, are approximately one-half million dollars' value.

Fig. 2. Water Ponded from canal Seepage and over Irrigation.

Villages and Populations

The approximate number of people in the 14 villages of the irrigated sections of Shabankareh area is 7,700. It is probable that these 7,700 people are supported by the productive work of about 2,000 farm families. After adequate drainage is provided, and leaching and reclamation of the soils achieved, the number of families and the total population of the area can and should be substantially increased.

Fig. 3. Sole surviving date-palm, the others on this plot have died due to High Water-table

Soils and Land Classes

A detailed land survey of the Shabankareh Project area has been made. The survey included 29,800 hectares covering both irrigated and unirrigated parts of the project area. The land was classified as follows :

Class II Land : 1,100 hectares (4.0 percent). "Moderately good irrigable land. Dominantly light textured soils with relatively low fertility and water-holding capacity."

Class III Land : 2,000 hectares (6.7 percent). "Fairly good irrigable land. Consists largely of land with a moderate salinity problem, but some land with moderately undulating micro-relief also included."

Class V Land : 26,660 hectares (89.2 percent). "Lands in this class are of temporarily undetermined suitability for irrigation. Under their present condition they appear to be unsuited and should be considered so until future economic and engineering studies prove them otherwise. Included are lands that are excessibely salty or imperfectly drained."

Comparisons of Areas Irrigated from two Rivers

Some areas that are irrigated by both Shapoor and Daleki Rivers. Water is diverted from the Shapoor River by the permanent modern diversion dam which irrigates the Shabankareh area. Water is diverted from the Daleki river by temporary diversion dams crudely constructed each season by the farmers.

The date-palms in the Zirrah district, irrigated from the Daleki river, are in good condition in spite of the fact that the water of the Daleki river is locally considered to contain a larger percentage of soluble salts than the water of the Shapoor river. Residents call the Daleki "The Salt River" and they call the Shapoor "The Sweet River".

Yields on the Daleki river irrigated lands remain normal even though irrigation was begun there many years before the diversion dam was built for the Shabankareh area.

The reasons for this seem to be that :

(1) the Zirrah district has fair natural drainage, and
(2) the farmers of the Zirrah district do not use excessive water in irrigating because the available water is not abundant.

Tcham-darvahi is a small part of the Shabankareh area, close to the river. Because of light, permeable soil and fairly good natural drainage, crops and date-palms grow very well there, and farmers' incomes are increasing year by year.

Problems to Solve

The foregoing makes it clear that there are many problems in the Shabankareh area which must be solved; but in the present report, only drainage and land reclamation will be discussed.

To lower the water-table, under-drainage is necessary. The salt which has concentrated for many years in the soil must be leached to make reclamation feasible. The first step of land reclamation, therefore, in the Shabankareh area, is to establish a drainage system.

Source of Water

(1) *Existing Canals:* The design of the existing canals is not good. If the topographical map for Shabankareh is studied in connection with the present alignment of the canals, it is clear that the canals were laid out in straight, parallel lines, all diverted at the same angle from the main canal, and without regard for the slope of the land, the zone to be irrigated, or the cut and fill that would be required. In some places it was necessary, to carry out this design, to construct fills to elevate the canals above the land. Because the canals are unlined, are sometimes elevated as stated, and their slope is very low, there is a great deal of seepage from the canals and laterals. *One of the big sources of water contributing to the drainage problem: is the seepage from the canals and laterals.* Redesigning of the Shabankareh canal system is necessary, and the direction of alignment must be changed where possible. Canals and laterals must be lined with cheap materials to prevent seepage and at the same time to prevent back-water.

(2) *Rainfall* : Precipitation is very intensive at Shabankareh area and in general the soil permeability is low. The slope of the land is low also. The water which comes from rainfall stays a long time on the ground and has an effect on the water-table and on waterlogging of soils.

(3) *Excess Irrigation* : There are no water measurement devices in the whole Shabankareh Irrigation Area. Water is not measured; the farmers pay a portion of their crops for its use by the year. They have not developed efficient, economical practices in the use of water. A part of the drainage problem in Shabankareh area is traceable to excessive irrigation. Because of the poor natural drainability of soils, the water-table has become high and soils waterlogged. Consumptive use of water studies are necessary in this area, together with instructions to farmers as to what amounts of water are found to be advantageous.

Conclusion

The necessities for drainage and reclamation are urgent and this fact seems to be recognized by all who are acquainted with the area. It is probable that without drainage, the waterlogged areas will increase, more trees will die, and the abandonment of lands formerly valuable will continue.

To solve problems of drainage and reclamation, field studies are very essential and economical. This is true because of the great variability in soil formations and especially in the permeability of the different soil materials. It is not intended to recommend or encourage so-called *fundamental* or technical research. The objectiive is to conduct *practical field studies* to find out how to solve the irrigation and drainage problems of the area.

Pilot Project

In order to attain the objectives briefly outlined above, a pilot project is prepared for an open drain system which will have the following advantages :

1. *River outlet favorable*

   The drainage outlet will be the Shapoor river, which is 10 feet or more below the land surface, except during flood water seasons.

2. *Area now cultivated*

   All the area in which the open drain is to be dug is *now under cultivation*, the water-table is *high*, and many parts are waterlogged.

3. *Date-palms pay well*

   The major portion of the date-palms that pay the highest proportion (1/3) of their crop for water toll are situated in this area. The area also has more date-palms than other parts of Shabankareh Project.

4. *Losses have been heavy*

   The people of this section have suffered loss of income from the damage to their crops. We believe they will be willing to dig the laterals on their own land, if the Irrigation Bongah will dig the main pilot drain.

5. *Population Density Greatest*

   The density of population in this section is greater than in other parts of the Project area.

6. *Results of Drainage Easy to See*

   Because the area is covered with date-palms already of bearing age, it will be easy to see the results of the drainage and know whether it is remedying the trouble, or whether leaching will also be necessary.

This pilot project which is in action now will drain about 1000 hect. in the badly waterlogged part of the area. The results and experiences which will be gained from this pilot project will help in preparation and execution of a design for the project area as a whole.

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PROBLEM OF IRRIGATED AGRICULTURE IN THE PUNJAB, INDIA

By

C. L. HANDA, I.S.E.[1]

Introduction

A stage has been reached in the science and practice of irrigation in the two neighbouring countries of this sub-continent when a great deal of advantage can be gained by exchange of thoughts on the several problems that have arisen in the hundred years of irrigated agriculture. Unquestionably a high level prosperity has been achieved through the introduction of irrigation and the fruit thereof has been enjoyed by several generations. Lately, some symptoms have appeared which have materially reduced the optimism that was flowing from the enterprise of constructing new projects for exploiting the irrigation potentials from snow-fed rivers. Whereas, irrigation still continues to be the major source of income in the economy beased on agriculture, certain elements have mounted due to the malfunctioning of the drainage aspects of the rich lands. Fertility of the soil has shown a decline in the affected places and the imbalance created between the surface irrigation and the outflow of drainage water has given way to a rapidly rising water-table. This disease is not amenable to any single remedy and a number of factors have to interplay in the developing phenomena. Amongst these are the amount of irrigation supplies, intensity of irrigation, capacity factors of irrigation channels, quality and texture of land including its salinity characteristics and the mode and the adequacy of the surface and the undergound drainage system. In this brief review, some of these aspects will be generally discussed with particular reference to the need for further remedial measures. Some of these measures will have to be novel and non-conventional.

Continuing need for Irrigation.—At the outset, I would like to emphasize that rather than getting into disuse, the science and practice of irrigation will need to be further developed as agricultural economy has nothing else for its stable foundation so far as arid regions are concerned. Even in places where rainfall is plentiful its vagaries leave the cultivator badly prostrated when the intensity or time of rainfall are unfavourable. Hence for a proper control over the elements that are capable of causing devastation, we have to ensure the sowing, nourishment and maturing of crops so as to have plentiful yields against the rising cost of labour. Apart from the profit motive, adequacy of food based on self-sufficiency has to be ensured to avoid under-nourishment and the consequent low standards of health and living. It is quite tragic that the crop yields in the Punjab regions are of the lowest. The rising population is therefore posing new problems despite the fact that there are conscientious and hard-working communities who devote their life time to agriculture in the face of several disadvantages. Effective remedies will have to be initiated not only by the concerned engineering authorities, but also by the leaders of public opinion and high level administrators who are rightly worried over the challenging situation.

1. Chief Engineer, North, Irrigtion Branch, Punjab, India.

Drainage Needs

Whereas we are ensuring on the side of engineering construction, the birth of reservoir controlled multipurpose projects, we have already fallen behind into a big-time lag so far as the critical demands of land and successful agriculture are concerned. *The irrigation engineer of tomorrow in the field of operation will have more and more to be a land and agriculture engineer.* He will need the closest cooperation and help of the soil Scientist for over-coming the problems which are now pressing us into a corner where the needs of the growing population require a higher productivity from each acre of land. The rates of commodities of basic food are so high that the average wage earner is finding it hard to give a proper subsistence to himself and his family.

The biggest hurdle in the way of irrigated agriculture has been the absence of adequate land drainage measures. The author can recall project after project in West Punjab and East Punjab where the main emphasis was on the construction of canal systems which would be safe carriers of water at the least cost. Problems of drainage were confined to the construction of cross-drainage works which would take care of the torrent versus canal danger in the immediate vicinity of the canal. What happened to the drainage after it had been safely passed under or over the canal was not made the concern of the Project. This surely was a short-sighted policy dictated more by the desire to make the Projects cheap rather than lasting in so far as the long range good of the land was concerned. But the day of reckoning could not be postponed for long and it has only taken some four or five decades for the situation to have reached critical proportions. And what is 40 or 50 years' in the economic life of a region ? Viewed in this light, the red signal has come soon enough.

It is now estimated in the case of the East Punjab that some three million acres of good

land have nearly gone out of cultivation due to waterlogged conditions. Another three million acres are on the border line between economic fertility and unproductivity. On much of the waterlogged land, there are signs of salinity increase which has reduced yield and cultivability. All this land is calling for action as Punjab's irrigated-agriculture-problem number one.

Drainage Program.—To cope with such a backlog of accumulated accretion to the water-table, the following remedial measures have been investigated :

(*a*) Minimization, if not total prevention, of flooding of the affected areas from rivers, big streams and creeks.

(*b*) Improvement of land surface drainage.

(*c*) Lining of water-courses, main canals and distributaries, subject to economic feasibility.

(*d*) Installation of an adequate number of tubewells and revival of percolation wells fallen into disuse to stabilize the subsoil water at the proper level.

(*e*) Construction of seepage drains.

(*f*) Proper crop rotation.

(*g*) Reclamation of Thur lands.

The above remedial measures have been put into practice, starting with the land surface drainage operations which have a most direct and vital bearing on the problem. The following aspects of this program are worthy of note :

1. The program of drainage, though theoretically capable of a sceintific solution, suffers from the handicaps of huge cost and practical difficulties. During the course of the expansion of the railway, road and canal systems of the State, the embankments constructed have blocked the drainage basins and the provision of waterways under the lines has been quite inadequate. As drainage works were not owned specifically by any of the agencies responsible for development in their respective spheres, the mistakes of omission and commission kept on mounting and only half hearted remedies were conceived and implementation showed still bigger gaps. Meandering, siltation, weeds and lack of suitable approach and exist conditions have vitiated whatever utility some of the existing drains possessed. There has been an intensification of activity on the reconstruction of these drainages to a suitable degree of efficiency but the work has so far been possible only on the main drainages in certain tracts up to the first stage of the required capacity (from 1/3rd to 1/2). It is imperative that this program be carried through to its proper completion.

2. Side by side with the reconstruction of surface drainage systems, the problem of their efficient operation and maintenance assumes immediate importance. This requires not only constant vigilance and repetitive work but also equipment like draglines which may maintain proper depth and cross-section against underwater silting and blockage. In the last analysis the manufacture of such equipment within the country itself is indicated.

3. Surface drainage derives its full efficacy only if the tracts and fields which are subject to flooding and waterlogging, are served by a network of tributary, link and field drains. These have their own problems of inter-connection as they too pass across roads and communications. The topographical conditions usually do not lend themselves to suitable alignments except by cutting through lands and properties with varied and often conflicting interests. Eventually the people affected have to make contributions of land and labour and in the last analysis such contributions have to be made jointly at the expense of the State and the beneficiaries themselves. This program demands utmost attention which has to be on a scale almost as large and systematic as irrigation itself. Its practical implementation requires that technical personnel make themselves available to the irrigator on the spot so that by living with him they can inspire confidence about the remedial measures which they suggest for the amelioration of the ailments witnessed in the course of irrigation practice.

New Approach Needed

If we analyse the constructive steps needed for solving the irrigation-cum-drainage operations in the programe of raising the productivity of the areas under irrigation, we come to the irresistible conclusion that a new chapter needs to be opened in the development of irrigation in the sub-continents of India and Pakistan. These two countries were initially the pioneers in the successful harnessing of the river flows and have developed the science of irrigation to a degree of perfection in which a remarkably small batch of irrigation engineers contributed a very big quota in the total

economic development of their States. This development became the frame-work, as it were, for the growth of the economic prosperity in the agricultural, commercial and semi-industrial fields. This edifice has now reached a height where there is more pressure on the foundations than can be safely supported. Hence the necessity for strengthening the very base of the structure which can only be done by further investments of an unusual character. Coupled with more money, there has to be scientific know-how based on the engineering practices of certain successful regions in this very sub-continent; or in some cases on the experience derived in other countries, notably of the West. The one new factor that has come to the help of the irrigation engineers is that of electric power. With this facility, the irrigation engineer can improve the slope in drainages by the establishement of suitable pumping stations from where water can be lifted with electric power. He can achieve the same results by resorting to large scale tube-well pumping. Both types of activities have already been initiated in Punjab India and it is now a question of their further expansion with necessary modifications based on the particular needs of each of the problem areas, that can bring about success.

Surface Drainage Necessary.—It may well be conceded that the back of this problem can be broken only with successful surface drainage. This has then to be followed by the construction of seepage drains which help to stabilise the ground water-table at a level not less than 5 to 10 ft. below the natural surface. There is such a range in which the ground water can be allowed to fluctuate. With this range the root zone of the particular crop is not harmed either due to the over-accumulation of surface water or the rise in the ground-water-table. The health of the land will be dependent on the efficient management of the total water that is made available to a tract through natural or artificial means. For this purpose, the cultivator will need to be trained further in the more economical use of water. If he improves the levels of his land with the help of an ordinary hand level, the accumulation of water in the low patches o his fields will be reduced. This will result not only in economic use of water but better cropping. Again in the case of land threatened with water-logging he will have to dig his field drains which will empty into link drains and tributary drains which will be laid out under the guidance of technical personnel. Each irrigation division in charge of areas threatened with waterlogging will need to maintain dragline equipment which will serve to ensure the proper depth of outfall and prevent siltation due to the flattening of slope. This will become a normal method of maintenance in which the irrigation and drainage aspects will be simultaneously catered for.

Economic Problem.—One big question is the funds needed for drainage work. The health and fertility of land are vital enough to deserve all necessary expenditure. If the resources are inadequate, it can only be a question of phasing. *In order to produce the food and other products essentially required for supporting the economy of a country, a re-orientation of the yardsticks of feasibility for land reclamation projects is indicated and should be adopted.*

It has often been said of our country that its economy is not fully developed. Primarily, this has reference to the poor yield of crops from land. It is the considered opinion of the author that the yield from land can be increased manifold; although the process is not capable of being hustled beyond a certain degree. The problems of irrigated agriculture do not get created except over a long period of years. For remedial measures to be successful, we must be prepared to wait till recovery is substantial. Some times impatience and over-anxiety for quick results, cut at the root of the remedies. This applies in particular to the aspects dealt with in this paper. With the advantages of extensive experience in the science and practice of irrigated agriculture and the new facilities in the shape of implements and electric power and chemical fertilizers, the difficult problems or irrigated agriculture can be faced with growing confidence.

REQUIREMENTS FOR A SUCCESSFUL PLAN OF LAND DRAINAGE AND RECLAMATION

By

JAMES S. REGER[1]

The permanence of irrigation agriculture has been seriously questioned by many writers. There may be, perhaps, some justification for this feeling. There exist in some parts of the world, notably in North America and in the East, extensive areas which in times past have been irrigated but are now abandoned. Still others are experiencing serious difficulties in successful crop production. Irrigation agriculture is a complex venture. Failures have been caused by technological reasons, such as the exhaustion of groundwater supplies that had accumulated through the ages, or siltation of reservoirs, or salinization of soils from the use of poor quality water and from inadequate drainage,

1. Formerly Drainage Engineering Advisor, USOM/Iran.

or by man's own negligence. Generally speaking, both failures and "trouble areas" are usually the results of poor planning and/or unwise utilization of water and land resources.

Inadequate drainage has probably resulted in more irrigation project failures than any other single factor involved in this type of enterprise. Adequate drainage is an integral part of a permanent irrigation agriculture. It can maintain productivity on good lands and it can reclaim potentially good but salinized or waterlogged lands for permanent productivity. It is fitting, therefore, that the requirements of planning land drainage and reclamation projects be discussed at this Seminar.

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 very important and must be considered, the chief concern of the engineer in draining irrigated lands in arid areas is usually sub-surface drainage to effect a general lowering of the water-table and to provide an outlet for saline waters. By so doing, leaching may be accomplished and a favourable salt balance may be maintained. To accomplish this however, is not as simple as it might appear. Answers to the following questions must be provided:

(*a*) What is the source of the water?
(*b*) Can the water table be maintained at a satisfactory depth below the ground surface?
(*c*) What will be the drainage requirement or, how much water will have to be removed by artificial methods?
(*d*) What type of drainage system will be the most effective?

Answers to the above questions require a detailed drainage investigation. Essentially, this is the basic requirement for planning projects intended to drain and reclaim land.

Basic data relative to the topography, climatology, soils and groundwater hydrology of the area are essential in formulating a plan for complete reclamation. Irrigation practices, types of crops grown, irrigation water requirements and quality of irrigation water are other factors which must be considered. The degree of detail and time required for the investigation will depend largely upon the degree of complexity of the physical characteristics of the area. A minimum time of one year however, is usually required to obtain a complete cycle of groundwater movements.

Reconnaissance drainage studies may be made in unsurveyed areas. Detailed studies however, should never be attempted in areas which have not been adequately surveyed and sub-divided according to some accepted standard. Both vertical and horizontal control are essential in the proper interpretation of field data obtained throughout the project area at required locations. A base map of the area, preferably drawn to a scale of 1:10,000 is therefore a prime requirement for such an investigation.

An understanding of the groundwater hydrology of an area is an essential requirement toward formulating a plan for drainage and reclamation. The tool most commonly used for obtaining data in this regard is the groundwater observation well. Although existing groundwater wells in the area should be used insofar as possible, the dangers of such wells yielding false data should be recognized by the drainage engineer. The static water levels in wells drilled for domestic, industrial, livestock or other purposes, may or may not reflect true water-table conditions—the very thing which the Engineer is seeking.

It is therefore essential that a grid of groundwater observation wells, designed especially for drainage study purposes, be installed in the area. The ideal well of this type is one which is bottomed approximately one meter below the water-table in those areas where the water-table occurs at a minimum of two meters below the ground surface. A minimum total depth of three meters is recommended for all wells. Wells may be installed by any one of the conventional methods, although jetting is not recommended unless done by experienced personnel In areas where the water-table is generally located within the practicable limits of augering, the augered well is recommended. This is accomplished by augering the hole to the required depth and casing it with a one and one-half or two inch galvanized or black iron pipe. The lower 18 inches of the pipe should be perforated with holes not exceeding one-eighth inch in diameter. The bottom of the pipe should be closed. A gravel pack around the perforated section of the pipe is recommended. Top of the pipe should be capped and a suitable concrete base installed to help prevent vandalism. Ground surface and top of pipe elevations must be obtained, the latter being the reference point for well readings.

Static water levels in these wells may be accurately obtained by using a simple bell sounder attached to the end of a metallic tape. Electrical sounders are not recommended.

For detailed studies, it is recommended that wells be installed on a two kilometer spacing. It is also recommended that a number of deep wells, 50 to 100 feet in depth, be installed at selected locations to determine sub-surface conditions at these depths.

All wells should be logged as carefully as

possible. Furthermore, during installation of the shallow wells, earth samples should be obtained at each textural change for certain laboratory determinations. These may include analyses to determine texture, pH, total salts, soluble cations and anions, gypsum, boron, exchangeable sodium and permeability. Complete analyses are not required for all samples although determinations should be made for total salts, pH and permeability for each sample obtained. An adequately equipped laboratory, staffed by trained personnel, is an essential requirement for conducting drainage investigations.

A land classification survey is an essential requirement in planning f. ' new irrigation developments. In conducting drainage investigations designed to reclaim existing developments, it is desirable to include land classifiers on the professional staff. It is also highly desirable for the drainage engineers and the classifiers to work in close cooperation in arriving at a final plan for reclamation.

Following installation of the grid of observation wells, a systematic program of well reading should be undertaken. Each well should be read monthly for a minimum period of one year. These readings should be closely correlated with water deliveries, types of crops under cultivation and the location of canals, laterals and other irrigation facilities which might affect the rise and fall of the water-table.

Water-table contour maps should be prepared monthly for the first year of groundwater readings. These maps will definitely show the direction of groundwater movement and to some extent the lithologic characteristics of the aquifer materials. They are most valuable in determining the sources of excess water. In this connection, it might be stated that 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. The lateral movement of free or unconfined groundwater and the upward flow of confined water from an artesian aquifer are often-times 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 of a project 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. By a comparison 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 drainage problem.

Maps showing the depth to the water-table should likewise be prepared on a monthly basis during the first year of groundwater observations. These maps will provide data relative to the annual and seasonal fluctuation of the water-table and to the necessity for drainage in various parts of the project area. By correlating the rate of change in position of the water-table with the application of irrigation water, a comparatively accurate determination can be made of the extent of the natural drainage in the area.

Data obtained from the observation wells will provide useful information in regard to estimating the drainage requirements or the amount of water which may eventually have to be removed by artificial drainage in order to effect complete reclamation. This important factor is usually the governing one in determining the performance and capacity specifications for a drainage system. Salts in the irrigation water, in the soil or in shallow groundwaters 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 harmful concentrations of salt in the root zone by upward flow must be established. It is therefore apparent that irrigation, leaching, and soil management practices involved in the control of salinity are most important in establishing the drainage requirement. In areas for which reliable data are available, this requirement has been found to range from 15 to 50 percent of the diversion requirement.

It is also recommended that stratigraphic profiles showing the logs of wells be prepared on north-south and east-west lines throughout the grid system. From time to time, the water-table profiles likewise should be plotted on these drawings. These will be of value in indicating the proper depth of drains, and to some extent will aid in determining the spacing of drains. An important factor in the proper location of drains, whether open or closed, is the direction of groundwater movement which is shown on the water-table contour maps. All such drains should be located at right angles to this direction of movement insofar as is possible.

Open drains, tile drains and drainage by pumping from wells are the most commonly used methods for draining irrigated lands. It is well to remember, however, that the most suitable type of system for any given area is dependent upon the physical characteristics of the area itself. These are determined by the investigation. A topographic survey for example, may reveal that the terrain is unsuited for the construction of open drains except at costs which might appear economically unsound. Sub-surface data as shown by the well logs might furthermore indicate the physical infeasibility of constructing and maintaining open drains. Lack of drainable strata below one meter may preclude drainage by tiling. Both open drains

and tile drains have their places although it has been found that tile drainage is more effective and more economical for farm drainage. Open drains provide outlets for tile systems and are desirable for the main drainage disposal system.

Quite often, especially in desert areas, the basin type of topography lends itself well to drainage by pumping from wells. Topography alone however, is often misleading and it may or may not reflect geological conditions which control the rise and fall of the water-table. Where physically feasible, drainage by pumping has many advantages. In many instances, the pumped water may be of an acceptable quality for re-use. Furthermore, drainage by pumping, similar to tile drainage, does not take land out of production. Open drains however, remove appreciable amounts of land from cultivation in view of the required rights-of-way. Other objections to the open ditch method are the high costs of construction and maintenance and the less efficient and less uniformity of drainage because open drains must usually be spaced farther apart than closed drains.

The installation of a complete and project wide drainage system, with the exception of the main outfall system, is not recommended unless *all* lands in the project are affected. Where such is not true, farm drainage facilities and lateral drains should be installed only for those lands presently affected or about to become affected. These segments of the system must be so designed as to fit in with the ultimate over-all system.

The mere installation of a drainage system, regardless of how well designed and constructed, does not necessarily bring immediate relief to all lands in the project area. The next step is to improve those lands on which the soils have become saline and unproductive. Generally speaking, soils are made saline by the movement of salt that is dissolved in either surface water or ground water. The salt accumulates when water evaporates at the surface, or is extracted by plant roots. Both processes separate the salt from the water—the salt remaining in or on the soil. For a steady-state salt condition to exist, the salt entering the soil in the irrigation water, on the average over a period of time, must be balanced by an equal amount of salt leaving the soil in the drainage water over the same period of time. Adequate drainage is essential in removing salts from the soil and maintaining a salt balance.

Salt-affected soils are classified into three groups —saline soils, sodic soils and saline-sodic soils. Saline are those which contain too much soluble salt Soils which have appreciable amounts of sodium adhered to their individual particles are called sodic soils. Saline-sodic soils occur when salinity and absorbed sodium affect the soil at the same time.

Saline soils may be improved by leaching. This is the process in which water is ponded on a field and allowed to percolate through the soil and drain away underground, either by natural drainage or by means of the drainage system. In practically all irrigated areas located in arid regions, the natural drainage is usually inadequate for this purpose, hence, an artificial drainage system is required in order to dispose of the saline waters and thereby prevent a dangerous rise of the water table.

The total amount of ponded water required to successfully leach saline soils is dependent upon the type of salts present and their degree of concentration. Generally speaking however, the average requirement ranges from one to two meters. Where boron is present in toxic quantities however, the leaching requirement is greater, ranging from four to as high as seven meters of ponded water. Careful levelling of the land makes possible a more uniform application of the water and better salinity control.

Sodic soils may be improved by adding chemical amendments, leaching the soil and then employing practices that build soil structure. Gypsum and sulfur are the most commonly used amendments. Some sodic soils however contain sufficient amounts of gypsum. When these soils are leached the gypsum is dissolved and the calcium replaces the absorbed sodium. The sodium salts formed from this reaction can then be removed by leaching.

Where amendments are required, however, the leaching should come after the amendment is applied. In the event sulfur is used, the leaching should be postponed for a period of two or three months following the application.

Saline-sodic soils may be improved in the same manner as sodic soils.

It is well to remember that a well-planned project may become worthless through poor construction, improper irrigation practices and inadequate maintenance. Drainage and salinity problems inevitably seem to occur when these conditions are at their worst. It therefore behooves the drainage engineer to be more than just a technical man. He should be an educator and a diplomat as well, and in his everyday contacts, he should do all in his power to encourage sound practices in the over-all operation of the project. This, together with sound planning, is the best insurance for keeping drainage and salinity problems at a minimum. In so doing, there is much reason to believe that irrigation agriculture can survive.

C

DISTRIBUTION OF WATER

DISTRIBUTION SYSTEM OF IRRIGATION PROJECTS IN PAKISTAN

By

DR. A. G. ASGHAR[1]

Introduction

As there is no existing major irrigation system in East Pakistan, only the distribution system in West Pakistan will be discussed. A typical canal system in the Indus Valley commences with a weir across the sandy bed of the river and the head-works of the canal. A canal may be either an irrigation canal or it may be a feeder or link canal. The main purpose of a feeder or link canal is to transfer water from one river system to another in order that the supplies may be balanced and deficiences in one river may be made good from the surplus in another. The construction of these carrier canals enables a more equitable distribution of water available in the valley rivers.

The Triple Canal Project was the first feeder canal system from river Chenab to river Ravi. The two feeder canals, Upper Jhelum and Upper Chenab, irrigate some area on the way before delivering water into the other river, Chenab in case of Upper Jhelum and Ravi in case of Upper Chenab Canal. The new link canals excavated after independence like the Marala-River-Bedian link and the Balloki-Suleimanki link are purely feeder canals and do not irrigate any area on the way.

Canal System

An irrigation canal system consists of the main line, branches, distributaries and minors. Fig. 1 depicts a typical canal system. The distributaries and minors discharge into the water courses which convey water to the farms. The maintenance of the main canal, branches, distributaries and minors is the responsibility of the Government and the water course is maintained by the farmers.

1. Director, Land Reclamation, West Pakistan

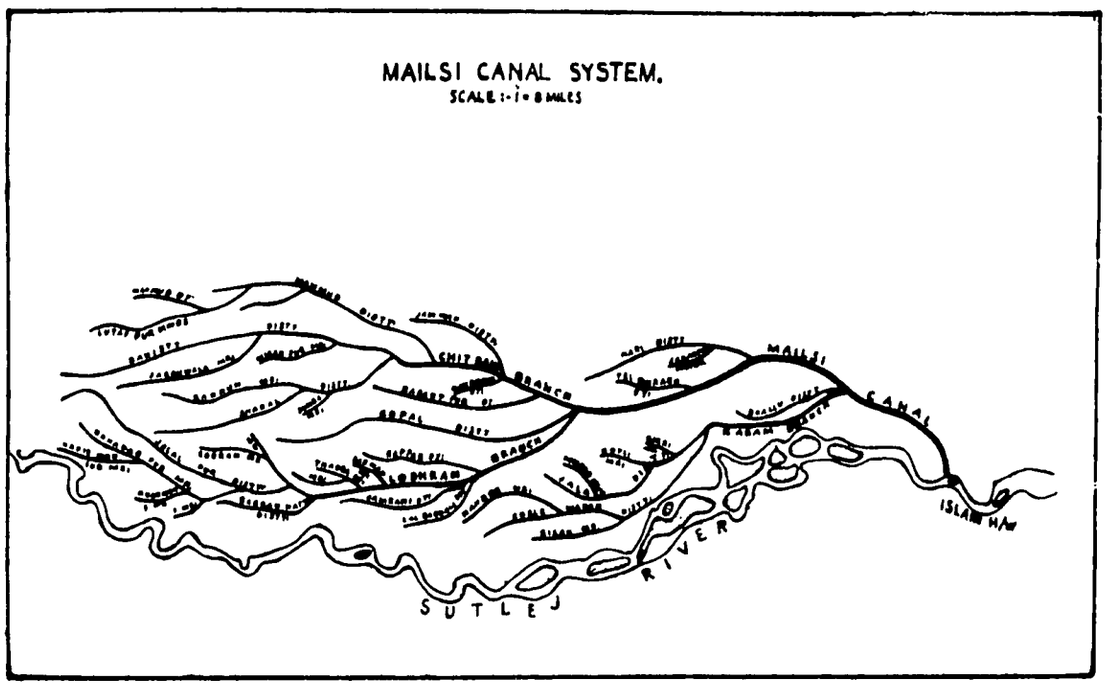

Fig. 1. Typical canal distribution system

Most of the irrigation canals run throughout the year but there are some, for instance, Dipalpur and Mailsi Canals from Sutlej river and Rangpur Canal from Chenab which are non-perennial and carry water only in summer for six months—15th April to 15th October; and remain dry for the other six months. On many canals a part of the system is perennial and another part non-perennial. For instance one branch of Upper Chenab Canal, The Reiah Branch, is non-perennial while the main-line is perennial. Some of the distributaries from a canal or branch canal may be non-perennial while the others are perennial. The non-perennial channels are generally situated in the head reach of a canal above the point on the main-line where the distribution of the perennial supplies begins. The existance of a number of non-perennial channels in the head reach of the canal is made possible because extra supplies can be run in the main-line during summer without affecting the perennial channels lower down. Instances of non-perennial channels, however, do occur in the lower reaches of canals. A fuller description of development to irrigation projects has been reported in the country report.

Delivery of Water to the Farmer

Water is delivered from a distributary into a water course by an off-take or outlets. Outlets are of different designs. An open flume outlet delivers an increased discharge with increase of head in the channel and can, therefore, over-draw. The adjustable-proportionate module (A.P.M.) is the type of outlet most commonly used as it does not allow over-drawal with increase of head and does not under-draw with fall in head as long as it is not below the outlet head. Sometimes temporary outlets are fixed when additional supply of water is to be delivered for a short period. For instance extra supplies are made available in summer for reclamation of deteriorated fields. Similarly under a '*Grow more food campaign*' additional supplies are provided in summer for growing food crops in an area for which water supply is not normally available. Temporary outlets are removed or closed at the end of the summer season. Any tampering with an outlet or any other canal work by the farmer is a panel offence and also any additional supply of water obtained by such tampering is chargeable at a special rate of upto 6 times the ordinary crop rate.

Water Distribution on an Outlet

The area which receives water from one off-take is called a "*Chak*". In the new canal colonies the land which was not under cultivation and the ownership of which vested in the Government was distributed in units generally of 25 acres and above. But under the law of inheritance and with the increasing population, sub-division of holdings has resulted in fragmentation. With the mass migration of population with the partition of the sub-continent, the situation with regard to fragmentation of holdings has been further accentuated.

The land irrigated from an outlet is in a large number of holdings. Sometimes the number of holdings in one outlet "Chak" is as high as more than one hundred. A single holding, as often as not, will be split up into more than one outlet "Chaks". Even in the same outlet chak the area of one holding is not always consolidated and may be in two or more fragments.

Under the land tenure conditions described above the only system of distribution of water which has been considered suitable is the "Turn System" in which each holding or part of holding gets the water from the off-take for a certain number of hours after a fixed number of days. The turn system is in our language is termed as "*Warabandis*".

The turn system for each outlet "Chak" is either agreed to mutually between the share-holders themselves or the Divisional Canal Officer determines the same for them under the Canal Act when one or more of the share-holders apply to him for such determination. The turn begins with the first holding at the head of the water course and ends with the one at the tail end. The time of each farmer's turn is proportionate to the area.

The main water course will deliver water to the holding at a fixed point from where the farmer takes it in his own water-courses to his fields. The turn system for an off-take will show the order in which the farmers will get their turns, the length of turn of each farmer and the point at which he will receive water from the main water course. The main water course is maintained jointly by all the farmers of the outlet chak. Sometimes when the discharge of the off-take is big and the area very large the main water-course is bifurcated into two water-courses at the head or some way down. In such a case the bifurcations have such a separate turn system. In a case in which the bifurcation of the main water-course is made lower down instead of at the head, there are actually 3 turn systems working—one for the area receiving the full quantity from the off-take and two for the areas below the bifurcation.

When additional water supply is provided with an existing off-take for reclamation or for the "*Grow more food campaign*" the existing turn system has to be revised. The area to be reclaimed has to get about 7 times the normal water allowance and, therefore, the time of the farmer's turn has to be increased accordingly. With the taking up of reclamation projects by the Soil Reclamation Board, tube-wells have to supply the additional water required which has to be utilized with or without mixing with the canal water already being

received. In such cases the turn system has to be re-drawn; some of the area may be receiving only tube-well water, some only canal water and some tube-well and canal water mixed. There will, therefore, be more than one turn systems within the outlet chak.

Affect of Distribution System on Irrigation Practices

The canal system influences the irrigation practices to the extent that the water supply may be perennial or non-perennial and that the canal is designed for a pre-determined intensity of irrigation and duty of water supply. An intensity of 50% means that water is provided for irrigating 50% of the culturable commanded area. The duty of water means the area which one cusec of supply will actually irrigate during the year. On the perennial canals the intensity of irrigation generally ranges between 50% and 80% and the duty is generally 264 acres per cusec with 2:3 ratio of summer and winter crops. This works out to a water allowance 3 cusecs for 1000 acres or thereabout. On non-perennial canals and distributaries the intensity of irrigation is generally from 25 to 40 percent while the duty per cusec is much lower than on perennial systems and is generally 88 acres per cusec.

For areas taken up for temporary reclamation the intensity of irrigation has to be 100 percent while the duty is generally 45 acres per cusec, but for certain areas duty of 35, 40 and 60 acres per cusec is provided. For areas taken up under the projects of the Soil Reclamation Board the water allowance is raised to 1 cusec for 150 acres, the duty is 100 percent and so is the intensity of irrigation.

Another way in which the canal system affects the irrigation practices is when, due to fall in the supply in the river and the canal, it is sometimes necessary to run supplies in the distributaries on a rotational basis. When the normal supply is restored all the distributaries get their authorised supply simultaneously again.

Problems of Irrigation Practices

Problems or irrigation practices arise both from the design of the canal distribution system and from the internal distribution system of the off-take. Some of these problems on which we have had to make studies will be discussed in detail.

1. *Non-perennial canals:*

1. On non-perennial canals the canal supply runs from 15th of April to 15th of October. The sowing time for the summer crop of sugarcane is end of February up to middle of March when canal water is not available. Also sugarcane and cotton crops need irrigation after the 15th of October for which canal water is not available. Many difficulties have been experienced in colonization of the area of Rangpur Canal. One of these difficulties is that the land is mostly saline and alkaline and the prospective colonisers cannot get any income from the land for the first few years. It was felt that if a cash crop like sugarcane can be successfully grown it might encourage colonizers. As sugarcane is a high delta crop it helps in reclamation of slightly deteriorated soil or in completion of reclamation of partially reclaimed soil. An attempt was made to see if the growing of sugarcane in Rangpur area could be encouraged by delaying the sowing time till the middle of April when canal supply becomes available. If the sowing time cannot be delayed, the only source from which water could be provided for sowing of sugarcane is shallow wells if sweet water is available at shallow depth.

Sowing time trials were carried out at the 7/3L Experimental Reclamation Farm on Rangpur Canal for two years—1952 and 1953. The sowing dates included in the trials were 15th March, 1st April, 15th April, 22nd April, 1 May. The results showed that the sowing of sugarcane cannot be delayed beyond end of March without affecting the outturn. The objective of delaying the sugarcane sowing to middle of April was, therefore, not achieved. The results are given in Table I.

2. The second problem of providing water requirements after the canal supply is withdrawn in October was more easily solved and the results showed that by applying waterings every week in September and in the two weeks of October which is not actually required by the crop during these months of low temperatures than the hotter months of June, July and August, sufficient moisture could be conserved in the soil to meet the moisture requirements after 15th of October and the crop can be successfully matured as the yield data in table I suggests.

3. In an other study at Haveli Reclamation Farm and 7/3L Reclamation Farm the problem of moisture requirements of cotton after 15th of October when non-perennial canals stop was investigated. During the period in which canal water was running irrigations of 3" depth were applied at weekly intervals, 4" irrigation at 10-day interval and 6" irrigation at 15-day interval. The total delta applied was equal. The second variable was different mulches after the last irrigation. The mulches were Sarkanda (SACCHARUM Sp), Toria Trash (BRASSICA NAPUS), Gram Trash (CICER ARIETINUM), Jantar (SESABANIA ACULEATA) and surface hoeing.

The overall results favoured the 3" irrigation and the hoeing treatments.

TABLE I—Month-wise delta in inches applied to Sugarcane sown on different dates and yield of Gur (Jaggery) in tons per acre.

Sowing date	15th MARCH									1st APRIL									15th APRIL									22nd APRIL									1st MAY								
Year	April	May	June	July	August	September	October	Total	Yield	April	May	June	July	August	September	October	Total	Yield	April	May	June	July	August	September	October	Total	Yield	April	May	June	July	August	September	October	Total	Yield	April	May	June	July	August	September	October	Total	Yield
1952	9"	9"	9"	6"	9"	12"	6"	60"	1.06	5"	9"	9"	6"	9"	12"	6"	56"	.63	3"	9"	9"	6"	9"	12"	6"	54"	1.05	3"	9"	9"	6"	9"	12"	6"	54"	0.36	x"	9"	9"	6"	9"	12"	6"	51"	0.4
1953	6"	12"	6"	9"	6"	15"	6"	60"	0.53	3"	12"	6"	9"	6"	15"	6"	57"	0.55	x"	12"	6"	9"	6"	15"	6"	54"	0.42	x"	12"	6"	9"	6"	15"	6"	54"	0.32	x"	9"	6"	9"	6"	15"	6"	51"	.14"

TABLE III—Water Delta applied in inches to cotton under each treatment to end of each month in different years.

Year	1952						1953						1954						1955						1957						1958					
Treatment. Month	2"	3"	4"	4"	6"	8"	2"	3"	4"	4"	6"	8"	2"	3"	4"	4"	6"	8"	2"	3"	4"	4"	6"	8"	2"	3"	4"	4"	6"	8"	2"	3"	4"	4"	6"	8"
April																																				
May	10	9	8	8	6	8	2	3	4	4	6	8	6	9	12	8	12	16																		
June	18	21	20	16	18	24	16	15	20	16	12	16	14	21	24	20	18	24	8	12	16	8	12	16	—	—	—	16	24	24	—	—	—	16	24	24
July	20	24	24	20	24	24	24	24	24	20	18	24	20	30	32	24	24	32	20	30	40	20	30	40	—	—	—	28	36	32	—	—	—	36	42	32
August	32	33	36	32	36	32	34	33	32	32	30	32	32	39	44	36	36	40	34	51	64	36	54	64	—	—	—	40	54	48	—	—	—	52	48	40
September	42	42	44	40	42	40	40	39	40	36	36	40	40	48	52	48	48	48	48	66	68	48	66	64	—	—	—	56	72	64	—	—	—	64	68	56
October	48	48	52	48	48	48	48	45	48	48	48	48	62	63	68	68	66	64	56	69	72	56	72	72	—	—	—	72	72	72	—	—	—	68	66	64
November	—	—	—	—	—	—	—	—	—	—	—	—	72	72	72	72	72	72	72	72	72	72	72	72	—	—	—	—	—	—	—	—	—	72	72	72

IRRIGATION UNDER SEVERE METEOROLOGICAL ENVIRONMENTS

The Thal was a desert area between the rivers Jhelum and Indus. The Thal Project was taken up for the development of this area by providing irrigation from the Indus river. The Thal canal has its headworks at Kalabagh. The soil is predominently sandy. According to the project survey, out of about 3 million acres area, 2.3 million acres had wind blown sand over alluvial sand or sand dunes over flat land. The rest was flat land free from sand dunes lying over salt bearing soil over alluvial sand. The rainfall is very low and unevenly distributed with long droughts. It ranges between 4" and 14" in different years. The day temperatures in summer are very high and sometimes touch as high as 125°F. Sand storms carrying huge quantity of sand are of very high frequency. In the year 1949 there were 64 sand storms occuring 46 times during the summer months of April to July. With the progress of colonization and cropping the frequency and intensity of sand storms is decreasing but still it is a highly determining factor for the water requirements of crops. For the last 6 or 7 years the frequency of sand storms has ranged between 30 and 40.

The extreme meteorological conditions of the area present a very serious problem in so far as irrigation practices for crop production are concerned. After each sand storm every field under summer crops needs watering. Under our land tenure conditions the distribution of irrigation water is by turn and not on demand. The crop has to wait for the next turn of the farmer which is one reason of low crop outturns in the irrigated areas of West Pakistan.

In the old canal colonies the length of turn is generally either 10 or 15 days which is by no means the optimum interval for high yields of crops especially the summer crops. The frequency and depth of irrigation for different summer crops under Thal conditions has to be determined to see how it can be fitted into the turn system of water distribution as with the length of turn adopted in the old colonies no crop can be grown under the severe meteorological conditions of Thal.

Methods and Materials

An experiment was carried out at the Experimental Reclamation farms in Thal at Kundian, Leiah and Bhakkar. The results obtained at Bhakkar farm are reported. The work was actually started in 1949 but up to 1951 there were unavoidable interruptions in the irrigation schedules. The results reported relate to the years 1952, 1953, 1954, 1955, 1957 and 1958. During 1956 the work was interrupted due to non-availability of canal water till late in the summer season.

(*i*) *Irrigation Delta*

In the old canal colonies, cotton receives five to seven irrigations during the growing season. The average water delta applied is about 24" Sugarcane receives from eight to twelve waterings and an average delta of 36" to 48". In high water-table areas, the water requirement of sugarcane are less than in deep water-table areas. At Moharanwala Reclamation Farm in Jaranwala area of Lyallpur District where the water-table is high, sugarcane is matured with 6 to 10 waterings. Under Thal conditions the water requirements of both cotton and sugarcane are much higher.

In the experiment reported in this paper the water delta applied to cotton was 48" for the first two years and 72" for the later 4 years for which results are reported. For sugarcane the irrigation delta was 72" for two years and 96" for the subsequent 4 years period.

(*ii*) *Treatments*

During the 4 years period for 1952 to 1955 the treatments for cotton as well as sugarcane were the following:—

- 2" Biweekly
- 3" Biweekly
- 4" Biweekly in the hotter months June, July and weekly and longer intervals in the later months.
- 4" Weekly.
- 6" Weekly and longer intervals as required.
- 8" Weekly and longer intervals as required.

During the 2 subsequent years 1957 and 1958 the 2", 3" and 4" biweekly treatments were omitted and only the last 3 treatments were under trial. Table II below shows the irrigation delta and treatments for each year:—

TABLE II.—Irrigation delta in inches applied for cotton and sugarcane in weekly and biweekly turns.

Year	Crop	Treatments		Total Delta applied.				Remarks.
		2" biweekly.	3" biweekly.	4" biweekly in hotter months and longer intervals later.	4" weekly.	6" weekly & longer intervals as required.	8" weekly & longer intervals as required.	
1952	Cotton ..	48	48	52	48	48	48	
	Sugarcane ..	72	72	72	72	72	72	
1953	Cotton ..	48	45	48	48	48	48	
	Sugarcane ..	72	72	72	72	72	72	
1954	Cotton ..	72	72	72	72	72	72	
	Sugarcane ..	96	96	96	96	96	96	
1955	Cotton ..	72	72	72	72	72	72	
	Sugarcane ..	104	104	104	104	104	104	
1957	Cotton ..	..	..	..	72	72	72	
	Sugarcane ..	..	..	..	96	96	96	
1958	Cotton ..	..	..	..	72	72	72	
	Sugarcane ..	..	..	..	96	96	96	

The total delta applied under all the treatments was equal for all the treatments in each year.

(*iii*) *Replications*

The size of plot was 1/16th acre (302.5 square yards) and number of replications 3. The treatments were randomized.

Results and Discussion

Cotton

Table III shows the total water delta applied under each treatment to end of each month in different years. The total water delta applied in 1952 and 1953 was 48" for all treatments. There was one deviation from the schedule in 1952 when in the '4" *biweekly*' treatment the actual delta applied was 52" instead of 48". Similarly in 1953 the delta applied in the treatment '3" *biweekly*' was 45" against 48" required. In the remaining four years there was no such deviation and the total delta applied under all treatments was 72". The deltas applied during the same month in different years under each treatment were not equal, the reason being that the number of waterings required in a month was determined by the eye test according to the water demand of the crop.

Table IV gives the mean outturn of seed cotton in lbs. per acre for each treatment for each year.

TABLE IV.—Outturn of seed cotton in lbs. per acre.

Year	Treatments						Total delta.
	2"	3"	4"	4"	6"	8"	
(*a*) 1952	563.47	420.75	572.37	684.65	371.50	358.87	48"
1953	437.25	387.75	594.00	610.50	363.00	313.50	
(*b*) 1954	246.85	301.12	358.87	311.02	309.37	206.25	72"
1955	371.25	393.42	436.42	330.00	381.97	376.20	
(*c*) 1957	..	..	..	693.00	363.00	325.87	72"
1958	..	..	..	934.72	825.00	693.00	

During both the years in which 48" delta was applied, the treatment '4" *weekly*' out yielded the other treatments. In one of the two years the difference in yield between '4" *biweekly*' and '4" *weekly*' was nominal but the difference from the other treatments was significant. In the next two years the treatment '4" *biweekly*' gave higher outturn than other treatments but the higher yield was not significant. During the two years 1957-58 when the biweekly treatments were not included the '4" *weekly*' treatment significantly out yielded both the other treatments of 6" and 8" irrigation.

From these results it can be concluded that with irrigation delta of 48" the '4" *weekly*' treatment is the best of the 6 treatments compared. The cause of higher outturn with this treatment than with treatments of shallower irrigations of 2" and 3" can be explained by the fact that with shallower irrigation moisture penetration to the lower end of root zone is less than with 4" depth of irrigation and the loss by surface evaporation is higher. With the other two treatments of greater depth and lower frequency of irrigation the moisture content in the soil tends to fall closer to the wilting point than with the higher frequency of 4" irrigation. The soil moisture determinations shown in Table V support these conclusions.

TABLE V.—**Soil moisture after different intervals under different water depths.**

Depth of Irrigation	2"	3"	4"			6"		8"	
No. of days after irrigation	3 days	3 days	3 days	6 days	13 days	6 days	13 days	6 days	13 days
Depth									
0—1'	8.43	22.8	26.37	4.83	6.69	13.98	5.63	16.62	8.78
1—2'	15.31	11.05	25.95	18.63	5.78	18.96	9.53	18.66	6.31
2—3'	17.39	11.32	16.38	20.57	7.75	20.96	6.89	24.32	7.11
3—4'	11.39	20.89	18.47	18.41	4.75	21.15	7.68	22.71	27.36
4—5'	11.61	21.58	16.95	22.12	10.03	21.95	8.30	26.41	10 89
5—6'	9.37	18.15	18.29	22.28	6.86	21.13	15.67	24.22	23.55
6—7'	6.79	21.87	23.11	20.90	9.06	17.64	4.42	25.75	5.23

During the remaining two years in which the 6 treatments were continued with 72" delta the 4" treatment with some biweekly applications in the months of higher temperatures gave higher outturns than the 4" treatment without any biweekly irrigations. From the results of these two sets of two years each, while it can be concluded that the 4" treatments were better than all the other treatments, it would appear that 4" biweekly treatment may or may not out yield the 4" weekly treatment.

Comparing the outturns between the years of different irrigation deltas, the yield for treatment with the maximum outturn was higher for 48" than with 72" delta applied in the following two years. The yield obtained during 1957 with 72" delta was nearly equal to that obtained with 48" in 1952 and 1953. In 1958 the yields obtained for all the three treatments were significantly higher as compared with those obtained in 1952 and 1953 with 48" delta. The effect of meteorological factors under Thal conditions is so marked that it can overcome the effect of increased irrigation delta in some years. With the data available at this stage it cannot be definitely concluded that 72" irrigation delta is necessary for cotton cultivation under the soil and meteorological conditions of Thal. On the basis of the available data it might be concluded that 48" delta in 4" irrigations can be practised to advantage. Even if the higher delta of 72" can give higher outturn, with the present water allowance on the Thal canal, the farmer may not be able to use this delta for cotton as it may not be possible to spare water for other crops or the area under cotton may have to be very much reduced.

Sugarcane

Table VI shows the irrigation delta applied up to the end of each month in different years.

Table VII gives the outturn for different treatments in terms of cane weight.

TABLE II.—Outturn of cane in tons per acre.

Year	Treatments						Total delta
	2"	3"	4"	4"	6"	8"	
(a) 1952	7.99	10.62	16.29	15.65	8.34	4.51	72"
1953	5.68	7.07	10.81	8.62	6.27	4.05	
(b) 1954	4.79	5.35	7.85	2.41	5.15	3.68	96"
1955	7.07	7.66	9.42	4.32	5.15	5.89	
(c) 1957	..	..	..	13.62	13.99	14.72	96"
1958	..	..	..	16.56	18.22	22.08	

These results show that during the two years in which the total delta was 72" the outturn for the treatment 4" *biweekly* was higher than all other treatments and the difference in yield was significant. In the next 2 years in which the number of treatments was 6 and the delta 96, (in 1955 it was 104), again the outturn for the 4" biweekly treatment was significantly higher than all other treatments. In the remaining two years, in which the biweekly treatments were not included, the 8" treatment gave higher outturn than 4" and 6" treatments although in one of the two years the difference was not significant.

The results obtained conclusively show that with 72" as well as with 96" delta the 4" irrigation given at biweekly intervals in the hottest months followed by weekly and longer intervals gives higher outturn than all other treatments. If it is not possible to provide any irrigation at a shorter interval than one week, the 8" irrigation at weekly and longer intervals gives higher outturn than 6" and 4" irrigations. This may be due to the greater depth to which the heavy eight-inches irrigation moistens soil profile and more moisture being stored for plant use. The moisture distribution pattern with different treatment for sugarcane is shown in Table VIII.

TABLE VIII.—Soil moisture percentages after different intervals under different water depths.

Depth of Irrigation	2"	3"	4"		6"			8"	
No. of days after irrigation	3 days	3 days	3 days	6 days	13 days	6 days	13 days	6 days	13 days
Depth									
0'—1'	18.27	19.98	27.82	17.55	6.95	19.82	9.76	20.92	5.75
1'—2'	19.73	22.68	29.10	15.49	9.78	21.26	7.95	24.00	29.59
2'—3'	20.77	19.50	21.35	18.31	7.76	29.25	6.34	21.90	7.23
3'—4'	23.93	16.11	21.69	18.70	14.79	19.75	10.14	23.39	9.51
4'—5'	22.15	20.72	18.18	13.87	5.68	25.98	6.26	39.05	9.51
5'—6'	20.09	21.21	17.81	12.82	7.97	22.82	18.43	25.96	7.22
6'—7'	14.39	20.48	19.57	13.61	5.62	23.84	10.85	18.23	10.72

The crop outturns obtained with 96" delta during 1954 and 1955 were not higher than those with 72" delta in the preceding two years. In 1957 and 1958 the outturns with 96" irrigation delta were higher than those obtained with 72" delta as well as with 96" delta in the preceding 4 years. On the basis of available data it cannot be conclusively stated that 96" delta can give higher outturn than 72" delta.

Conclusions

The results both for cotton and sugarcane strongly suggest a water distribution system in which some of the irrigations can be applied at shorter interval than one week and also that such a short interval for the whole of the summer season will not be required; rather it will be an inferior distribution system to a weekly turn system.

The problem is that it will be rather difficult to adopt a system in which weekly turns have to be provided for a major part of the year and biweekly turn for a couple of months or so. However, the farmers in the old Punjab Canal colonies have had to adopt two distribution systems during the year in connection with reclamation operations for which with the additional supply is given in summer for saline fields to be reclaimed. The existing distribution system has to be changed for the summer season. After summer the farmers have to revert to their permanent distribution system. With effort and extension work on the part of the Irrigation Department as well as the Thal Development Authority it might be possible to popularize a distribution system with twice a week water turn for three months during the year—May, June and July. As long as such a system cannot be adopted, cotton irrigation should be done with 4" and sugarcane irrigation with 8" depth of irrigation.

Irrigation Practices

A description of water distribution would not be complete if it did take into account how the water is distributed to the farmers and is used by them. The irrigation practices determine the efficiency of water use. The practices common in the canal colonies in the Indus Valley are basin, furrow, border and flooding.

Basin irrigation has been recommended to the farmer and even imposed in the early stages of colonization. It is practised voluntarily by progressive farmers to a considerable extent. For colonization of new areas, 25 acres has generally been the unit of holding. This is typically divided into 25 one-acre units.

Each acre field is divided into 4 quarter-acre square basins. Basin irrigation is one of the most efficient irrigation practices and it is fortunate that some emphasis was put on it by the Departments of Irrigation and Agriculture. This should not have been relaxed. For reclamation of saline land, basin irrigation is obligatory both for temporary reclamation work organized by the Irrigation Department and permanent reclamation projects of the Soil Reclamation Board.

Border irrigation is more commonly practised by the farmer. For this, the acre field is divided into two parts instead of four, each plot then having a length equal to twice its breadth.

Furrow irrigation is practised for potatoe and other vegetables. At some of the Experimental Reclamation Farms, furrow irrigation of cotton was found to give higher yield than flat irrigation.

Flood irrigation is the practice to which the ordinary farmer is most tempted as a labour saving device. The farmer does not confine flood irrigation to an acre field but irrigates up to 5 or even 10 acre fields from a single cut in the water course. In rice growing areas this is the most common practice. Flooding of course is the most inefficient irrigation practice.

Improved irrigation practices like irrigation of furrows and basin with syphons have not been practised by the farmers in Pakistan. At the Jagattan Reclamation Farm, a comparison of flat, furrow and furrow with syphon irrigation of cotton was made in 1957.

Size of plot was 1/12th of an acre and number of replications was four. Moisture samples were taken before and after irrigation up to eight foot depth which contains nearly 100% of the root zone of cotton. Decrease in moisture between the sampling after one irrigation and the sampling before the next irrigation is the consumptive use component of irrigation applied. The data of this trial is summed in table IX.

TABLE IX.—Comparison of Different Irrigation Methods for Cotton

Method of Irrigation	Application (Inches)	Rain (Inches)	Total (Inches)	Consumptive use (Inches)	Consumptive use efficiency.	Yield in lbs. of seed cotton/acre.
Syphon	14.05	12.05	26.10	19.93	76.36%	1011
Furrow	13.52	12.05	25.57	18.84	73.68%	976
Flat	15.30	12.05	27.35	20.50	74.99%	865

TABLE VI.—Water delta applied in inches to sugarcane under each treatment to end of each month.

Year	1952						1953						1954						1955						1957			1958		
Treatment Month.	2″	3″	4″	4″	6″	8″	2″	3″	4″	4″	6″	8″	2″	3″	4″	4″	6″	8″	2″	3″	4″	4″	6″	8″	4″	6″	8″	4″	6″	8″
April	—	—	—	—	—	—	2	3	4	4	6	8	4	6	8	8	12	16	—	—	—	—	—	—	—	—	—	—	—	—
May	12	12	12	12	12	16	14	15	16	12	12	8	12	18	24	20	30	40	4	4	4	4	4	4	4	6	8	12	18	24
June	22	24	24	20	24	24	24	24	24	24	24	24	20	30	36	32	36	48	14	17	20	16	20	24	24	36	32	32	48	56
July	24	27	28	24	30	34	32	33	32	28	30	32	26	36	44	40	42	56	28	38	44	28	38	48	36	54	56	48	72	64
August	36	45	44	40	42	40	42	45	40	40	42	48	38	45	52	48	48	64	40	56	68	44	62	80	48	72	72	64	78	72
September	52	57	56	52	54	56	52	51	52	52	48	56	54	51	60	56	60	72	54	77	92	56	80	88	68	90	88	84	90	88
October	64	66	64	64	66	64	60	57	60	60	60	64	72	69	80	76	84	88	60	86	92	60	86	88	84	96	96	92	96	88
November	72	72	72	72	72	72	72	72	72	72	72	72	88	87	92	92	90	88	78	101	96	80	98	96	92	96	96	96	96	96
December	—	—	—	—	—	—	—	—	—	—	—	—	96	96	96	96	96	96	96	104	104	96	104	104	96	96	96	—	—	—
January	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	104	104	104	104	104	104	—	—	—	—	—	—

As the results show for furrow irrigation with syphons the water applied was more efficiently used than for the other two treatments as the higher percentage of water applied was consumptively. The crop outturn was also higher for this treatment than with the other two treatments. The consumptive use data for the three treatments is shown in figures 2.

Discussion

Mr. Ayazi asked for clarification regarding the basis for design of the canal capacity. He commented that in Iran in the early season where plenty of water is available, irrigation may be by basin method; but after one or two months they change to furrow. Dr. Asghar replied that the canal design depends upon the area, the intensity of cropping, and the availability of water supply. He further stated that the design is made by the Engineerng Department and also takes into account the gross and cultivable areas, as well as the command of the canal.

Mr. Anderson inquired regarding methods of sowing under "flat" irrigation. If "broadcast" have any studies been made of labor saved over row planting? Dr. Asghar replied that in the basin method, cotton, for example, was sown in lines and the ridges were constructed afterward. Some limited cost information is available.

Mr. Young inquired about the lessening damage due to sandstorms under irrigation and wondered if there was factual information on the cause—such as windbreaks. Is the rotation schedule ever broken to alleviate sandstorm damage? Dr. Asghar replied that presumably the meteorological department has such information on sandstorm incidence and velocity. However, the decreased damage is doubtless due to increased cultivation. The rotation schedule cannot be changed.

Mr. Vernon inquired if increased use of water required delivery of additional amounts by the canal, or whether this remained constant. Dr. Asghar stated that the experiments were worked out on a farm where water was available during the entire year with the objective of demonstrating that water should be made available in accordance with the needs of land and crops. In the Thal Area the water allowance will be higher at first, but will decrease as colonization proceeds.

The great problem is that no one, neither the Irrigation Department nor the Agricultural Department, takes the responsibility of the actual use of water by the farmer after it has reached the farm.

Mr. Rajaratnam inquired if the duty of 3 cusecs per 1,000 acres was the basis for design of the channel system and also if any allowance was made for intensity of the crop. Dr. Asghar stated that about two-thirds the area is irrigated during winter and one-third during summer. On this basis the actual area on which the water is applied is calculated. The figure of 3 cusecs per 1,000 acres is frequently mentioned. In the Thal, however, this comes to 264 acres per cusec. This is an average and varies from place to place. (Under actual operation, a figure of 1 cusec for 264 acres would mean that one cusec would irrigate 88 acres during summer and 176 during winter under usual practice).

DISTRIBUTION SYSTEM TO SERVE SMALL HOLDINGS

By

V. N. RAJARATNAM,[1] A.M.I.C.E.

INTRODUCTION

The staple industries of the Island of Ceylon are tea, rubber and coconut. Employment provided by these industries has hitherto largely been the means of livelihood of the population which during the years of prosperity crowded into parts of the wet zone where these industries are situated. A slump in these commodities reduced employment in the wet zone and brought about the vital necessity for expansion in the dry zone. The population pressure in the wet zone forced the Government to initiate schemes of colonization and land utilization under irrigation projects in the dry zone. The primary purpose of these schemes to colonize the dry zone was social and envisaged the development of the area under rice on a consumer-producer basis working a subsistence agriculture.

Economic Unit of Holding

Since 1932, the general policy of the Government has been to establish the peasant on a unit of holding consisting of a wet land area and a dry highland area to enable him to settle on the land and derive from it an income sufficient to maintain himself and his family in reasonable circumstances.

1. Asstt: Director of Irrigation, Ceylon.

He is to obtain the money income from the wet land by rice cultivation. His homestead to be on highland where, besides his home, he can cultivate it for permanent crops and vegetables mainly to meet his own requirements of food.

In the earlier schemes, the wet land unit was 5 acres and highland unit, 3 acres. This unit of holding was based on the price of agricultural produce prevailing then (1935—1939). It was also considered that 5 acres of wet land could be managed and worked by a family of five of whom there may be effective workers. As the price of agricultural produce improved, or the prices were guaranteed by Government, the demand for land by the peasant settlers increased. It was then decided to reduce the unit of holding and at the moment it stands at 3 acres of wet land and 2 acres of highland. The schemes of development are now planned on this basis.

Initiation of Irrigation Works

An irrigation scheme consists of two parts:

(*a*) Head-Works
(*b*) Distribution System

The Headworks consist of purely engineering works to store or divert a source of water supply. The construction of headworks generally precedes a few years the construction of the distribution system.

The distribution system for the commanded lands under an irrigation project taken for development as a colonization scheme, should ensure to the colonist, a water supply to his 3 acre allotment at the place and time required by him and in such quantities as are required for the varying demands of his crop during the period of crop growth. The distribution system consists of two sections:

1. Planning and blocking out of wet or irrigable lands together with its complementary lands.
2. The design and construction of irrigation systems, roads, drainage lines and other ancillary works necessary to put the water on the irrigable lands.

This paper sets forth the steps followed in the initiation of works required for the development of an area under an Irrigation Project, complete with an efficient distribution system to supply water to each of the small allotments of 3 acres in extent given to a colonist.

PLANNING AND DISTRIBUTION SYSTEM

Preliminary Considerations

The preliminary studies to determine the feasibility of an irrigation project are made in the first instance on the one inch to the mile topographical maps. These maps give sufficient details to locate a scheme, assess the catchment area and its irrigable potential, layout access roads and other general features that are necessary to locate in a general way the sites for development and determine the prospects of an irrigation scheme. It is on these maps that the general engineering feasibility of a project is also determined. The data available on these maps are supplemented by small-scale field investigations by the Irrigation Department as a check on the office studies and to work out the approximate cost of the headworks and the suitability of the site for the development of the water resources. Based on these studies, a report is prepared for submission to the Ministry of Agriculture and Lands with recommendations as to its engineering and economic feasibility and suggesting that further investigation of the project should be undertaken. This report is accompanied by what is known as a "Scheme Plan" which gives a general idea of the possibilities of development in the region. This plan also forms the key to the future development proposals to be undertaken in this area and is simply a reproduction of the one inch to the mile topographical maps of the area on which the scheme of development has been superimposed.

Control and Soil Surveys of Commanded Area

When the scheme is approved for further investigation, a further reconnaissance is undertaken. At the same time, a preliminary soil survey of the lands to be developed for agricultural purposes is carried out by the Directior of Agriculture. This investigation is generally confined to the irrigable area and very little work is done in the highland area, where the main purpose of the land is for development as a homestead rather than for agriculture. The soil survey carried out by the Director of Agriculture is general, as its main purpose is to classify and indicate the soil types that fall within the scheme and to make recommendations as to the manner in which the productive capacity of the soils can be maintained or improved in the development area according to the crops to be grown.

This stage of investigation is nothing but a mere detailed check of the deductions made in the earlier studies as to the availability of land, suitability of the sites of development and other controlling factors which influence the selection of the area for development. The survey work undertaken at this stage also forms the ground work for a more detailed survey to be undertaken at a later stage when the scheme is finally approved for development. This survey is carried out by the Surveyor General according to the specifications issued by the Director of Irrigation and is called the *Control Survey* of the development area. The plans re-

sulting from this survey are drawn to a scale of 8 chains (528 feet) to an inch and show contours at 5′ intervals. Copy of the specifications for contour survey is given in Exhibit 1.

When the reconnaissance survey plans are received from the Surveyor General and soil reports from the Director of Agriculture, the earlier assumptions made are checked and any amendments to the scope of the scheme are made and the proposals finalized to take the investigations to the next stage, namely, the engineering or close contour surveys of the development area.

Engineering or Close Contour Surveys

The Engineering Survey of the development area is a very detailed survey which is carried out by the Survey Department to specifications issued by the Director of Irrigation. The plans resulting from this survey are drawn to a scale of 4 chains (264 feet) to the inch showing vertical form lines at 1 ft. intervals. A copy of the specification for this survey is shown as Exhibit 2.

The Engineering Survey of the development area covers the irrigable lands, highlands (unirrigable lands) for homesteads and such other lands as are required for development of community services. The survey specifications for all these are identical because the entire area has to be developed as one organic whole with a system of water distribution, roads, wind belts, drainage of excess water in the irrigated area and the drainage of surface water in the highland areas etc. Both the drainage system and the road system in the irrigable and highland areas have to be designed and constructed together, so that they link up one area with the other. It is for this reason that close contour surveys of the highland areas are carried out to the same specifications as the irrigable lands.

Irrigable Command

The prerequisite for an Irrigation Project, besides the availability of water, is the availability of suitable land; a correct assessment of which can only be made by complete surveys of the area to be developed particularly in a country like Ceylon, where the land is heavily wooded and undulating. The land has to be closely contour-surveyed to bring out clearly the actual configuration of the ground and to determine the irrigable command. From plans resulting from this survey, the net area available for development for irrigation is obtained after excluding reservations for channel systems, wind belts, roads and cart tracks, tanks and streams, drainage lines and other reservations required for water and soil conservation.

Highland Area

In the highland area, no investigation is carried out to determine the availability of ground water for domestic purposes. The colonists are expected to depend on the nearby channels for their supply of domestic water and where suitable sites exist, small tanks are restored or constructed to store surface water for domestic purposes. In schemes where the geological conditions are such as to provide sources of ground water, the peasants are expected to sink their own wells.

Layout of Irrigation System

On the plans resulting from the Engineering Survey, a general irrigation system is laid out for the area. In the first instance, the channels and natural drainage lines are shown which, when taken together, form what is known as a *Tract Plan*. Thus, the irrigable area is subdivided into tracts and a tract may be 50—500 acres in extent. This is followed by a *preliminary blocking out plan* for the purposes of estimating the net irrigable area available in each tract. This data is used in the preliminary channel designs and the controlling levels for irrigation. This plan is also made use of to set out on the ground, the channel system and for surveying the system for design and construction.

Channel trace at this stage is not final. It forms more or less a base line for the channel trace survey on which the final trace is to be developed. The channel trace survey is carried out by the Surveyor General to the specification of the Director of Irrigation. Copy of these specifications are given in Exhibits 3 & 4. On the completion of the channel trace surveys, the Surveyor General prepares what is called the *Longitudinal Section* of the channel trace and a *Flat Plan* of the strip of land on either side of the channel trace. On this plan, the final trace and the final design for the channel are laid down indicating the grade, irrigable command, location of structures, distributary channels etc. It also forms the plan on which construction specifications and estimates are prepared.

Final Blocking Out Plans

As the designs of the channel trace are completed, the final trace is replotted on the preliminary blocking out plans after making necessary amendments to the blocking out plans, a *final blocking out plan* is prepared showing the 3-acre allotments, main channel distributaries, field channels, drainage lines, wind belts, areas reserved for public utilities, homesteads etc.

The highland areas are also blocked out at the same time showing the disposition of each unit, main roads, subsidiary roads, community centers,

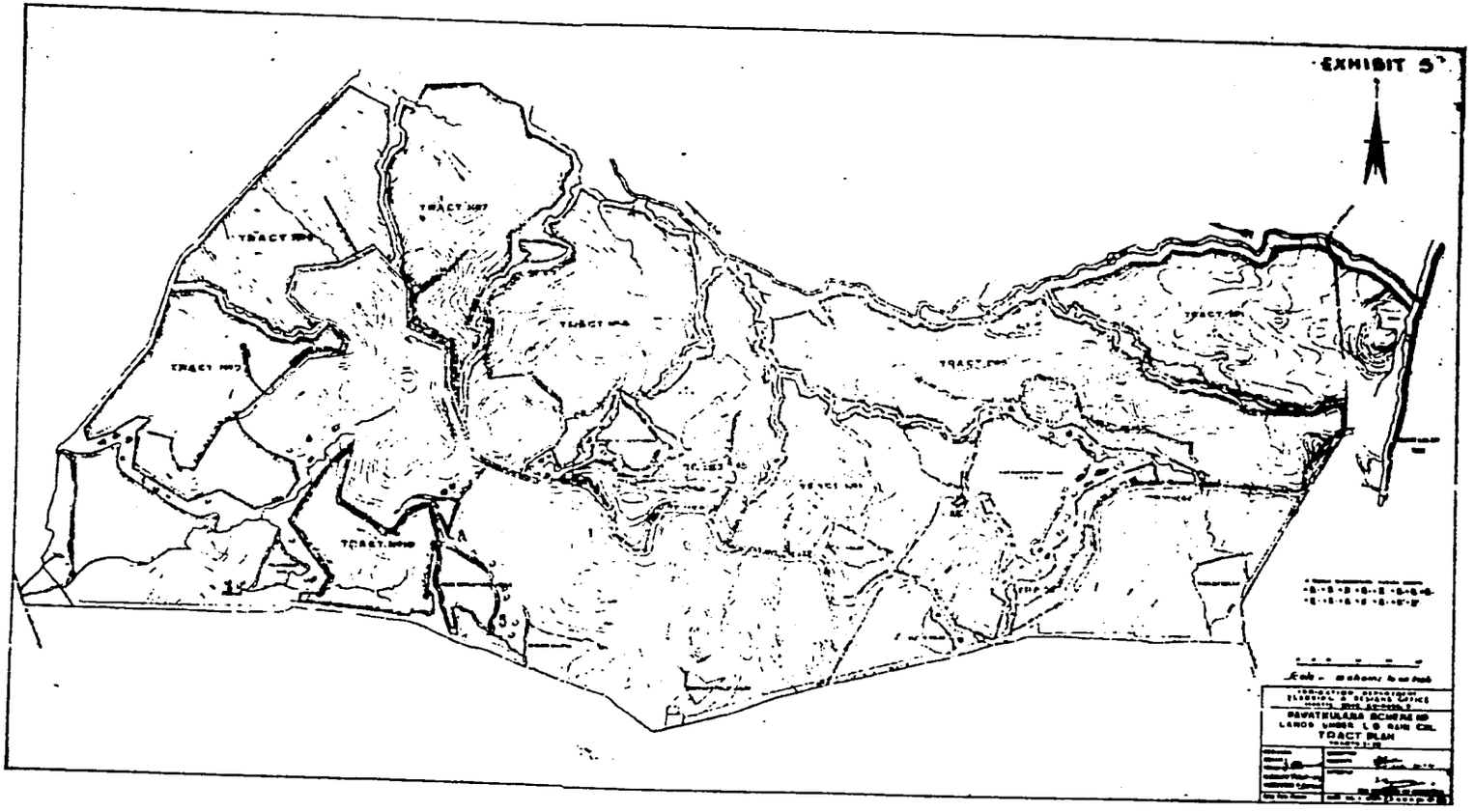

Fig. 1. Typical Tract Plan.

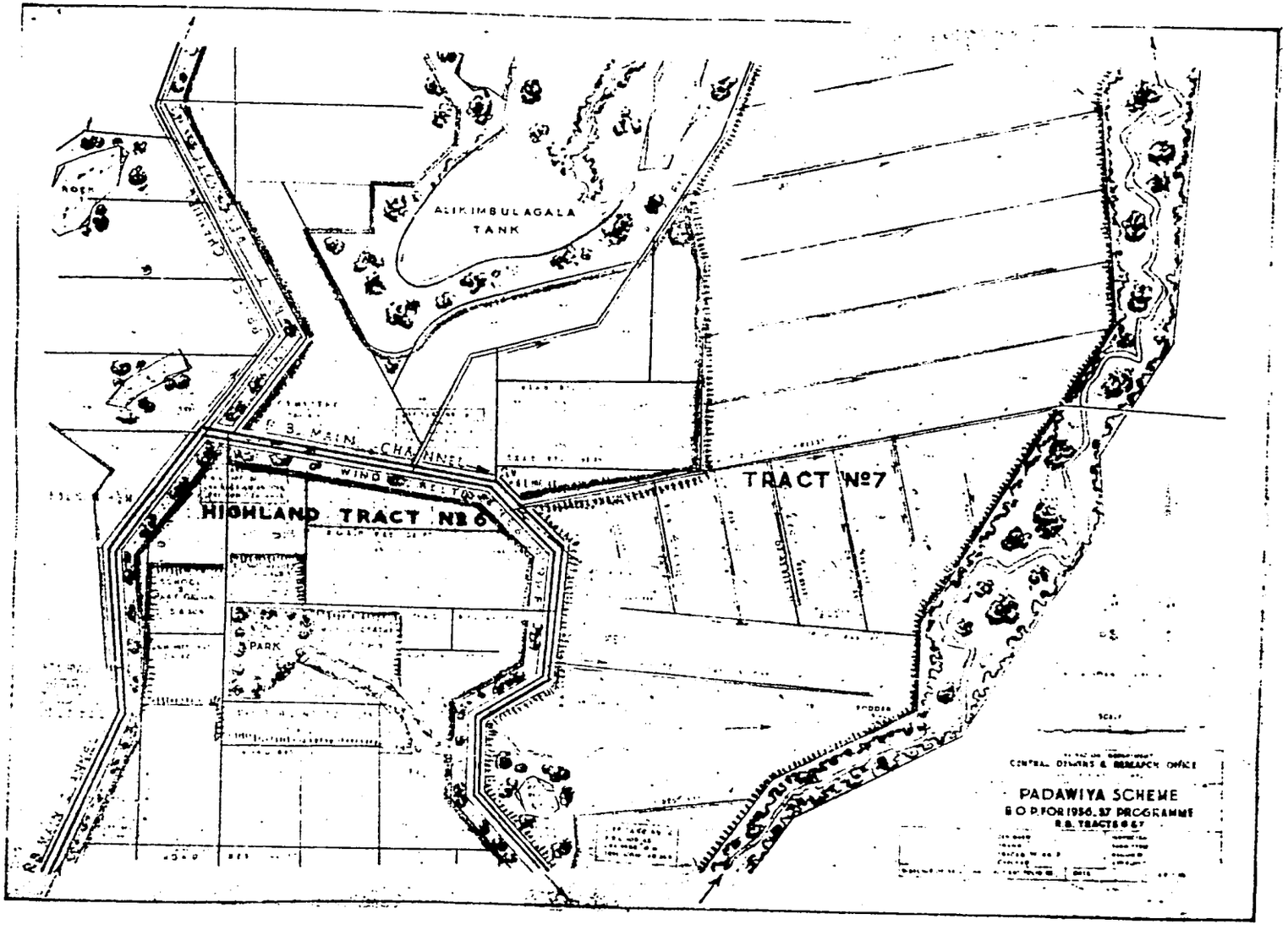

Fig. 2.—Typical Blocking out plan.

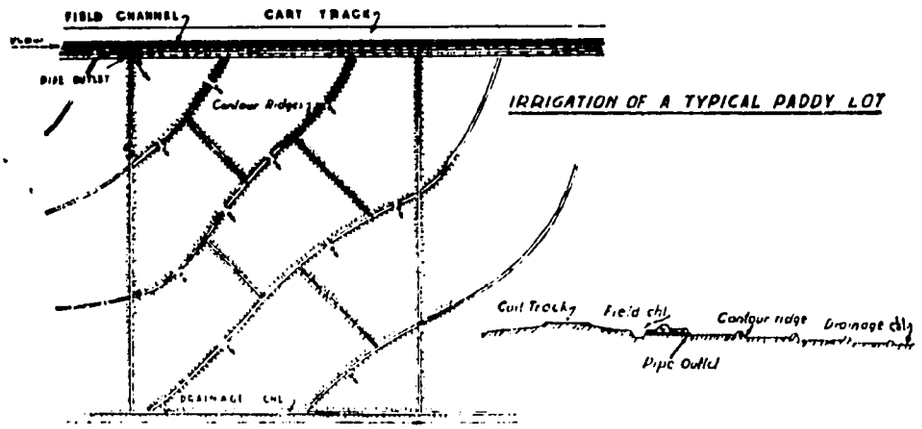

Fig. 3.—Irrigation of a Typical Paddy Lot.

surface drains, wind belts, etc. The blocking out plans of the irrigable area and the highland form a composite plan of development of the area. After this, the plans are taken a stage further by assigning to the blocks, serial numbers, numbering of distributaries, field channels, and other relevant data required to finalize the blocking out plans, which will form the working plans both of the Irrigation Department and the Land Development Department and for the purpose of alienating land and granting the peasants their lease bonds. A typical blocking out plan of a few allotments is shown as Fig. 2.

Development

When the blocking out plans are issued to the Director of Land Development, he gets the boundaries of the allotments on the ground demarcated after the area has been cleared of jungle. The necessary reservations for the channel and the drainage systems are also land marked. Then the Irrigation Department carries out a survey to obtain the final longitudinal sections of the distributary channels, field channels etc. and prepares plans and estimates for the construction of the channel system. Until this work is completed, the land developed for cultivation cannot be issued with irrigation water. This forms the final phase of land development.

While this work is in progress, the Director of Land Development is expected to clear the jungle in the highland area, construct houses, make roads and build other community facilities in the highland areas as well as clear the irrigable lands and get them ready for cultivation.

The sequence of investigation and planning for the design of the distribution system should be:

1. Preliminary investigations.
2. Soil survey of the area to be developed.
3. Control surveys of the development area.
4. Engineering surveys of the entire area to be commanded by the scheme.
5. Preparation of general development, layout of channels system, roads settlement centers etc. together with site investigations and detail surveys for their development.
6. Final development plans and estimates.

Points Considered when Blocking Out

(*a*) *Unit of allocation*—Paddy allotments are blocked out now into 3 acre units and highland into 2 acre units.

(*b*) *Highland allotments* are approximately located within 1½ miles of their complementary paddy lot.

(*c*) Lands that are blocked out for *alienation* are:

(*i*) All Crown lands falling within the irrigable command of the scheme, except those Crown lands that are required for other purposes.

(*ii*) All undeveloped freehold or leasehold lands.

(*d*) *Expansion of existing villages*—Where old established villages fall within the irrigable command of a new scheme, sufficient Crown land is reserved for expansion of these villages within the scheme.

(*e*) *Village Tanks:*

(*i*) Working Tanks—These tanks are left intact to serve the lands under them. No irrigation facilities are provided to these lands, nor supply to the tank augmented by the new scheme, unless the catchment of the tank has been interfered with by new development.

(*ii*) Abandoned Tanks—Suitable tanks in the highland area are restored and

supplied, arranged if possible for domestic purposes.

(*f*) *Pasture*—This is usually provided in the highland area whenever land is available. Approximately, 10 per cent of the highland area is set apart for this purpose.

(*g*) *Fodder*—Unsuitable lands falling within the paddy units are set apart for growing of fodder grasses. Approximately 5 per cent of the paddy area is set apart for this purpose.

(*h*) *Forest*—These requirements are met by conforming to the basin development of the area and the necessary reservations for streams, drainage lines, wind belts.

(*i*) *Reservations for streams and main rivers* are provided according to the general orders and wherever possible the reservations are increased to provide the necessary forest for extraction of firewood and other forest produce, by the settlers.

(*j*) *Social Amenities-Villages and Townships:*—In the blocking out of the highland, 150 units are grouped together in a village and are served with a Community Center to provide for the following services:

(*i*) Health: Dispensary, clinic, creche, preventive services—extent reserved 4 acres.
(*ii*) Social: Community Hall, park and playground, marketing center, school and garden—extent reserved 10 acres.
(*iii*) Miscellaneous: Blacksmith, carpentary, laundry, boutiques, cemetery etc.—extent reserved 16 acres.

Thus a total of 30 acres, approximately, is reserved to provide the amenities for a village. A township is generally established to serve 5 villages and approximately 60 acres are reserved for health, social and other amenities as are normally required.

CHANNEL SYSTEM

Channels

Channel types referred to in the blocking out plans are:

(*a*) *Main Channel*—This is the principal supply channel and takes off from the outlet sluice in the case of storage reservoirs or from the head sluice in the case of diversion schemes. It is usually a contour channel with a mild gradient and no direct issues are made to the fields.

(*b*) *Branch Channel*—An off-shoot from a main channel from which also there is no direct issue.

(*c*) *Distributary Channel*—This takes off from a main or branch channel and supplies water to field channels. Sometimes direct issues are also made from this channel to isolated allotments.

(*d*) *Field Channel*—This is the channel which provides direct issues to fields.

(*e*) *Drainage Channel*—These carry the surplus surface flow from individual allotments to the natural drainage lines.

Layout of Supply and Drainage Systems

The irrigation and drainage system adopted for each tract depends on the nature of land to be irrigated. Two systems to suit flat and steep terrain commonly met with are as shown in Exhibits 8, 9.

First type shown in Exhibit 8, is the system provided for a flat terrain. Here, the field channels take off from a distributary channel which runs along the contour. Field channels are laid at right angles to the contours, and similarly the drainage channels.

The second type as depicted in Exhibit 9, is that of a steep terrain. Here, the distributary channles are laid at right angles to the contours while the field and drainage channels run parallel.

Duty of Water

The duty of water relates to the total quantity of water which is required to bring a crop to maturity and may be referred to different bases. It may be reckoned as the number of acres which are irrigated by one cubic foot per second running constantly for the whole time the crop is under cultivation. A duty of 60 acres means that one cubic foot per second will suffice for maturing that area of crop; it refers only to the rate of irrigation, as it does not take the element of time into consideration; it assumes that the rate of supply is constant throughout the whole period of cultivation which under actual practice is not so.

In determining the mean supply that a channel should carry to irrigate an area, the following standard is adopted:

	Area Command in Acres	Duty Acres/Cusec
Main Channel	5000	40
	5000—10000	50
	10000—15000	55
	over 15000	60
Branch Channels		40
Distributary Channels		35
Field Channels		30

Channel Design

The channel capacities are based on the above duty and the design must be such that for the operation range of conveyance between +30% and —30% of the mean supply, the channel must be stable. The channel designs are done according to accepted theories of flow in open channels. The criterion of the design however, is the velocity permissible in the material through which the channel is cut. In the design of earthen channels, the velocity is kept within 1.1 and 1.25 times Kennedy's critical velocity.

Method of Distribution

The method of distribution is by the continuous flow system. In this system of distribution, water is supplied to each peasant colonist in a continuous stream. The cultivator draws his supply directly from a 4" diameter pipe outlet fed by a field channel which in turn gets its supply from a distributary which takes off from the main channel.

The outlet consists of 4" diameter pipe located at the highest point of the field; the cultivator leads the water into the several bays (or compartments) sub-dividing his 3-acre allotment vide Exhibit 7. The outlet can be closed by the cultivator when he does not require water by blocking the mouth of the outlet with wooden plug or earth. The site of the outlet is not fixed in the initial stages of the scheme and is left to the cultivator to locate a suitable site for it by trial and error. When the cultivator finally fixes the site for his outlet, permanent headworks are constructed and no further alteration to the site is permitted. The issue of water to the field channel is from a distributary controlled by gates provided with locking arrangements. The issue from main to the distributary is similarly controlled.

Conclusion

The method of laying down channels and blocking out as given in this paper represents the basic principles followed in providing irrigation facilities to any area commanded by an Irrigation Project. Usually, the area is a mixture of all types of terrain and hence deviations from the general pattern as described in this paper have to be made when laying down the channel systems.

Discussion

Mr. Rajaratnam stated that irrigated land in Ceylon can be classified as (1) free hold lands, or (2) crown lands, blocked out into plots for colonization. The paper deals with the latter category of lands. It is estimated that 400,000 acres of such lands have been given out over the past 15 or 20 years; this is rehabilitating and providing a new way of life for 100,000 families. The development planned for the country will envisage the development of 400,000 acres in the next 10 years.

Sayyid Hamid asked regarding the inconvenience because of separation of the dry plot and the wet plot both held under a single ownership. He also inquired as to whether the three acres of wet land together with the dry land allotted to the cultivator was adequate to keep him busy and provide a livelihood. Mr. Hamid was particularly interested in the matter of full employment.

Mr. Rajaratnam replied that the three acres of paddy did not provide adequate employment. This has led to subsidy for wells to irrigate some of the dry lands (about ½ to 1 acre per cultivator) to produce money crops like tobacco, chillies and vegetables. Where this is possible, living standards have been greatly improved. The dry land development has been recommended. However, the problem is one of the Government finding the money. The cottages were placed on the highlands because of the former prevalence of Malaria in the low lands.

Mr. Macksoud inquired regarding the relation between the farmer and the management of the irrigation system. Mr. Rajaratnam said that committees are formed by the farmers in areas of 200 to 300 acres extent. A head-man is appointed who takes the responsibility for the water issue among the colonists under the committee's jurisdiction. Water is issued to the head-man by the Department upon his requisition. The water is delivered to the three-acre unit at the point where the farmer needs it and then by the farmer on his field successively to a system of bays.

Dr. Asghar commented that it would be helpful if Mr. Rajaratnam could make a later statement of the problems which arose in connection with the colonization scheme in order that others might avoid the mistakes and benefit from their experience.

In response to a question by Mr. Vernon about duty of water, Mr. Rajaratnam stated that a paddy crop, with a growing period of 120 days, required 4 acre feet of water per acre. This calculates to a duty of 1 cu. sec. for 60 acres.

The channels are designed to handle 30% additional capacity, since the water requirements for the paddy are not uniform over the growing period, being greatest during flowering. At other times the requirements are less than mean and the channel must be stable between these two limits.

Mr. Vernon discussed the so-called "rational" method of determining water requirements for canal design. In this method the various crops are considered together with crop-rotational patterns; and from this, an integration for water requirements is made based on the net irrigated area. The net

irrigated area takes into account land out of cultivation for farmsteads, roads, etc. and in fallow. A cropping pattern is based on the agronomists' evaluation and the water requirements are estimated in terms of climatic factors.

Mr. Dufalla asked if the farmer was qualified to determine his own water requirements under the committee system mentioned. He also inquired as to how the distribution was made from the canals to the individual holdings. Why was the headworks built before the network distributaries and prior to colonization? Mr. Rajaratnam replied that under paddy flooding the farmer requires water whenever the water level recedes in his field. He is given whatever amount he wants. The distribution of water from the sluices to the cultivators is by a separate organization under the Department of Revenue. This is done through the head-man of the cultivators' committee.

The headworks are completed first because of the long time required to make the surveys in the wooded country. Construction of headworks may thus proceed concurrently with the surveys.

There are 10,000 to 12,000 tanks in the dry zone which were constructed by the ancients, but abandoned. Approximately 100 tanks are being reconstructed per year. (Mr. Rajaratnam explained that "tanks" refers to small reservoirs formed by earth embankments).

In response to a question by Professor Macksoud, Mr. Rajaratnam stated that since tanks are reasonably close to rice paddies (within 10 miles) the cultivator can usually get his water delivered within one day of application.

Mr. Ramsay inquired what happened to free-held lands under canals built in connection with the colonization scheme. Mr. Rajaratnam replied that if such lands are not developed they are taken over by the scheme with compensation to the free-holder. If developed, the free-holder may receive water from the scheme and pays appropriate charges for the same.

EXHIBIT 1

SPECIFICATIONS FOR SURVEYS

Control Surveys—General

I. The probable area to be developed under an Irrigation Scheme shall be covered by a control survey to determine :

(*a*) Probable irrigable command and extent of land available for irrigation under the proposed scheme;

(*b*) Areas suitable and available for high land development in the vicinity or within the irrigable area.

II. All the field work that shall be done in connection with the control surveys shall be so designed and laid out that it shall form the basis for the more detailed and complete engineering surveys to be undertaken at a subsequent stage. Therefore, all pickets and bench marks established during the control surveys shall be permanent and be available for use in the engineering surveys. The Bench Marks shall be of standard construction and be located at the corners of one-mile squares.

III. The area to be surveyed shall be broken into half-mile squares and a quarter-mile grid system established. Along the grid lines, spot heights shall be taken at 160 links or at closer intervals if the topographical features crossed by the grid lines are such as to necessitate spot levels at closer intervals to indicate more clearly the configuration of the ground covered by the control survey.

IV. All existing roads, paths, channels, watercourses, tank bunds, rock outcrops and their reservations and/or boundaries together with physical features crossed by the grid system shall be surveyed and shown on the plans. Wherever possible, high flood levels, full supply levels of watercourses and/or of tanks shall be levelled and shown on the plans. The boundaries of all developed lands shall be surveyed and shown on plans.

V. The plans shall be drawn to a scale of 8 chains to an inch. All topographical features surveyed under para IV above and the spot heights along the grid lines shall be shown on the plans. From the spot heights, form lines at 5 ft. intervals shall be sketched in. All levelling shall be reduced to the geodetic datum before plotting.

EXHIBIT 2

ENGINEERING SURVEYS

I. Using the grid system established during the control surveys, the area to be covered by the Engineering Surveys shall be broken up further into quarter-mile squares and a 4-chain grid system shall be established.

II. Along the grid lines, spot heights shall be taken at 160 links apart or at closer intervals if the topography of the area crossed by the level lines necessitates additional spot heights to indicate the configuration of the ground. Spot heights along river and stream beds and banks, tank bunds, roads, irrigation channels, and controlling levels of all structures such as culverts, bridges, irrigation sluices, spills etc. shall be taken. In the levelling of tank bunds, flood bunds, irrigation channels, streams and roads, levels in sufficient detail shall be taken to permit the preparation of longitudinal and cross sections. All subsidiary features described in para 354 in the Technical Instructions of the Surveyor General shall be shown on the plans.

III. All topographical features such as rock outcrops, rivers and streams, their boundaries and reservations shall be surveyed and shown in the plan. All permanent improvements such as roads, tanks, irrigation channels, drainage channels and buildings together with their boundaries and/or reservations coming within the area shall be surveyed and shown on the plans. The boundaries of lands developed for permanent cultivation, paddy, garden, chena etc. shall also be surveyed and shown on the plans.

IV. Engineering plans shall be drawn to a scale of 4 chains to an inch showing all the topographical features and other details described above together with spot heights. From the spot heights, form lines at 1 ft. intervals shall be sketched in. Where the ground is steeper than 1 in 100 the form lines shall be at 2-ft. intervals. All levelling shall be reduced to the geodetic datum before plotting.

V. Full-supply and high-flood contours of water courses and/or tanks shall be surveyed in sufficient detail to be plotted in the plans.

VI. Together with the 4-chain engineering plans, a set of reduced plans to a sclae of 12 chains to an inch shall be printed.

EXHIBIT 3

CHANNEL TRACE SURVEYS

I. The channel trace surveys shall cover :

(*a*) Main channels,
(*b*) Branch channels,
(*c*) Distributaries, and
(*d*) Field channels.

II. *Main & Branch Channels.*—The porposed channel trace shall be covered by a strip survey as indicated on the 4-chain engineering survey sheets. The trace thus shown shall be pegged out on the ground and a traverse survey of this line shall be made. All topographical features, rock outcrops, roads, streams, channels, embankments, property lines crossed by the trace and coming within the strip shall be surveyed and levelled. In the case of rock outcrops, spot heights shall be taken to indicate their magnitude.

III. With the channel trace as the center line, a strip extending 5 chains on either side of the center line shall be covered by a close level survey. For the level survey the center line shall be pegged out at 100-ft. intervals and off-set lines at right angles to the center line shall be set out extending 5 chains on either side of the center line. Along the off-set lines, spot heights at 50-link intervals shall be taken. Spot heights along the center line and the off-set lines at closer intervals shall be taken if necessary to indicate any features that may be desirable to indicate the nature of the country covered by the trace.

IV. The center line shall be demarcated on the ground by sawn wooden pegs at every 100 ft. The pegs shall extend 3 inches above the ground and shall show the mileage and the 100-ft. chainage number. Concrete pickets at quarter mile intervals and at changes of direction of the trace shall be established and marked as specified above.

V. Permanent bench marks of standard construction shall be established at half mile intervals about 150 links away and above the center line of the trace.

VI. A flat plan of the survey shall be plotted on a single sheet for each mile to a scale of 4 chains to an inch. The plan shall occupy the upper portion of the sheet leaving sufficient space at the bottom for the longitudinal section to be drawn to a scale of 200 ft. to an inch horizontal and 10 ft. to an inch vertical. The longitudinal section shall be plotted by Irrigation Department after the final channel trace has been selected.

VII. All the details surveyed, topographical features, spot heights, position and value of bench marks shall be plotted and shown on the flat plan. All levelling shall be reduced to the geodetic datum before plotting.

VIII. When the channel trace is carried through an existing or abandoned channel system, the survey of this section shall be made according to the general specificatio ns above. In addition, C.S.S. shall be plotted to a natural scale of 20 ft. to an inch and sufficient information given on the flat plan for identification of the cross section, that is, channel bed width, slope of bank and bank heights.

EXHIBIT 4

DISTRIBUTARY & FIELD CHANNELS

I. The poposed channel trace as shown on the 4-chain engineering survey sheets shall be located on the ground and a traverse survey of the trace shall be carried out.

II. Spot heights at 100 ft. or at closer intervals if necessary, to bring out the undulations of the ground along the trace shall be taken. At every 500 ft. intervals, off-set lines at right angles to the trace extending two chains on either side of the trace shall be set out and spot heights at 50-link intervals along the off-set lines shall be taken.

III. All topographical features, rock outcrops, roads, streams, channels, embankments, property lines coming within the 4-chain strip described above, shall be surveyed in and shown on the plans. In the case of rock outcrops, sufficient spot heights shall be taken to indicate their magnitude.

IV. The center line of the trace shall be demarcated on the ground by sawn wooden pegs at every 100 ft. The pegs shall extend 3" above the ground and shall show mileage and the 100 ft. chainage number. Concrete pickets at quarter mile intervals and at changes of direction of the trace shall be established and marked as specified above.

V. Permanent bench marks of standard construction shall be established at half-mile intervals about 50 links away and to the right of the center line of the trace.

VI. The survey shall be plotted and a flat plan drawn to a scale of 4 chains to an inch on a separate sheet for each mile of the channel trace. The flat plan shall occupy the upper portion of the sheet leaving sufficient space at the bottom for the longitudinal section to be drawn to a scale of 200 ft. to an inch horizontal, and 10 ft. to an inch vertical. The longitudinal section shall be plotted by the Irrigation Department.

VII. All the details, and topographical features surveyed, position and value of bench marks and the spot heights shall be plotted and shown on the flat plan. All levelling shall be reduced to the geodetic datum.

VIII. Where the trace is carried through an existing channel system, the survey of this section shall be made according to the general specifications above except that cross sections shall be taken at 100 ft. intervals along the trace. These C. S. S. shall be plotted to a natural scale of 20 ft. an inch and sufficient information shall be given on the flat plan for identification of the cross sections.

D

RESEARCH AND DEMONSTRATION FARMS

TARSUS RESEARCH INSTITUTE OF TURKEY

By
RAGIP BOYACI[1]

Introduction

In regard to climate, soil and water resources Gukurova is one of the highest potentially productive regions of Turkey. "Gukurova" is a common name given to Hatay, Adana and Igel provinces. It has 3,500,000 decars of irrigable land between the Mediterranean Sea and Taurus Mountains.

Cultivation was begun 90 to 100 years ago on this alluvial plain where several large rivers flow. Historical reports indicate that the plain was completely pasture land about a century ago. The rivers, namely Seyhan, Ceyhan and Berdan, which formed this alluvial plain, have changed their beds several times. There were times when the two or three of them discharged into the Mediterranean sea at the same point. For example; it is recorded that Seyhan and Ceyhan came together and separated six times between 450 B.C. to 1696 A.D. Since 1696 Ceyhan delta has gained a large area, increasing about 24 Kilometers towards the sea. That is, 94 meters of land was gained each year.

The rivers have remarkable elevation differences between their upper and lower ends. Their beds have steep gradients deep into the Taurus mountains; and they meander when they reach the plain. The discharge varies greatly during the year and from year to year. For example: the minimum and maximum discharges for Seyhan is 50 and 2500 m^3/Sec; for Ceyhan 35 and 1800 m^3/Sec; for Berdan 10 and 820 m^3/Sec; respectively.

Because of the different factors effecting their formation there are several different types of soil on the Gukurova Plain. These factors are:

1. Climate.
2. Changes of the river beds.
3. Destruction of the vegetative cover on the Taurus hills by the ancient civilizations.

This alluvial plain has high water-table and salinity problems. In order to plan, construct, and efficiently operate the irrigation and drainage systems for the agricultural development of the area, the required standards for these works have to be supplied by research.

During the last 25 years, the Turkish Government and individual farmers have established some partial irrigation systems and have practised irrigation. But, because of the lack of knowledge and practice of irrigated farming, and also because the systems were not soundly based on research, the expected increase in production has not been obtained. Consequently the results of this misuse lead to a fear of irrigation in the farmers mind from the following problems:[2]

1. High water-table and salinity.
2. As a result of monoculture (continuous cotton), limited irrigation area, and the lack of insect and disease control; epidemic diseases such as pink boll worm have infested the area.
3. Land preparation for irrigated farming was omitted.

Establishment of the Station

The rise of the problems given above indicated the need for irrigation research stations on irrigation project areas. Because of the close relation between the engineering and agronomy phases of irrigation and drainage the Ministry of Agriculture and the Ministry of Public Works in 1946 decided to establish a formal agreement for coordinative work. Briefly it was agreed that State Hydraulic Works would purchase the land and construct the buildings for Irrigation Experiment Stations, and the Ministry of Agriculture would operate the Stations and conduct experiments to develop the required basic information for the works of State Hydraulic department.

1. Agricultural Engineer, Head of Climate-Soil-Water Division, Irrigation Research Institute, Tarsus, Turkey.

2. Some of these problems of the area have been presented in detail by Muzaffar Alap, Director, in his report "The Farm Needs and Farmer Interese Sarvey" in the first seminar held in Turkey in 1956.

When this formal agreement was put in effect, Muzaffar Alap (who is the present director) was asked to established the first irrigation experiment station in Turkey. So on 17th of September 1947, 450 decars of land between main irrigation canals A-VII and A-VI of Seyhan Right Hand Irrigation System was expropriated as representative of the irrigable land of Gukurova. At the beginning the name (1947) "Alifaki Irrigation Experiment Station" was assigned. In 1948 it was assigned to work as "Tarsus Regional Irrigation Experiment Station."

Right from the beginning of the establishment to the time that the first building were made in 1950, Muzaffar Alap by himself conducted all the experiments. He started to work in a tent and without any farm machinery, but only mules for cultivation and horses for transportation. It was only after 1951, that he had three assistants to work with him.

In 1952-53 the Station began to get the results from some experiments and initiated field demonstrations on farmer's fields. In those years short period training courses on soil, irrigation and drainage practices and techniques were started for the personnel of proposed experiment stations and soil conservation services. It is a great pleasure to remember ICA Advisor Mr. Carl Forsberg's lectures during this period.

In 1956 the name of "*Tarsus Irrigation Research Institute*" was assigned to the Station.

It should be stated that almost all the personnel of The Soil and Water Conservation and Farm Irrigation Section of Turkey have been trained during the courses held in Tarsus.

At the present time a "Soil Conservation and Irrigation Training Center" building is under construction financed by U.S.I.C.A. This year it is hoped that training will start under special programs prepared by Turkish and American specialists.

At present (1960), the land pieces owned or leased from farmers for research and demonstration purposes are as follows:

1. *Institute Center:*

This includes 450 decars of land located on the alluvial plain. The soils are silty clay in nature and the water-tables is about 120 cm below the surface. Most of the experiments listed in Appendix A and B were carried on here. Office, laboratory, storehouse and workshop buildings are located here.

2. *Alifaki and Salinity Reclamation Substation:*

450 decars of land located on hydromorphic saline-alkali soils. The depth of water-table is about 70 cm below the surface.

The principal experiments carried on here are based on leaching and reclamation of these soils which are representative of 350,000 decars of land of Gukurova.

3. *Topqu Soil Conservation Research Sub-station:*

The size of the farm is 1,300 decars. The farm represents the upland, apparently infertile, soils which are effected by continuous erosion lying between Taurus Mountains and Gukurova plain. It has a rolling topography. The experiments are conducted under dry-farming conditions. Soil conservation practices are considered (See Appendix B.)

This land will also be used for demonstration and practicing purposes of the training center during the soil conservation practice courses.

4. *Homurlu Truck-crops and Orchard Management Farm:*

This consists of 197 decars of land located on the early vegetable growing and orchard area of the Gukurova Plain. Because the water-table is quite deep (below 2m.) the irrigation water requirements experiments for different crops are conducted by the soil-moisture depletion method.

5. *Deliminnet General and Livestock Farm:*

The studies on this 1470 decares of land started last fall. The main purpose is to promote the use of forage crops and irrigated pasture in crop rotation with rice. It would also promote livestock enterprises for furthering the agricultural economy of the Gukurova. Reclamation possibilities of wet and saline spots will also be studied.

6. *Namrun Small Family Farms:*

The total size of these plots is 75 decars. They are located on the Namrun Plateau (elevation 1200m), over the Taurus mountains. During the hot summer season most of the people living on the Plain use this place for a summer resort. The main objective is to determine the minimum size of land on which a family can have a house and run a small vegetable and fruit garden for the season.

Purposes and Duties of the Institute

The Institute has two main objectives—Research for supplying the necessary basic data and know-

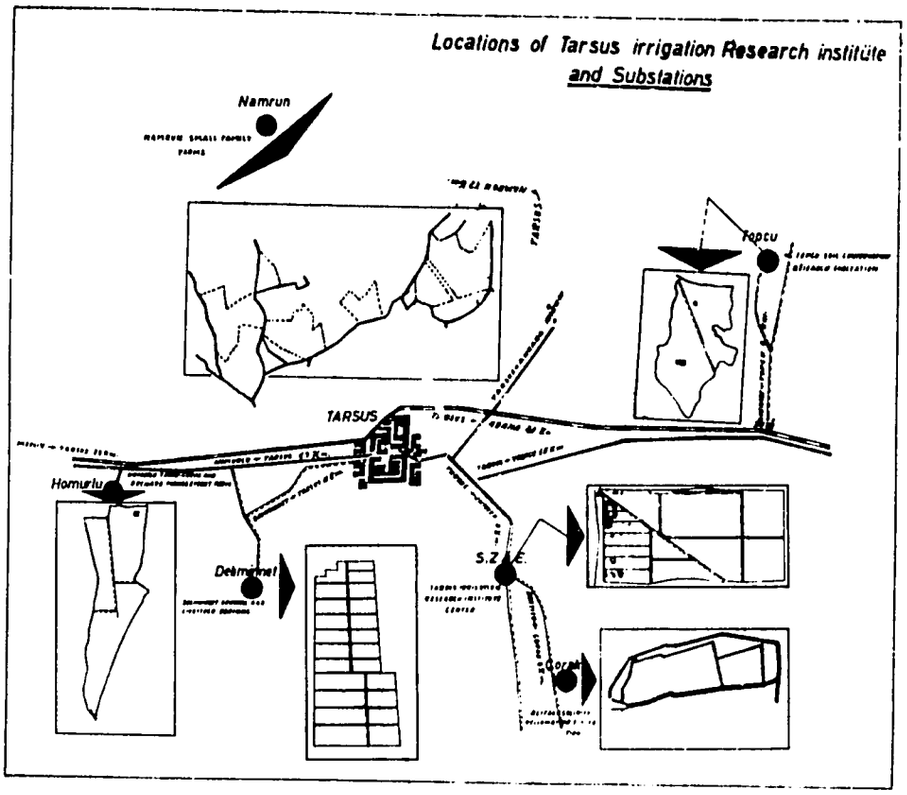

Fig. 1.— Layout of Tarsus Irrigation Research Institute.

ledge for the large irrigation projects of the territory and research on using water in agriculture.

I. *Research for the Large Irrigation Projects*

A.—Research for obtaining necessary data and knowledge which will be used at the survey and planning stage of the irrigation projects.

1. To determine the profitable crops economically adaptable to the region.
2. Consumptive use of different crops and under different soil conditions.
3. Irrigation water requirements of different crops.
4. The most economic types of crop rotations for different soil types.
5. Yields of different crops under irrigation and dry conditions.
6. Production cost of different crops.
7. Cost per decar of land preparations for efficient and modern irrigation practices such as land clearing, land levelling, farm irrigation and drainage system.
8. Evaluating land for irrigation suitability.
9. Determination of the quality of the irrigation water.
10. To study the soil-water relationships of the different soil types and classes, such as field capacity or moisture equivalent, wilting percentage, pore space, horizontal and vertical permeability, intake rate, etc.
11. Determining the different sizes of farming types for the region such as large, medium and small sizes of general irrigated farms, livestock and dairy farms, truck-crop farms, fruit crop farms and specialty farms.

B.—Research for obtaining the necessary data and knowledge which is needed to operate the irrigation projects.

1. Research on methods of water delivery, such as continuous flow, rotation, demand and periodic deliveries.
2. To determines the time of the water deliveries to the irrigation canals.
3. Research works on the operation and maintenance of irrigation systems, such as efficiencies of the irrigation project, efficiency of farm irrigation system and irrigation practices, weed control of the canals.

II. *Research on using water in agriculture*

A.—Research work in relation with land preparation for irrigation.

1. Determining the irrigation methods best fitted to soil characteristics, types of crops, topographic conditions and available water supply.
2. Determining the most economic equipment, devices and water control structures for farm irrigation systems.
3. Determining the desirable types of land levelling under different conditions of soil, topography, slope and crops.
4. Determining the necessary standards for planning farm irrigation systems such as length of run, for furrows and borders, size of streams, width of borders, etc.
5. Determining the necessary information and standards for planning farm drainage systems, such as horizontal and vertical permeability of the soils, spacing and depths of drains, side slops of drains and ditches, economic feature of the different drainage types.
6. Research on farming practices under irrigation conditions.

B.—Research for efficient irrigation practices.

(*a*) Determining the time and frequency of irrigation for different crops.
(*b*) Irrigation water requirement for each irrigation and for the growing season.
(*c*) Determining the field irrigation efficiencies, such as, water application efficiency, water storage efficiency, water distribution efficiency.
(*d*) Determining the irrigation time of the different crops.
(*e*) Preparing the irrigation guide for the specific area.

Discussion

In response to a question by Mr. Ayazi about difference in horizontal and vertical permeability Mr. Boyaci pointed out that soil permeability may be anisotropic. He stated that during Dr. Don Kirkham's visit to Turkey in the summer of 1959, a new trans-permeameter suitable for determining permeability of the soil in place below the water-table has been developed. This device determines both horizontal and vertical permeability and has extensively tested against other methods.

Mr. Ayazi felt that the irrigation efficiencies should be the same for different crops on the same soil; however Mr. Boyaci stated that these may be different due to different root systems.

Mr. Jones reviewed the development of the Tarsus station, stressing the faith and perseverance demonstrated by the founders, particularly Muzaffar Alap, over the past 13 years. He pointed out that in 1952 and 1953, after research results began to be available, demonstration work was begun, and that the station began to train personnel for work at other stations and for the Land Reclamation and Irrigation Service; and that at the present time a Soil Conservation and Irrigation Training Center is being established. Mr. Jones mentioned the importance of the task of getting the research results available to the farmers and asked for amplification regarding the present training program.

Mr. Kaleli replied that at the time the training first began in 1953, the center was placed near the research station in order that the trainees could benefit by inspecting the research work. He stated that the present program involves training at three levels (1) the agricultural engineer, (2) the extension worker, and (3) the skilled irrigator or operator. Most of the teachers will be drawn from experienced personnel of the research stations or the Land Reclamation and Irrigation Service; the latter will have experience at the district or work unit level. This arrangement makes it possible for the trainee to know what is happening at the research station and also to become familiar with different crops. On-the-job training will be provided. Subjects include drainage, land reclamation, soil conservation, land preparation for irrigation and farm irrigation.

Dr. Peterson asked how the research information fed back into the design work. Mr. Boyaci replied that full information regarding the work of the station was made available to TAMS who are designing the local system. The station provides an irrigation guide for each crop and this was used extensively in the design work. The engineers also received information regarding the rotations developed for different classes of land which the laboratory is recommending to farmers. The crop rotations were considered in the designs for the drainage and irrigation system. The "rational" method was used for determining canal capacities. Consumptive use data furnished by the Institute was used for this purpose.

In connection with design of laterals, results on irrigation practices were used for lengths of runs. Results of seepage tests on the different soils were also used together with information about water-table fluctuations. It has been found that eucalyptus trees transpire about 2½ meters per year; and now they will be used as a means of lowering the water-table. By planting eucalyptus trees mid-way between the drains, it is possible to space field drains twice as far. This design is being employed in important vegetable growing areas.

Mr. Vernon inquired regarding the educational level of the people selected for the training program. In explanation Mr. Kaleli replied that the trainees would be chosen from the Farm Reclamation and Irrigation Department which has three levels—

the national office, regional offices, and work unit offices. The Department perfers that college graduates entering the program spend from six months to a year at the work unit or district level; then, if they continue with the department, they will be given the opportunity to attend the training center. At the training center the trainee will receive work in his special field. The first level will be for the Agricultural Engineer, the second level will be for extension workers. The extension worker must be familiar with the various programs; but, where technical work is required, the farmer will be referred to the work unit. At the third level, which is the skilled level, although some people at this level are trained in agriculture, there are none who specialize in irrigation and reclamation. It is anticipated that graduates from the eighth grade will receive irrigation training at the skilled level at the Center. There is a demand by farmers for people with this background for hire.

At the first and second levels there will be two kinds of courses, a basic course and then an advanced course to which people may return after three or four years.

Mr. Ismail inquired regarding the staff of the Tarsus Station. Mr. Boyaci stated there were two Agricultural Engineers in the laboratory, together with the necessary forces to make the analyses—clerical and technical. At each sub-station there are two people. Altogether there are 15 agricultural engineers, two crop technicians and two machinery specialists. The personnel increases during the summer and the total personnel employed may approached 200.

Appendix A.
BRIEF RESULTS OF THE SOME EXPERIMENTS COMPLETED TO DATE

Objectives	*Experimentation period, years*	*Results obtained*
Climatic Characteristics of Tarsus	8	C1 B3 S2 b4. C1 = Arid and semi-humid, general humidity index is 20-0. B3 = Third mesothermal climate type. S2 = Significant lacking water in summer and more in winter. b4 = Evaporation rate of summer to the yearly is 50.1%.
Drought Index of Tarsus Plain	8	The index is 17—24. Irrigation is the most necessary factor in increasing the yields of the crops.
Moist and dry months	8	In general, all of the months are dry for the growing season. In only one of the 8 years, a moist month is recorded.
Length of growing season of Acala-130	8	Growing season is 161—187 days. Seeding time is March 20th-April—25th. Harvesting time begins from August 20th to Sept. 18th.
Water Consumptive use of Acala-130 per month and per year	6	Consumptive use per year: 771 mm. April: 27.5mm. May: 49.0 mm. June: 107.0mm. July: 145.7mm. August: 215.4mm. Sept: 160.9mm. October: 65.5mm.
Plant and row spacing of cotton under irrigation condition	3	Under irrigation condition, row spacing should be 80—100 cm. for furrow irrigation. Crop density should be 3500—4000 plants/decar. The highest yield was obtained with spacing of 80 × 25 cm and 4100 plants/decar.
Irrigation water requirement, irrigation period and irrigation time of cotton.	6	The highest cotton yield is obtained by using 450—600mm. of irrigation water. Rainfall during the season is omitted. Mean daily consumptive use of cotton is 4.2mm. during the growing season. Available water in the root zone should be maintained from seeding until 2/3 of the ball appears.
Earlier and later irrigations for cotton	5	During the period of branching and budding, drought decreases the yield. For this period soil moisture in the root zone should not be less than 50% of available moisture. The highest yield is obtained by two earlier irrigations, one in May and one in June. The increase in yield is 63% more than control.

Objectives	*Experimentation period, years*	*Results obtained*
Liming practice for cotton	3	Application of 20 kg. of powdered lime per decar increased the yields for the 3 years of experimentation. The increase in yield is 26%.
Effect of farm manure on cotton yields	4	Manure is extremely effective in increasing the yield of cotton. The highest yield was obtained by applying 4 tons/decar of manure.
Effect of cotton stalk compost on cotton yield	3	Same results are obtained as the manure application.
Effect of green manuring (vetch) on cotton yield	2	Vetch, used as a winter legume and plowed under in early March, increased the cotton yield 24%.
Crop rotation for cotton	3	3 years rotation of cotton-grain-cowpea increased the cotton yield 57% over cotton—grain rotation.
Crop rotation for cotton	3	Cotton-grain-cowpea rotation in 2 years increased the cotton yield 33% over cotton-grain rotation.
Standards for furrow irrigation of cotton	2	Under clay loam soils and about 0.3—0.4% slopes the maximum length of run should be 150—170m. and maximum furrow streams are 1.5—2.0 liters/second. Estimated application time of water for each furrow is 157 minutes.
Yields of cotton varieties	3	The following results of yield were obtained: Coker 100: 238 kg/decar (seed cotton) Acala 4-42: 215 kg/decar ,, New-mexico: 200 kg/decar ,, D.P.L. fox: 199 kg/decar ,,
Water requirement of cotton (scala)	3	The highest yield was obtained when the top 60 cm. of soil was continiously kept at a soil moisture content a little more than 50% of available moisture, or cotton should be irrigated when the soil moisture content of top 60cm. reaches to the level between the field capacity and wilting point. 5 irrigations are necessary for the season. The consumptive use range is 480—692 mm. per season. The peak water demand is 8 mm. per day in July. (when the plants are in flowering and bolling stage).
Yield of cotton-irrigated against non-irrigated	1	104 kg/decar more seed cotton was obtained from the plot that received 12 kg. N/dec. and 4 kg. P/dec. and 5 irrigations (75mm. each) than the non-irrigated fertilized plots with the same N and P.
Seeding time of corn	3	In Gukurova plain, the corn should be seeded (1) on normal seeding time and (2) late seeding. Normal seeding is in early April. Late seeding is delayed after grain harvesting, usually in June. Yields of these different seeding times do not show significant differences. Late seeding is preferred because it is possible to get 3 crops in 2 years.
Fertilizing the corn	3	The highest yield obtained was 317 kg/decar by the application of N and P.
Spacing of corn seeding	3	Seeding 4 seeds (4000 plants/decar) to each hill, spaced one meter gave highest yield than 3 seeds (3000 plants/decar) to a hill.

Objectives	*Experimentation periods, years*	*Results obtained*
Irrigation time of sesame	2	Two irrigations; one on flowering stage and one on when 2/3 of the capsules appear was best.
Water consumptive use of Osmaniye peasants per month and per year	3	Consumptive use if 610mm. per year. April: 50.0mm. May: 80.0mm. June: 150.0mm. July: 145.0mm. August 135.0 mm. Sept: 50.0mm.
Irrigation frequency and amount of water per irrigation for Osmaniye peasants.	3	On clay silty soils irrigation every 20-25 days applying 75-100 mm. at each. Four irrigations are needed in the season. According to the results the yield is increased 33% over non-irrigation.
Plants and row spacing for red cloud tomatoes	2	Under Gukurova conditions the highest yield was obtained with 1 × 0.8 meter planting.
Irrigation water requirement of red cloud tomatoes	2	Irrigation should be applied when the soil moisture content of the top 60 mm. reaches to the level between the field capacity and wilting point. 8 irrigations are necessary for a season. Water consumption is 831mm. per season. The yield is 4390 kg/decar.
Adaptation of the fiber crops	2	The experiment was carried with jute, hibisous, abutulon and hemp. The highest yield was obtained from hibisous (III kg/decar).
Crop rotation experiments	4	According to randomized block crop rotation experiments under Gukurova conditions the highest economical yields are obtained from 2 years rotation of wheat/cowpea-fertilized cotton; and 3 years rotation of wheat-peanuts-cotton. The other rotations were continuous cotton, fertilized wheat-manured cotton, wheat-manured cotton.
Sprinkler irrigation in the Gukurova plain	2	During irrigation season in Gukurova the prevailing winds occur between 9-17 o'clock in day time. Sprinkler irrigation could be used outside of these times. Otherwise application and pattern efficiencies are too low.
Yield of rice varieties on saline soils	3	The experiment was conducted with risetto, balilla, bereani, violona, maretelli and americano varieties. The most adaptable variety for the saline soils is belilla (412 kg/decar), then comes risetto (259 kg/decar) and violona (239 kg/decar). The yields of all varieties were decreased by 32—69% from the yields of normal soils. Also plants were 21—41 cm shorter.
Irrigation module for rice	2	The water delivery for rice should be 1.4-2.0 litera/second/hectar under Gukurova conditions.
Grazing experiments on irrigated pasture	2	On four rotated grazing experiments with southern red cattle on borders seeded to 60% grasses and 40% legume mixture carried on both leached saline and non-saline soils.
The effect of depth of cut on yield in land levelling	2	Experiments have been designed with latin square method under the treatments of 0,7.5, 15,25,45 cm. of cut depth. In two years 3 crops (beans, peanuts, vetch) were planted. The result were always the same: the stands and yields were in inverse ratio with the depth of cut. On the plots with 25 and 45 cm. of cut the plants could not mature the seeds.
Pre-testing for pump drainage of Aiifaki saline soils	1	According to five wells at different depths (9.5m, 25m, 15m, 52m, 73m) ground water of the area has artesian pressure in connection with Taursus mountains by different aquifer layers. The measurement of piezometer batteries showed that artesian pressure is quite strong below 4.5m. depths and from 4.5m to 1.25 depth, artesian pressure is 2 cm/meter. To establish an efficient drainage system for this area to lower the water-table, artesian pressure should be release by pumping of the ground water. Pumping tests are to continue.

Appendix B.

CONTINUING EXPERIMENTS

A.—*Studies on climate-soil-water interrelations of Gukurova.*

1. Laboratory studies to determine the physical and chemical properties of Gukurova soils.
2. Laboratory studies on irrigation water quality of sufrace and underground sources.
3. Comparison of determining wilting percentage by dwarf sunflower and laboratory methods.
4. Ca CO_3 accumulation in the Gukurova soil profile and determination of $CaCO_3$ content changes in the horizones.
5. Comparison, for correlating purposes, between laboratory and field methods of determining permeability of soils.
6. Potential fertility determination of citrus soils around Mersin.
7. Determination of the intake rate, and vertical and horizontal permeabilities ranges of the different soil series and types in Gukurova.
8. Studies on climate-plant interrelations in Gukurova.
9. The effect of the different depths of cut on yield in land levelling.
10. The degree of salt accumulation in the profile by using different quality of irrigation water.
11. Salt tolerances of different cotton varieties.
12. Tolerance of different fruit trees, field and vegetable crops, pasture and forage grasses to Alifaki saline soil conditions.
13. Salt tolerance of different eucalyptus varieties.
14. Irrigated pasture establishment and grazing experiments on Alifaki saline soils after leaching by continuous flooding.
15. Methods of leaching and reclamation by using chemical amendments of Alifaki saline soils.
16. Pump drainage tests of Alifaki salty area.
17. The effect of flood duration on different crops growth.
18. Experiments to determine surface runoff, soil losses and rainfall penetration on Gukurova conditions.
19. The effect of the different crop rotations on surface runoff and soil losses (Topqu soil conservation substation).
20. The effect of organic matter on surface runoff and soil losses. (Topqu).
21. Comparison of surface runoff and soil losses between subsoil and top soil (Topqu).
22. The effect of the degree of slopes on surface runoff and soil losses. (Topqu).
23. The effect of gravel content on water retention and yield.
24. Determination of standards for soil conservation practices.
25. Water conservation of soils of terraced lands.
26. Seepage losses from irrigation canals of different materials.
27. Control of seepage losses under different canal lining.

B.—*Studies on plant-soil-water interrelations:*

1. Consumptive use and irrigation water requirements of the different crops by soil moisture deplation method such as: alfalfa, irrigated pasture, tomatoes, clover, vetch, rice, orchards, etc.
2. Standards for border irrigation methods.
3. Fertilizer experiment of Red Cloud tomatoes.
4. Experiments on fertilizer application methods and depths for different crops.
5. Fertilizer experiments of peanuts and cotton.
6. Water requirement of cotton at different levels of N.
7. The effect of N-fixation by legumes on cotton yield.
8. Crop rotation experiments under irrigation conditions.

C.—*Studies on adapted and adaptable crop varieties for farm plannings in Gukurova.*

1. Grazing experiments on irrigated pasture.
2. Determination of mixture for irrigated pastures for different soil types in Gukurova.
3. Adaptation of the different cold and hot summer grasses and legumes to Gukurova conditions.
4. Seasonal cover crops for hot summer grazing. (cowpea, millets, sudan grasses).
5. Yields of different cotton, peantus, vetch, soybean, sesame, fiber crops and vegetable crops varieties.
6. Possibility of coffee plantations on Mediterranean coastal area.
7. Adaptation of strawberry varieties.
8. Adaptation of wheat varieties.
9. Experiments on different commercial fertilizer.
10. Weed control experiments in irrigation Canals.

Appendix C.

LIST OF PUBLICATIONS OF BOOKS AND BOOKLETS BY THE INSTITUTE AND INSTITUTE STAFF.

1. How to irrigate cotton. By Muzaffar Alap, 1951.
2. Argentine flax, sesame, sunflower and peanut growing, By Muzaffar Alap and Akif Uretmen, 1951.
3. Home-made irrigation equipments. By Muzaffar Alap, 1953.
4. Technical control of pink boll-worm. By Muzaffar Alap and his assistants, 1953.

5. Pre-studies on leaching and reclamation of saline and alkali soils. By Muzaffar Alap, 1953.

6. Studies on reclamation possibility of Gukurova saline soils. By Dogan Dinqer, 1953.

7. Pre-studies on rice production in Gukurova. By Yaqar Yilmaz, 1953.

8. Citrus irrigation. By Muzaffar Alap, 1953.

9. Principles of Irrigation applications. By Muzaffar Alap, 1954.

10. Surveying. By Behquet Sentirk, 1955.

11. Farm irrigation structures and equipment. By M. Alap and B. Sentirk, 1953.

12. Irrigation of row-crops. By Muzaffar Alap, 1956.

13. Peanut growing and irrigation techniques. By Muzaffar Alap, 1956.

14. Cowpea growing and irrigation techniques. By Muzaffar Alap, 1956. .

15. Annual Report for 1955.

16. Sesame growing and irrigation time experiments. By Ragip Boyaci, 1956.

17. Piezeometer gage. Ozdemir Beyce, 1956.

18. Rice growing in Gukurova and irrigation techniques. By M. Alap, 1957.

19. How the irrigation time and amount of irrigation water is determined in the field. By M. Alap, 1957.

20. Guides for irrigated grasses of Southern Turkey. M. Alap, 1957.

21. Concrete pipe irrigation system. By M. Alap, 1954.

22. Methods for determining the consumptive use of crops. By M. Alap, 1957.

23. Land levelling: Survey and design. By Irfan Oktenoglu, 1957.

24. Farm drainage: Survey and design. By Sezai Ozqelik, 1957.

25. Irrigation techniques for vegetables and production costs. By Sen Ozqelik, 1957.

26. Weed control of irrigation systems. By M. Alap, 1957.

27. Annual report for 1956.

28. Studies on the drainage requirement of Yuregir Plains that will be irrigated from Seyhan earth Dam. Institute Staff, 1957.

29. Cotton growing and trade. By M. Alap, A. Karaelmas, K. Bilgic, 1957.

30. Home made border diker. By Mehmet Akin, 1957.

31. The montaj and operation of 9-12 PL model eversman land leveller. By Mehmet Akin, 1957.

32. Needs for topographic maps in irrigation practices. By Ali Ediz.

33. Seepage losses and research methods. By R. Boyaci, 1958.

34. Instructions for determining irrigation efficiencies. By R. Boyaci, 1958.

35. The evaluation of furrow and sprinkler irrigation. By R. Boyaci, 1958.

36. Construction of farm irrigation systems: design and cost analysis. By Nazim Durlu, 1958.

37. Irrigation guide for Adana-Yuregir and Iqel-Tarsus plains. By Muzaffar Alap and his assistants, 1959.

38. Handbook for measuring irrigation water in the canals, By R. Boyaci, 1959.

39. Handbook of canal designs for soil and water conservations. By Yaqar Yilmaz, 1959.

40. Hydraulics of wells. By Yaqar Yilmaz, 1959.

41. Annual report for 1957-59 (in press).

42. Alkali soils. Ozdemir Boyace (in press).

43. Salinity and water table indicator plants. By Ozdemir Boyace (in process).

EXPERIMENTAL AND DEMONSTRATION FARMS IN EAST PAKISTAN

By

M. S. MINHAS

Introduction

Irrigation development is of major importance in East Pakistan but the present productivity of farm crops is extremely low because of dependence on natural conditions which are often unfavourable. The farmers follow old methods of cultivation and raise paddy as their main crop mainly during the monsoon season. Floods, as well as droughts at critical periods, affect the crops adversely. The first irrigation project, Ganges-Kobadak is designed to insure crops against these hazards and make double or triple cropping possible by making water available whenever necessary for the crops in a regulated manner all the year round. An area of 175,000 acres in the Kushtia and Jessore districts will be brought under irrigation by the end of 1960. The steady and assured supply of water will not only increase rice production but will also enable double and triple cropping patterns leading to diversification of farm produce. Cash crops such as sugarcane, tobacco, maize, wheat, pulses and oilseeds can be grown in a large measure and bring additional income to the growers.

The transition from the present rain-fed cultivation practice to one utilising a modern irrigation system, however, requires some problems to be solved in advance of the completion of the engineering of the project.

Presently 3 pumps of 1,300 cusecs capacity will be installed near Hardings Bridge on the Ganges to lift the water for irrigation to feed the Kushtia Canal. This unit forms the first phase of the Ganges-Kobadak Project. The regulation on the canals is done by automatic gates which close as the demand for water slackens. The system of distribution is in the form of canals, secondaries and tertiaries. This is comparable to the canals branches and distributaries of the irrigation system as practised in West Pakistan.

Need for Farmer Education and Research

The implementation of any irrigation project involves three phases: (1) to make water available up to the tertiary canal, (2) to distribute the water evenly into each small field, and (3) to use the water for growing better and more crops. According to the present design and cost estimate, the engineering work will stop at the tertiary canals. Each tertiary canal will command, on the average, 500 acres of cultivated land. After tertiary canals, it is up to the farmers to dig their own laterals (in this project, they are called field channels and plot channels) and to use water at their own wishes and expenses.

These three phases are actually interlinked, even though the first two are mainly the tasks of the engineers. The success of the implementation of the third phase will depend largely on: (1) good work and low costs of the first phase, and (2) the early completion of the laterals and effective distribution of water of the second phase. However, only when the implementation of the project shifts from the second to third phase, the problem of and the need for improved irrigation practices will become acute.

Within a block of 500 acres, where average size per farm is 3.5 acres, there are more than 140 farmers. According to the present planning, it is they who will contribute their labour to dig the laterals. The farmers in this project area, as well as the farmers elsewhere in the world, must have the knowledge of and the incentive for digging the laterals. No laws can compel them to do so unless they see the benefit. In view of the fact that this is the first irrigation project in East Pakistan, a monsoonal area where irrigation is only a supplemental means to insure against risk, it is important to educate the farmers to become irrigation minded first. To this end, a few pilot irrigation projects have been established to demonstrate the good results of irrigation and to convince the farmers that they will be benefited by the endeavour of their labour.

The cost of pumping water from the River Ganges, feeding it into all gravity canals, and distributing it to the small field is quite expensive. Naturally it is hoped and planned that the farmers will fully utilize the available water and pay for its use. In East Pakistan where rainfall is sufficient during the monsoon season, the farmers are usually not accustomed to pay for the use of water. When the problem of collecting water charges arises, they may ask for free water, or for reasonable rates, or for rates under optional uses, or for supply of water at their requested time and quantity. Many water disputes may occur due to the collection of water charges. Higher water rates will also add overhead costs to the management which may discourage the farmers to use the water. To reduce and avoid such difficulties, studies are being made on a group of farms to determine the benefit of irrigation and the ability to pay of the farmers. This is being organized under an extension service, whose additional rask will be to advise the farmers within each block when to begin their land preparation, sowing, weeding, harvesting etc. in order to coincide with the timing of water supply. Usually the time and quantity of irrigation are different among crops. Farmers will be consulted and guided to work out suitable cropping systems within the blocks for efficient water management.

Pilot Projects and Farms

For educating the farmers, pilot irrigation projects and farms were therefore started, namely:

Experimental Farms:

(1) Amla Experimental Farm—111 acres depicting soil condition of the upland area of G.K. Project.
(2) Benerpota Experimental Farm—100 acres, depicting saline zone of G.K. Project.
(3) Bheramara Experimental Farm—about 100 acres.

Demonstration Farms:

(1) Baradi Pilot Farm—528 acres near Kushtia.
(2) Bheramara Pilot Farm—2,500 acres.

The experimental farms are owned by the Government for carrying out diverse experiments on cropping patterns, water requirement, use of fertilizers etc. The experiments are conducted through departmental labour. For experiments requiring larger areas association of the tenants on share cropping patterns is achieved, thereby initiating them into modern irrigation practices and improved cropping patterns.

On the demonstration farms, the land remains with the farmers and the irrigation and agriculture workers cooperate to initiate them into the use of

water for irrigation and adoption of new cropping patterns.

In the Teesta Barrage area, where irrigation facilities will be provided in the near future, some farms have already started, such as the Mahipur Demonstration Farm, to study the seepage losses in the field channel, acclimatisation of crops and seeds and their yields.

Baradi Farm

This block covers an area of 550 acres including 247 private small farms with an average size of 2.14 acres per farm. The total irrigated area for the first year (1956) was 38.86 acres, for the second year, 81.23 acres and for 1958, 212.42 acres. Of the irrigated area each year, about 45 to 50 per cent received regular irrigation and the rest, only once or twice. The reasons of slow progress are both social and technical. In the beginning, the farmers in the Baradi Block were in fear and suspicion. They thought that the Project may take over the whole block of land as government experimental farm. They wouldn't agree to give up their land for canal purpose unless they received compensation.

On the technical side, the engineers, underestimated the amount of work required to demonstrate the value of modern irrigation and drainage systems. The siltation of canals required clearance. Difficulty in drainage caused waterlogging in the lowland area. Leakage and seepage reduced the supply of water. Despite those difficulties, the work in this block did make progress every year. This will be seen from tables I, II and III.

The project did not collect water rates. Checking with the irrigation record (Table I), it was interesting to note that (1) the paddy crop needed frequent irrigation in the monsoon, (2) the demand for water in the months of March, April, and May will become heavy when double cropping of paddy widely adopted, and (3) the rabi crops in Baradi would require irrigation as the lowland area of this Block was drained.

It is believed that, when the whole block is put under irrigation, double and triple cropping systems will be fully accepted by the farmers. The following interesting trends of change was observed: (1) the transplantation of aman paddy as second crop became the accepted practice, (2) the practice of mixed jute and aman disappeared entirely, (3) the practice of mixed aus and aman started reducing, (4) for double paddy, transplanted aman after boradcated aus was the most popular pattern, and (5) when the income from two crops of paddy was higher than that of one crop of sugarcane, the acreage of sugar cane seemed to decrease. According to the present plan, more rabi crops will be grown in the lowland area after the drainage problem is solved.

Amla Farm

Each block is sub-divided into plots one acre in size and rectangular in shape which are fit for field trials of irrigation crops.

Operation of the farm was started in 1955, but field trials were first conducted in 1956 and much strengthened in 1958. Due attention was given to the introduction of new varieties, development of multiple cropping patterns and crop responses to irrigation and fertilizers. Field trials conducted in the years 56—59 are shown in Table 1.

TABLE 1

For Rice	1956	1957	1958	1959
(A) Introduction of new varieties	1	2	3	3
(B) Development of multiple cropping	1	1	2	4
(C) Study on Irrigation responses and requirement	—	—	3	3
(D) Study on fertilizer responses	2	5	8	4
(E) Study on cultural practices	1	1	--	5
	5	9	16	19

For Dry Land Crops *	1956	1957	1958	1959
B.F.	5	9	16	19
(A) Introduction of new varieties	—	1	2	5
(B) Study on Irrigation responses	1	1	4	33
(C) Study on Fertilizer	--	1	2	1
	6	12	24	28

*Wheat, soybean, maize, rape seeds, tobacco, peanut, sugarcane, sweet potato.

Conclusions.—The trial period, so far, is too short to draw final conclusions, because of the influence of climate and other factors. Nevertheless, the information gathered from these trials as given below indicates a bright future for irrigation farming in East Pakistan.

1. Paddy varieties of Indonesian, Indian and Formosan origin were tested for regional adaptation, seasonal reactions and other characters. A few of them were found to be promising in yielding capacity (30—40 mds/acre) and in growing period (106—115 days). Both the characters are required for a crop which is grown as the main

crop in any double or multiple cropping pattern. They have been selected for further tests in Aus, Aman and Boro season in the current year.

2. Many dry land crops were introduced in the previous years. Among which the Indonesian Maize grew very well in both summer and winter seasons within a period of four months with a yield of 16 maunds. They give indications that the maize will become a promising crop which can be rotated with many other crops in forming a multiple cropping pattern. Further tests of this crop and others are still needed before reaching any definite conclusion. Formosan wheat, soybean and rape seed have been introduced recently. Field tests of these crops will be done in the coming winter.

3. Different systems of double and multiple cropping with rice as main crop such as Aus followed by Rabi, Aman followed by Rabi, Aman followed by Boro and Aus followed by Aman and Rabi are being tested. The previous results have indicated the feasibility of most of such systems provided irrigation, fertilizers and manures are applied and a medium maturing variety of four months are used. The increase of output for the same field is almost double. Due attention is being paid to the combinations, of rice and a second crop which gives good response to irrigation and their market values are high. Based on this information, the suitable cropping patterns under different soil types of the Project Area will soon be finalized.

4. It has been learned from studies that the water requirement of Aman rice for period of 100 days was 35 inches while that of Boro rice for a period of 120 days was 42 inches. The same study on Aus has been conducted in 1959. Among the Rabi crops, wheat gave a better response to irrigation. Its yield was almost double. Lentil, mustard and particularly gram with shorter growing periods showed less response to irrigation. A comprehensive study on the irrigation responses of wheat, peanut and sugarcane are being carried on in the current year. From the above studies, the annual irrigation requirement of different cropping patterns under different soils types will be worked out.

5. All the rice varieties, improved or local, responded well to organic and inorganic fertilizers. Best returns, however, have been obtained from a balanced combination of nitrogenous and phosphatic fertilizer. Further study on the combination of NPK elements and their optimum inputs are being conducted.

6. According to the study on the cultivation practices of Aman, the finding showed that mid-August was the best time for transplanting. The yield declined rapidly as the transplanting was delayed. Studies on optimum time for broadcast and the response of line sowing and transplanting of Aus and optimum spacing of Aman as well as the Japanese method of rice cultivation etc. are being carried out in recent years. All these investigations are essential for drawing up the crop calendar and establishing farming practices under a new system.

7. In the Amla Farm, some land has been set apart for seed multiplication purpose. A quantity of pure rice seeds has been distributed to the nearby villagers at a rate which is sufficient to cover an area of 2,000 acres. Among the varieties, Latisail and Nazirsail are the most acceptable samples due to their high yielding capacity and fair milling quality. Seeds of wheat, peanuts, and stocks of sugarcane had also been distributed with full satisfaction of the growers.

DEVELOPMENT AND DEMONSTRATION FARMS

By

EDWIN F. LANDERHOLM

The difference between a development farm and a demonstration farm is that a development farm is put into operation before an irrigation project has been developed; while a demonstration farm may be set up at any time after an irrigation project has been built, but generally during the early years of a project.

In connection with all of the recent projects of the Bureau of Reclamation of the United States Department of the Interior, detailed land classifications have been made. The purpose of these land classifications, of course, is to find out whether or not the land proposed for irrigation is suitable for agricultural production. However, even after

these careful land classifications are made, there still may be doubt whether or not an area of land is really suitable for farming over a long period of years.

During the time that I was associated with the Bureau of Reclamation as Regional O & M Supervisor for its Region VI, consisting of the major portions of the states of Montana and Wyoming and all of North and South Dakota, we set up several development farms to study the irrigation farming potentials of land in South Dakota in the lake plain area, in the Bowbells and Mandan areas of North Dakota and the Riverton area of Wyoming. The water supply for these farms was usually obtained by pumping from a near-by lake or river, or in one case from an irrigation canal.

By carrying on farming operations on these farms for a few years we were able to determine the irrigation, drainage, and soil problems that would confront the cultivator, if and when the project were developed. For example, in the case of one farm, the Bowbells farm in the glaciated, heavy soil area of central North Dakota, it was found that the area was wholly unsuited to irrigation agriculture. That portion of the Missouri Basin Project was abandoned and the diversion canals taken from a different reservoir and water used in another area.

On these development farms various types of irrigation were tried. For example, the use of border dykes, furrow, and sprinkler systems were tried; and the economic feasibility and advantages and disadvantages of each were determined. In one case, on the Riverton Project in Wyoming, practical means of solving a serious problem of wind erosion on light soils was carefully analyzed from the results that were obtained on the farm and a fairly successful solution obtained.

Demonstration farms, as I mentioned before, are set up after a project has been completed insofar as the water supply is concerned. For example, on the Yuma Mesa Project in Arizona, the government planted crops, principally alfalfa, for a few years prior to turning over the land to farmers. This was done because the soil of the project was extremely light (sandy) and required an excessive amount of irrigation water. In this case there was also a problem of wind erosion; but it was possible by growing alfalfa to stabilize the soil and increase its organic matter content. It since has become a very profitable irrigation project.

Similarly on the Columbia Basin Project in the State of Washington a number of demonstration farms were set up to determine the most economical means of irrigation—such a border dyke, furrow, or sprinkler—and also to determine the crop which could be grown most successfully and for which a suitable market could be found.

During the years that I was in Libya (North Africa) we developed a small irrigation project by pumping water from the Wadi Nam. This is the only project irrigated with surface water in all of Tripolitania (the north-western province of the three provinces of which Libya is constituted). We planted crops for two or three years on this land before cultivators were moved on to it. The reason for doing so was to get the land in suitable condition for the farmers who had had little, if any, previous irrigation experience. As a result they were able to carry on profitable farming from the very start, which otherwise would not have been possible.

On the Ghulam Mohammed Project, which is located in the Sind area north-east of Karachi, it is proposed that the government plant crops on a large area of this land, not only for the purpose of getting immediate food production, but also to get the land in condition for settlers who will subsequently move on to the project and to help get the settlers properly started in irrigation farming.

I think that the use of both development and demonstration farms should be increased in South Asia and the Middle East. In the case of development farms, it could prevent the building of projects and serving of lands which are unsuited to continuous irrigation farming. Demonstration farms could be developed, as the name implies, to demonstrate better methods of irrigation, better crop rotations, better farming practices, and result in increased production on irrigated land. This is particularly important in countries such as Pakistan where the average yield of crops is very low as compared with more fully developed countries.

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PROJECT PLAINNING FOR ULTIMATE WATER USE

INDIA'S EXPERIENCE, PROBLEMS AND PLANS FOR PLACING LARGE AREAS OF AGRICULTURAL LAND UNDER IRRIGATION

By
YADAVA MOHAN, I.S.E.

INTRODUCTION

Land Resources

India lies to the north of the Equator, between latitudes 8° and 37° 10′ north, and longitudes 68° and 98° 25′ east, and is the seventh largest country in the world. It measures about 2,000 miles from north to south and about 1,850 miles from east to west. The geographical area of the country is 806 million acres. Out of this land utilization statistics are available for about 720 million acres. The details of the land resources of India for 1956—57 are:

		million acres
(*i*) Total geographical area	..	806.3
(*ii*) Area under cultivation	..	320.7
(*iii*) Cultivable land, not yet cultivated	..	97.0
(*iv*) Fallow land	..	58.7
(*v*) Forests	..	125.5
(*vi*) Land put to non-agricultural uses	..	32.6
(*vii*) Unculturable land	..	85.2
Total Reported Area	..	719.7

The country has considerable water resources. The total annual runoff of her rivers is estimated to be 1,356 million acre feet, of which about one-third is utilizable. The utilization up to the First Year Plan period, *i.e.*, up to 1951 is estimated to have been about 88 million acre feet. After completion of the First and Second Plan projects the total utilization will be about 184 million acre feet, representing about 13.6 per cent of the total and 41 per cent of the utilizable water resources.

History of Irrigation

Irrigation has been practised in India from ancient times. Some of the irrigation works in South India date as early as 200 A.D. During the nineteenth century some important irrigation works were executed on the major rivers; Ganga, Jamuna, Ravi, Sutlej, Godavari, Krishna and Cauvery. A number of other large irrigation works were constructed towards the end of the last and at the beginning of the present century, and again after the end of the first World War, with the result that in the undivided India, the area irrigated by canals and storage works increased from 14 million acres in 1892 to 40 million acres in 1947. In 1950—51, the total area irrigated in India from various sources rose to 51.5 million acres as detailed below:

Source		Area irrigated in million acres
Canals	..	20.7
Tanks	..	8.8
Wells	..	14.7
Other sources	..	7.3
Total	..	51.5

PLANNED IRRIGATION DEVELOPMENT

Necessity of Irrigation Projects

Although the history of irrigation development in India dates back to 300 B.C., large scale, planned development of irrigation began only after the advent of independence, when steps were taken to spread the benefit of irrigation in a systematic manner.

The population of India has been increasing rapidly during the last few decades, but without a commensurate or significant increase in land produce. Agricultural development was compara-

tively stagnant during this period particularly between 1906 and 1935, during which period the cultivated area remained more or less consistant, being 205 and 210 million acres respectively. On the other hand, the population increased from 235.5 million in 1901 to 275.4 million in 1931. The population went on increasing and was 361 million in 1951. In addition to the increasing requirements of the expanding population, the partition of the country in 1947 aggravated the food problem in India, as large parts of the highly developed canal irrigated areas got transferred to West Pakistan. Indian economy is essentially agrarian. Since agriculture in India is primarily dependent on regular monsoons, their failure on any wide scale is apt to produce scarcity conditions or famines in the affected areas. The vulnerable section of India's rural population is threatened with starvation whenever such calamities occur. The resources of the country are, however, not inadequate to raise the economy of the agriculturist and meet the food shortage. Quantity and variety of India's resources in water, land and men are capable of tackling all these problems and making the country self-sufficient in food production. Therefore, high priority was given to river valley projects in the First and Second Five Year Plans.

Plan Projects and Achievements

First Five Year Plan (1951—56). The First Plan being essentially one of preparation or laying the foundation for more rapid irrigation development in the future, its targets of investment and of increase in production were modest compared with what had to be achieved within the next twenty years or so. The irrigation sector of the First Five Year Plan which commenced in 1951 endeavoured to present a coordinated view of the requirement of the economy and of the resources available with the general aim that the irrigable area under irrigation projects should be doubled over a period of 15 years. Irrigation and agricultural development, therefore, had the highest priority in the First Five Year Plan.

The projects undertaken in the Plan are expected to bring under irrigation an additional area of 33 million acres on full development. This is inclusive of irrigation of 11 million acres from minor irrigation schemes. The Bhakra Nangal, the Hirakud, the Tungabhadra are some of the well-known projects of the First Plan which have already started yielding benefits.

Second Five Year Plan.—Apart from some of the continuing schemes from First Plan to Second Plan, about 216 new major and medium irrigation schemes have been included in the Second Plan, to bring an additional area of 16 million acres under irrigation on full development. In addition, 9 million acres will be brought under irrigation by minor irrigation works.

Achievements.—The total ultimate potential for the major and medium schemes under the two Plans is 38 million acres. Out of this an effective potential of about 13 million acres is expected to be created by 1960-61 (*i.e.*, at the end of the Second Plan) leaving a balance of 25 million acres to be realized thereafter. About 18 million acres are expected to be irrigated by the end of the Second Plan from minor irrigation schemes.

Irrigation faciiities were provided for an additional area of 5.3 million acres by 133 major and medium irrigation projects during the First Five Year Plan, and this was raised to 7.2 million acres by the end of 1957-58. The actual utilization by the end of March 1958 was 82 per cent.

PROBLEMS AND PLANS TO OVERCOME THEM

Synchronisation of Project Components

For achieving the objective of quick increase in agricultural production, projects should not only be completed within the minimum time possible-but also steps should be taken to relate the construction program with availability of funds, materials, labour technical personnel. Stress has been laid on the need for synchronization of the completion of project components with the extension activities so as to result in ready utilisation of water. Oversight in this regard results in non-utilization of water from reservoirs completed much before the canal system.

Agrarian Trends

In spite of our ancient tradition in agriculture, our methods of cultivation needed, in many places, modifications to take full advantage of scientific methods of cultivation supported by irrigation facilities provided by new projects. The existing pattern of land holdings also was instrumental in discouraging improved agricultural practices. Our problems in this aspect are two-fold. On one side we have the problem of small uneconomic holdings by majority of farmers. On the other side, the counter problem of very large holdings where, in most of the cases, the farmers evinced insufficient interest in agriculture, or it was beyond their means to bring the whole or major portion of the area under cultivation every year. Based on this observation, the Planning Commission made certain recommendations on the land policy. The objectives of this policy in the Plan are, firstly to remove such impediments in the way of agricultural production as arise from the character of the agrarian structure, and to create conditions for evolving as speedily as possible an agrarian economy with high levels of efficiency and productivity, and secondly to establish an egalitarian society and eliminate social inequalities.

A census of land holdings and cultivation was, therefore, undertaken in the country. Based on this, some of the States have already enacted the necessary legislation for consolidation of holdings and as also on the ceilings for holding land. The National Development Council recommended in 1957 that States which had enacted the necessary legislation on ceilings for land holdings should ensure that the program was administratively implemented within a given period, and States which had not yet enacted legislation for ceilings should complete the legislative measures by the end of 1958-59. This legislation has been designed to speed up irrigation development in the country.

Socio-economic Measures

By the very nature of his profession the income of the small farmer is not adequate to meet his yearly requirements. Agricultural operation being of long duration the cultivator has to wait for several months before he can collect the harvest. Once a crop is sown, he cannot switch over in order to take advantage of better prices, to another crop. Because of fluctuating prices of agricultural produce, the farmers does not often get a fair return on the capital and labour, and has no reserves to invest for further development of lands.

The new areas brought under irrigation by a project have to be prepared for receiving water. This requires levelling, and bunding. It has been observed that the cost of levelling, bunding and preparing the land to receive water varies from Rs. 200 to Rs. 500 per acre, depending upon the topography of the area and soil structure. In addition to this, money for purchase of better seeds, manure and bullocks to plough new areas is required. The few months before the harvest are almost always a time of hardship for the peasant, as the grain retained for home use and the money from the sale of the last harvest may both have been exhausted. With no savings of his own, the farmer is forced to incur debts. Due to this indebtedness, not only the farmer but the whole irrigation or agricultural system is thus impoverished. The main problem, therefore, is to find an agency, other than the private money-lender who is at present exploiting the helplessness and ignorance of the farmer, which can provide finance for the cultivator on reasonable terms.

Cooperatives for Rural Development.—Realizing the farmer's chronic indebtedness and the vast additional land provided with irrigation facilities by Plan projects, our Government considered that the agency which best fulfils the necessary conditions for providing cheap and adequate credit for the cultivator is the Cooperative Society. The experience of other agricultural countries also proves that only in the cooperative principle can a solution to the problems of rural life be found. Accordingly, a comprehensive program for the development of cooperative agricultural credit, marketing, processing, storage, warehousing and staff training has been drawn up and has started operation in most of the States.

These cooperative societies are being financed by the Reserve Bank, through the National Agricultural Funds. For the effective function and also promotion of schemes of cooperative development and storage of agricultural produce in the country, we have got a National Development and Warehousing Board which sanctions loan assistance to State Governments for contribution to the share capital of cooperative marketing and processing societies and to State warehousing corporations for grant of loans to cooperative societies for construction of godowns. The main object of the program is to link up credit with non-credit activities so that the agriculturists could be provided with credit for seeds, fertilizers, agricultural implements and also to help dispose of the produce without being exploited by intermediaries.

Agronomic Measures

Yield from Land.—It is axiomatic that the success in bringing large cultivable areas under irrigation depends primarily on the initiative, knowledge and enthusiasm of the cultivator. The agricultural lands are in the hands of the rural community. As per the census of 1951, out of the total population of 361 million, about 295 million were from rural areas in which 249 million were engaged in agriculture. Although the variety of India's agricultural production is great, the average yield per acre is poor. The F.A.O. estimated that in 1954, India obtained only 670 lbs of wheat from an acre of land, while Egypt obtained 2,040 lbs and Japan 2,016 lbs. Italy produced four times and Japan three times as much rice per acre as India. The average yield of sugarcane in India is about one-fourth of that in Java. The main reason of the poor yield in India is that our cultivator has not been able to apply to agriculture the productive knowledge and appliances which science has made possible.

The literacy in our country as a whole is only 16.6 per cent and still poorer in rural areas. It is not therefore easy to educate the cultivator to the advantages of irrigation, methods of growing improved seeds, the development of improved tools and the economic methods of switching on to modern methods of irrigation. In the majority of cases, the cultivators are not aware of such agricultural aspects as water requirements of crops in relation to the system of irrigation in vogue, frequency of watering, crop pattern as influenced by soil structure and application of fertilizers in requisite quantity to get the maximum yield.

In view of the above facts, an agro-economic survey has been considered necessary in the project areas where large agricultural lands have to be brought under irrigation in order to determine the steps needed for the initiation of irrigation promptly. These surveys are intended to collect sufficient data on the present conditions existing in the culturable commanded areas regarding population, adequacy of cattle, availability of agricultural implements, existing patterns of cultivation, yield per acre, habits of the cultivator and the staple food crop, etc. With the results of the surveys and experience, the agricultural departments, which have to demonstrate to the cultivator (*a*) the new crops to be irrigated, (*b*) how irrigated cultivation can be undertaken in the most economic way so as to derive maximum yields, are being upgraded and strengthened in the various States. The departments have started their functions in (*a*) research and investigation, (*b*) demonstration, propaganda and education, under a number of irrigation projects.

Agricultural Research, Demonstration and Seed Farms.—In the agricultural research farm established under a project, different varieties and samples of crops are tested to determine by selection which are the most suitable for the local conditions. After sufficient experiments the strains which appear to be best are selected and made popular in the commanded area through establishment of demonstration farms and also by extensive visual and oral propaganda. This improved crop is grown in the departmental seed farms for the supply to cultivators through cooperatives, as the question of the supply of pure seed is of the greatest importance for agriculture, the next in importance being the problem of organisation of an agency to distribute the seed. The cultivators are being trained in the improved methods of agriculture, use of water and manures also through the demonstration farm.

Animal Husbandry.—The cattle population and quality too have been inadequate in some project areas. In order to improve cattle strength veterinary hospitals and cattle breeding farms are proposed to be established in almost all major irrigation project areas. Agricultural exhibitions and cattle fairs are being organised to demonstrate to the farmers the advantages of improved techniques and implements.

Community Development Program.—Besides the activities of the agricultural departments and cooperatives, we have the Community Development Program, which aims at the individual and collective welfare of India's vast rural population. It is a program of aided self-help to be planned and implemented by the villagers, the Government offering only technical guidance and partial financial assistance. Agriculture receives the highest priority in the program among ot her activities such as provision of better communications, improvements in health and sanitation, better housing, wider education, etc. The program is implemented in units of blocks each comprising generally 100 villages to cover an area of 150 sq. miles and population, ranging between sixty and seventy thousand. The program is being carried out initially for a period of three years under a supplementary program of somewhat less comprehensive character, called the National Extension Service. The achievements of the community development program up to the end of September 1958 in some important aspects of the agricultural sector are:

1.	Improved seeds distributed	7,053	tons
2.	Chemical fertilizers distributed	1,743	,,
3.	Improved implements supplied	117,500	
4.	Agricultural demonstrations	485,100	
5.	Area under green manure	4,150,000	acres
6.	Compost pits dug	5,015,000	
7.	Improved animals supplied	45,600	
8.	*Kacha* roads constructed	78,600	miles
9.	Existing *kacha* roads improved	91,400	miles
10.	Cooperative societies established	127,125	

Control of Pests and Crop Diseases.—Good seed, fertilizers and timely irrigation are the obvious pre-requisites for growing good crops. Unless, however, the crops are protected from the ravages of insects, pests and plant diseases all labour will be lost. A good deal of pioneering work has been done in India to combat these. We have an organisation, called the Locust Warning and Control, to take effective action during locust attacks. Insects and pests are being biologically controlled and with insecticides. In order to overcome wheat rust, our agricultural research farms have evolved a rust-resistant variety of wheat. Based on the results of experiments on agricultural research farms many crops diseases have been eliminated by changing the time and conditions of sowing. The concerned departments have taken necessary steps for popularising plant protection and pest control methods. In addition, arrangements have been made for supply of pesticides and insecticides in adequate quantity to the cultivator through different agencies.

Development of Rural Communication

Lack of communications in rural areas is another problem to be solved for effective development if irrigation. For, the land produce has to be transported to the market or storage godowns. The construction of a network of roads—a vital link in the program of irrigation development—have already been taken up under some of the projects by development authorities.

Colonisation.—India is the world's second most populous country. But the density of population in different States differs widely, varying from 10 persons to 3,044 persons per sq. mile. In projects located in arid zones where the population is sparse, agricultural labour during crop seasons has been found inadequate to cope up with irrigated cultivation. In such cases agriculturists from neighbouring areas are being encouraged to settle in the project areas. The Rajasthan Canal project which will irrigate an arid area is being tackled on these lines. Villages with essential amenities, such as water supply, markets, medical aid and schools, will be brought into existence simultaneously with the execution of the projects. Under some projects, where the population density is inadequate for increased agricultural operation through irrigation, import of agricultural labour from nearby States where lands are not, but people are, available for cultivation, are under consideration of State Governments.

Measures to accelerate the Utilization of Irrigation Potential

Necessity for early Utilization of Irrigation Potential.—In the context of the present stage of development in the country, it is natural that attention is constantly drawn to the urgency of utilization of the irrigation potential newly created. The pace of development cannot obviously be the same under all the projects of the country. Besides, the enthusiasm and economical conditions of farmers, it would naturally vary from State to State and from project to project; depending upon (*i*) the situation of the project, (*ii*) whether the project is intended to stabilise the existing precarious irrigation system, (*iii*) or for the extension of irrigation by remodelling or extension of the canal system, (*iv*) or to irrigate new areas.

In order to minimise the period of irrigation development by concentrating the effort of all concerned departments and the cooperation of the cultivators, suggestions have been made to the State Governments by the Planning Commission. The attention of the Chief Ministers of the States has been drawn to the food and agriculture situation in the country. It has been pointed out that the fulfilment of agricultural targets are largely dependent on organisation of the administrative machinery, including the National Extension Service, for securing the maximum effort for production in every village. It has also emphasised the necessity to intensify the agricultural production program and to ensure better utilization of the available irrigation facilities from the Plan projects.

Working Groups.—In order to evolve a coordinated effort, Working Groups have been proposed at various levels, commencing from the State level to the village level. The working group at the State level is generally composed of the Development Commissioner and officers of the agriculture, irrigation and cooperative departments to review at regular intervals the progress of irrigation on each major and medium work. Half-yearly reviews are submitted to the State Cabinet regarding the measures taken and the progress made, with a copy to the Planning Commission at the Centre. It has also been suggested that for each project there can be a working group of officers directly concerned with it, so that they could follow the various steps needed at each level down to the village. The working groups are functioning in almost all the States.

Concessional Water Rates.—To encourage agriculturists to take to irrigation so as to step up the pace of development, certain concessions in water rates have been sanctioned by some States for the first few years. The collection of water rates has been proposed on a sliding scale, with the supply of free water for the first one or two years.

Assured Supply of Water.—In order to create confidence among cultivators regarding the assured supply of water from the canal system, it is proposed to ensure that, before a canal is opened for irrigation, all the works are completed and are sound, so that the possibility of breaches and interruption during the early period of service is avoided as far as possible.

Timely Preparation of Land.—It is necessary to see that the lands are ready to receive water as soon as the water is made available to the fields. In the majority of cases, the culturable commanded area proposed to be irrigated from new projects will require *jungle* clearance, breaking up, levelling and bunding before it can be put under crops. This aspect of the problem has been proposed to be solved by agriculture, revenue and community development organisations through advance planning.

Field Channels.—The lack of field channels under some of the projects is among the chief bottlenecks causing delay in the speedy and efficient utilization of irrigation potential. In the past there was no definite policy in regard to the construction of field channels. In order to bring about a uniform policy in the construction of water courses, the Planning Commission suggested to the State Governments a policy to be followed in this regard. Accordingly, project authorities are now responsible for the construction of channels or "water courses" up to 100-acre blocks. This limit might, however, have to be varied in different States depending on local conditions such as topography and crop pattern. Beyond this limit the farmers are expected to make their own arrangement for leading the water to fields. Further the

Planning Commission recently instructed that the project authorities should mark the position of outlets and also alignment of the water courses and field channels, at the time of marking the alignment of distributaries and minors. Copies of village maps on which the alignment of water courses and field channels are made should be supplied to the block and district development officers and also to the village level workers. Therefore, it is proposed that the program of construction of field channels can be taken up by the block and district development officers in consultation with the project authorities to synchronise with the construction of distributaries and minors in the area. It is suggested that efficient carrying out of all these programs is the responsibility of the community development agency and implementation should be reviewed periodically by block and district committees and steps taken to rectify any defects that may come to notice.

Concurrent Sanction of Estimates for Developmental Activities and Project Estimates.— According to prevailing practice, sanction of an irrigation project is limited to the construction of engineering components only. There is usually no provision in the estimate for developmental activities such as development of lands, advance of short and long-term loans for purchase of livestock, seeds, fertilizers, insecticides, etc. Nor are estimates sanctioned for these activities on the basis of preliminary agro-economic and socio-economic surveys or any other scientific assessment. With the realisation of this defect and to ensure that coordinated effort should be forthcoming in the fullest measures from irrigation, agriculture, cooperative, revenue, animal husbandry departments and the community development organisation, the Planning Commission is considering the proposal that, each department should make matching provisions for the activities falling under it, concurrently with the provision of allocations for the irrigation project itself. For this purpose, each department would have to examine what development activities already exist in the project area, and how much expansion would be required to meet the needs of the project. Unless suitable provision, under each concerned sector is made in the State plan, and detailed plans are chalked out and implemented in time to fit in with the progress on the irrigation project, there is the likelihood that full coordination of effort from the concerned departments will not materialise, which will inevitably lead to delay in the utilisation of the newly created irrigation potential.

PROBLEMS OF WATERLOGGING AND ALKALINISATION OF SOIL UNDER ESTABLISHED CANAL IRRIGATION SYSTEM

Ever since the introduction of heavy irrigation in India, the problem of waterlogging and the consequent alkalinisation of the soil has confronted the irrigation engineer. Numerous investigations on the different aspects of the problem have been carried out by engineers, geologists, soil physicists and chemists. This problem is more acute in the irrigated tracts of the Indo-Gangetic plains which have very flat slopes and bad outfalls. The worst affected States are the Punjab and the Utter Pradesh. There are no regular statistics regarding the area waterlogged and the rate at which the water-table is rising. Rough estimates however disclose that in the State of Punjab, an area of as much as 3 million acres has sub-soil water level within 5 feet from the ground level. A considerable proportion of this area grows either no crops or very poor crop.

It hes been observed that the rise of the water-table is progressively increasing in the areas under unlined canals in Punjab. Except for a few mountainous and sub-mountainous areas, practically every part of Punjab has its waterlogging problem. Fazilka and Abhor, in Ferozpur district, and Hansi in Hissar district, are some of the worst effected areas. The unlined distribution systems account for a good deal of seepage of water to the sub-surface, raising the water-table over its entire length. Heavy irrigation of crops augmented by the field-to-field irrigation practice also contributes to the rise of water-table. Another factor contributing to waterlogging has been the inadequate or blocked drainage arrangements. In the past, no serious efforts were made to minimise the complications arising out of the introduction of heavy irrigation in such areas. Now the question assumes fundamental importance in the present context of food shortage in the country.

Anti-waterlogging measures and land reclamation operations are not only complicated but costly. Besides, they cannot bear the normal productivity tests. Realising the magnitude of the damage caused by this, the Food and Agriculture Ministry is vitally seized of this problem. The Punjab Government is also naturally keen on tackling the situation. The State lies in the region between monsoon and western cyclonic type of climate. With the construction of new roads, railways and canals systems, most of the natural drainages have been blocked. Thus, rain water, instead of being drained off, soaks the soil, with the rise of the water-table, salt has come to the surface, rendering the soil unsuitable for cultivation.

In order to rescue the land and the people from the effects of waterlogging, the State Government set up an 'Action Committee' to make a thorough study of the problem and make suitable recommendations. The recommendations of the committee were recently discussed between the representatives of the Central Water and Power Commission and the Planning Commission with the chief engineers of Punjab. As a result of these

discussions, the representatives of the Centre have made the following suggestions:

(*i*) Work should be concentrated on improving surface drainage.

(*ii*) A correct appraisal should be made of the extent of waterlogged areas. A map should be prepared to depict the depth of the ground water-table in the various regions.

(*iii*) The *thur* (salt) affected areas should be carefully assessed and demarcated on maps before any large scale remedial measures are considered.

(*iv*) The treatment of *thur* (salt) land should be taken up in stages, beginning with a pilot scheme to demonstrate results.

(*v*) Anti-waterlogging measures should be concentrated in selected areas to produce significant results instead of spreading works over large areas.

(*vi*) Lining of distributaries and minors, as the main stems of water courses, should be taken up in selected regions where the problem is acute.

(*vii*) The use of percolation wells should be encouraged where ground water-table is high. Electricity at concessional rates might be made available for pumping from such wells.

(*viii*) A pilot scheme for making underground tiled drains in a selected area should be prepared and executed to demonstrate their effectiveness before a large scale program is launched.

With the experience gained so far on the problem of waterlogging and alkalinisation of soils, it has been considered necessary to tackle this menace in the initial stage of development itself by providing efficient drainages in the commanded areas. The Planning Commission therefore recently suggested to the State Governments that, while formulating new schemes, provision for drainage should form an integral part of the project estimate.

CONCLUSION

A large multipurpose project roughly takes two to five years for detailed investigation and planning, and five to ten years for completion, depending upon the magnitude of the project and resources available for the implementation. Although many of the big multipurpose projects of the First Plan are still under various stages of construction, yet, with proper coordination from irrigation, agriculture, community development and revenue departments, we have been able to draw considerable benefit from about 133 projects. The ultimate benefits of these projects after full development is 12.5 million acres. The effective potential created at field level and actual area irrigated, by the end of March 1958, were 5.98 and 4.82 million acres respectively. Therefore, even in the initial stage of development itself, the utilization was 80 per cent of the created potential. It may, however, be mentioned that under some projects the utilisation may not be up to the mark, due to the poor economic conditions of the cultivators, especially in the backward areas, of scarcity-affected areas. The present condition of food shortage in our country is expected to end by the end of the Second Plan. But to meet the requirements of growing population, more and more irrigation projects need to be taken up, in well-considered, zonal or regional plans of an all-India basis for the optimum utilisation of the untapped resources of land and water in the country.

Discussion

In reply to a question by Pir Mohammad Ibrahim asking for clarification about the surface and subsurface drainage system, Mr. Mohan stated that the drains referred to are open drains which will reduce the water-table to from 3 to 5 feet below the surface. This is considered satisfactory in the worst areas.

Mr. Rajaratnam stated that the problems of colonization were of particular interest to Ceylon since it is necessary to relieve the unemployment in the wetter industrial areas by colonizing in the dry zones. He inquired regarding the problems encountered in resettling people in arid zones and asked regarding what assistance is given to the settlers. Mr. Mohan stated in the Rajasthan Project, an area of the order of 5,000,000 acres, the entire area is arid. In this area the government proposes to construct items of common interest including roads, railroads, and tanks where storage is possible. Houses of an inexpensive type will also be provided along with community development assistance and extension.

With regard to the size of the holdings, the matter has not been definitely set on the Rajasthan project; however, the general policy of the country is to provide about 30 acres for five people.

Dr. Nazir Ahmed stated that the experience in Pakistan is that seepage losses from main canals are greater than from distributaries and minors than from main canals. He inquired regarding the relative merit of lining larger canals or minor canals. He also asked if lining larger canals had been effective in controlling waterlogging and inquired about the maintenance of open drains due to weak growth, sloughing of banks and silting up.

Mr. Mohan stated that a Seminar of the Chief Engineers of the States has concluded that losses in main canals are 15%, in the distributaries 7%, and in the water courses 22%. Although

it is easier to organize and construct the lining of the large canals, cost benefit studies made prove that it is more beneficial to line the small channels. While it is true that the open drains will be subject to sloughing and silting, as with canals constant maintenance attention must be given to them. In those areas where open drains exist, the Irrigation Department has the same responsibility for their maintenance as for the maintenance of canals and distributaries. With regard to the effectiveness of canal linings, laboratory experiments show that the seepage rates are reduced from 8 to 12 cusecs per million square feet to about 2 cusecs per million square feet. While the water table may still rise, the conclusion must be that it would have risen much more rapidly without lining.

Mr. Haque inquired regarding the waiver of water charges during the early periods of colonization and how these rates are raised thereafter. Mr. Mohan replied that concessional rates are not exclusively applied to new projects; this policy also applies to areas which are already populated. The rate structure varies from State to State. Usually the first year or the first two years are free and the full rate is reached in four or five years.

Dr. A. G. Asghar asked for additional information regarding the type of tile drains, the slopes used and the effectiveness of them. He also asked at what stage of development colonization took place pointing out that it was necessary to provide time for extension and training work. Mr. Mohan stated that tentatively it has been decided to use burnt clay tile with butt ends. A new method of installing a chemically lined tunnel in place as used in Germany was considered. However, the burnt tile was decided upon due to proven success. The matter of slopes will be decided on individual projects. Some difficulty is anticipated in the slope design of the trunk drains because of their great lengths. It is anticipated that laterals and field drains will not constitute a difficult problem. Flatter slopes may be used for tiles than for open drains. Of course, all tile drains must eventually discharge into open drains.

The question of colonization is a very difficult one on the Rajasthan Project; Mr. Mohan stated that they are attempting to obtain colonizers now who will work on the construction until the land is ready. They are scheduling as much of the work as practical by hand to provide enmployment so that workers will have to be imported anyway.

HARNESSING THE RIVERS OF EAST PAKISTAN

By
M. CHOWDHURY[1]

Presented by M. S. Minhas.

Physical Characteristics

Most of East Pakistan is a remarkably flat alluvial plain, built by the delta-forming activity of the principal rivers, namely, the Ganges, the Brahmaputra and the Meghna. The average slope, north to south, is roughly one foot in four miles. The entire province is laced with a dense network of water courses. Where the lands are mostly flat and low, the enormous discharges brought down by the rivers in the monsoons cause regular floods. Roughly, one-third of the cultivated area is subjected to yearly flooding, which helps in restoring the fertility of the land.

Floods

Annual floods of varying intensities are a normal feature of the region, but sometimes, as happened in 1954 and again in 1955, they assume very destructive proportions. Such floods are caused by some unusual combination of hydrometeorological conditions in the drainage basins of the contributory rivers, and take a heavy toll of life, either directly or through epidemics left in their wake. Crop and property damages, in such a case, are of a very severe nature.

Vital Statistics

East Pakistan had a population of about 42 millions in 1951, spread over 58,000 villages, with an average density of 777 per square mile. The urban population is only 4% of the total, which indicates that the economy of the province is likely to remain predominantly agricultural for a long time to come.

Principal Rivers

The principal rivers in the region are perennial, though their discharges are low in winter. They are (*a*) the Ganges series including tributaries and spill channels. (*b*) The Brahmaputra series including the Teesta, and (*c*) The Meghna. The Ganges, traversing a length of 1,540 miles, and

1. Chief Engineer, Irrigation, East Pakistan.

draining an average annual rainfall of 42 inches over a catchment area of 350,000 square miles, with a recorded maximum flood discharge of 2 million cusecs (at Sara), is mainly responsible in the building, raising and fertilizing of the delta. The Brahmaputra traverses a length of 1,800 miles and drains an average annual rainfall of 85 inches over a catchment area of 361,000 square miles. Though the Meghna does not drain such extensive tracts, its catchment comprises the Cherapunji and other extremely wet areas with some of the highest rainfall records in the world. The total annual volume of water in the rivers flowing into East Pakistan is estimated at 900 million acre-feet, of which at present, practically nothing is utilised for systematic irrigation, except by the natural process of over-flowing the banks during the monsoons, and for a negligible amount of controlled flood irrigation.

Land Classification

The agricultural soils of East Pakistan are of secondary origin, formed of the alluvium transported by the rivers. The agricultural land in the region may be divided into four classes :

Class I land—The land which is above the normal flood level and receives water only from rains and irrigation; if available. This is referred to as "highland".

Class II land—The land that receives flooding to an extent beneficial to crop raising. This is termed as "medium land".

Class III land—The land that remains submerged under flood water for a considerable part of the year, but can be improved by adequate drainage methods. This land is called "low land" and in some parts of the country is referred to as "haor" area.

Class IV land—The land which remains submerged under flood water almost all the year around and cannot be improved by ordinary drainage methods. This land is called "swamp land".

During the dry season, classes I, II and III lands are all irrigable, provided the proper facilities are available. As the perennial rivers are very big and wide, irrigation water would have to be pumped, which appears feasible provided that power can be supplied at reasonable cost. The respective areas of land use are shown as follows :

Land Use Classification	
Gross area	34.9 million acres
Culturable	26.4 " "
Under cultivation	22 " "
Sown	20 " "
Irrigated	0.5 " "

Long Range Development of the Region

Irrigation is the oldest applied science in the world. The most ancient centres of irrigation were the seats of the oldest civilizations, because healthy irrigation on an extended scale was and is the great school of civilization. There are historical evidences that the system of "overflow irrigation" in the Gangetic Delta was evolved by the rulers of ancient Bengal some 3,000 years ago. Bengal with heavy monsoon rainfall between June and October was marked out for rice cultivation. The fertilizing waters of the rivers in floods used to be mingled with the poor water of the monsoon rainfall in the fields of standing rice. This was possible, because the river floods and the monsoon rainfall came concurrently. The distinguishing feature of the irrigation was that :

(1) The canals were broad and shallow, carrying the crest waters of the river floods, rich in fine clay and free from coarse sand.

(2) The canals were long and continuous and fairly parallel to each other, and at the right distance from each other for purposes of irrigation.

(3) The irrigation was performed by cuts in the banks of the canals, which were closed when the flood was over.

This system of irrigation was also in vogue during the days of the Moghul Empire. The irrigation cuts were known as "Kanwa". In those days, the irrigation and flood protection works were managed and maintained by the Zamindars and Tenants under a system, known as "Pulbandi". The long continued fight between the Mahrattas and the Afghan before the break up of the Moghul Empire disorganized the ancient overflow irrigation system of Bengal and negligence in its maintenance by the Zamindars began to creep in, during the troublous Mahratta-Afghan wars.

None-the-less, "Pulbandi" persisted up to the time of Independence, although in a less positive and effective manner. As a result of the partition of Bengal, a large number of Zamindars migrated to India and some measure of reform in land tenure was initiated, but no effective substitute for the Zamindari system has, so far, emerged, in the form of local leadership, and Government have had to assume the responsibility for such limited maintenance as is possible under the circumstances.

In the early part of the British regime, the Englishmen who were traders and sailors placed greater importance to river navigation connecting the principal trade centres of the Province with

the port of Calcutta and also providing water communications with the neighbouring provinces of Bihar and Assam in India. In order to shorten the distance by water between Calcutta and the Ganges, and Madaripur Bil Route was opened early in the present century. This route practically monopolized, in the early days before deterioration of the approach channels from the Ganges, the whole volume of water-borne traffic between Calcutta and Bihar and upper Assam.

Flood regulation, drainage, flood flushing and overflow irrigation projects are types of development which have been undertaken traditionally in the region. These were mostly localized schemes intended to solve the immediate particular local problems. Instances of such development which were carried out time to time in the past are : The Gumti Embankment in the district of Tipperah, the Ganges flood flushing sluices and embankment at Rajshahi, those along the Lower Kumar River in the Madaripur Bil Route, and artificial cuts such as Halifax cut, Gaznavi cut, etc. for the purpose of flushing and improvement of water channels of the deteriorated rivers.

In the thirties of the present century and just before and after the Second World War, the idea of multipurpose comprehensive schemes was conceived to deal with problems in the compact tracts of similar topographical conditions in the region. The objects aimed at were :

(*a*) To arrest the growing deterioration in health and productivity of the soil and restore the old prosperity of the North and Central Bengal.

(*b*) To lower the level of the destructive flood in the Ganges so as to make it harmless and beneficial.

(*c*) To improve the drainage channels, including the tidal reaches, and make them self maintaining.

(*d*) To arrest the advance of salt water limit up the delta.

Accordingly, hydrological investigations and comprehensive contour survey of the decandent tracts in North and Central Bengal were taken up. This program got dislocated due to partition of the Sub-continent, as the project areas fell partly in India and Pakistan. However, of late, a comprehensive approach has been made to harness within the region as many of the river systems, as possible. The Karnafuli Multipurpose Project, Teesta Barrage Project, the Ganges-Kobadek Irrigation Development Scheme, which are now under implementation, are the results of the first endeavour for utilising the water resources of the Province.

Water Resources Development Since Independence

Developments undertaken since Independence comprise (*a*) multipurpose. (*b*) irrigation and (*c*) flood regulation and drainage. No multipurpose project was started before 1952. Flood regulation and drainage projects are types of development which have been undertaken traditionally in East Pakistan, and a number of them were initiated immediately after Independence.

The multipurpose projects undertaken are the Karnafuli, the Teesta and the first phase of the first unit of the Ganges-Kobadak. With the creation of WAPDA, East Pakistan, these projects and similar other major projects have been transferred and placed under that Authority.

Flood regulation and drainage projects consist of a large number of relatively small schemes for the purpose of opening up congested water channels to facilitate drainage of lands, thereby providing a means of increasing agricultural production. In a number of cases, the improved channels provide a means of water transport for country boats and improved fishing facilities. Control gates in protective embankments provide the means of flood irrigation of the drained lands, during periods of low rainfall. These developments are considered more or less as a program for the maintenance of river channels. About 331 of such schemes costing Rs. 51,000,000 have so far been put under execution, out of which 248 have already been completed benefiting 1,470,000 acres of agricultural lands, the balance of 83 are in various stages of construction, most of which are nearing completion, and 982,000 acres of land would thus receive benefit in the near future. Besides, 60 such miscellaneous irrigation, drainage and flood regulation schemes have been made ready. The approximate cost of these schemes would amount to Rs. 15,000,000 and on completion they would benefit an additional area of 254,000 acres.

Irrigation by Power Pumps

The flood tracts in the districts of Sylhet, Mymensingh, Tippera and Dacca are locally known as "haors". The lands in "haor" remain under deep water for six months in the year. When water recedes after monsoon, the land dries up and is over grown by long rooted grass which makes it very difficult for the bullock-drawn ploughs to break the soil. But once the soil is broken by means of tractors, and crops grown thereon, it becomes amenable to the bullock-power. "Boro paddy" (winter rice) and other winter crops can be grown on such broken lands, if irrigation water could be make available.

To speed up food production, a large number of low lift, small portable pumps have been purchased by Government. Water is pumped from the nearby sources, such as river channels, lakes and "beels" (swamps). These pumps are made available to the cultivators either (i) by outright sale or (ii) by hiring. Details of power pump irrigation measures are shown in Table 1.

TABLE 1.—Power Pump Installation in East Pakisan.

Type	Horse Power	Number	Capacity in cusec.	Area irrigated in 'Boro' land per pump.
Portable	7.5	789	1 X X	50 acres
"	8.0	187	1 X	
" ..	12.0	4	2	80 acres
" ..	22.0	13	3	100 acres
Mounted on boat ..	23.0	11	3	125 acres
Mounted on pontoons ..	44.0	10	4	200 acres
" ..	55.0	24	5	225 acres

TABLE 2.—Cost of Operation of Pumps.

Sl. No.	Type of set	Cost/acre of irrigation (3 months only) in rupees
1	Mounted on pontoon (44-45 H.P.)	26 5 0
2	Medium size mounted on boat (20-25 H.P.)	30 13 0
3	Small portable sets (5-8 H.P.)	50 3 0
	Average Rs.	35 12 0

Area Irrigated is as follows :

Years	Acreage
1955-56	3,187
1956-57	8,272
1957-58	27,345
1958-59	31,398

River Problems with Reference to Health and Productivity of the Soil

In all accounts that have been preserved from ancient sources, East Pakistan is reported to have been healthy and prosperous. Bernier wrote about 1660, "The knowledge that I have acquired of Bengal in two visits inclines me to believe that it is richer than Egypt". The faulty distribution of the available water resources which has brought about the present deplorable condition is attributable partly to human interference with the natural process of building up of the delta and partly to natural causes. Extensive deforestation, soil denudation, etc. in the catchment basin, mostly beyond the borders of East Pakistan, are increasing the silt-charge and deteriorating the rivers, thus raising the flood level and affecting navigation owing to the formation of shoals and reduction in dry weather flow.

Another international aspect of the river problems in the region is the harmful effect on a river regime that may result from excessive tapping of its supplies for purposes of irrigation in the upper riparian, especially during the dry season. Unlike air and light, when the gift of nature is of limited quantity, as in the case of river supply, no particular country or state should take advantage of its geographical position and monopolize this gift, but it should be equitably distributed among all the riparian owners having regard to their varying needs.

Sufficient supply of upland water in the dry season is an essential requirement for the preservation of past development in the region along

with the tidal channels and to push down the salt water limit which is tending to advance up the delta. In fact, the lack of dry weather flow is mainly responsible for deterioration of many of the tidal channels, causing serious concern in the matter of drainage, reclamation of low tidal lands and inland navigation. Equitable distribution of the available river supply is therefore, an essential requirement of river conservancy. It will hardly be possible to achieve the objects most efficiently unless the international aspect of the main rivers, which are tending to raise the flood level and diminish the dry weather flow, can be scientifically tackled on the basis of multiple purpose unified river basin development with international co-operation.

Having regard to the delay that will inevitably occur before the effect of any measure in the international sphere between India and Pakistan can materialise, urgent measures must be taken to maintain the East Pakistan rivers as going concerns. The principle of controlled diversion of the upland perennial supply, for the purposes of irrigation, flushing of the decadent tract and resuscitating the moribund spill channels, should be applied systematically to the regions suffering from low productivity of the soil and deteriorating sanitary conditions.

The river problems, especially in the tidal region, are highly complex. Research is, therefore, necessary to find out a satisfactory solution. What is required is a well equipped research laboratory to study this and other questions amenable to laboratory treatment, thoroughly and scientifically, to guide the engineers in their effort to solve these problems. Many of these problems are unique and practices followed elsewhere will not help much. The solution will have to be found out by long concentrated study of the local conditions.

In the meantime, as short term measures, the following criteria may be fixed, according to which developments in the field of water resources should be carried out, as quickly as possible:

(*a*) Execution of schemes, designed to prevent presently cultivated areas from going out of cultivation, due to shortage of water, or unregulated flood flows.

(*d*) Reclamation of land going out of cultivation and prevention of further deterioration.

(*c*) Small local projects, designed to enhance the production of presently cultivated areas.

Comments by Mr. M. S. Minhas

This paper deals with the small irrigation projects of East Pakistan. You have some general idea of the conditions in West Pakistan, which is essentially an arid zone, but East Pakistan differs materially in climate, as the annual rain fall is from 16" to 100", whereas in West Pakistan the annual rain fall is from 5" to a maximum of 40". The question on doubt arises in your minds regarding the necessity of irrigation in an area where the annual average rain fall is 16" to 100". This you will recall, I referred to in connection with the remarks or Mr. Yadara Mohan in respect to some similar climatic areas in India. The conclusion has been reached that in order to cope with the rising population and the demand for food grain, irrigation has got to be pushed in order to produce double crops in these areas. In East Pakistan, 60 inches rainfall is confined to the months of May through September. But even during the summer months, the early rains and the late rains sometimes fail and the crop is severely affected. Added to this is the menace of the floods due to erratic rains. The floods of 1954 and 1955 in East Pakistan brought into focus the necessity of controlling the floods. Therefore, the problem of East Pakistan is not merely one of irrigating during the dry season, but also of controlling the floods during the monsoons.

The geological formation of East Pakistan is that of an alluvial deposit brought in by the rivers. But the formation of these plains has been rather erratic so that on the eastern fringe in which the Meghna flows and which does not bring sufficient amount of silt, there are still large areas which have remained unfilled by the river sediments. During the monsoon when the river fills, these areas are flooded, so that raising of the crop during the monsoon season is a problem also.

Up to the time of Independence and till recently there has been practically no irrigation and it was only recently that attention was focussed on the importance of irrigation. Much of the water control work has in the past been confined to the expansion and improvement of water gates and indirectly they served to drain lower areas where cultivation could be done during the dry season. In areas lying in the south near the Bay of Bengal the tides brought havoc to the crops during the monsoon and dykes have been constructed to ward off the saline water. The construction of the dykes is also in the nature of an irrigation project, since they were designed to protect the crops from the saline waters.

Again control of flooding and silting out the lower areas is considered part of the irrigation project. These projects are regarded as irrigation since mainly they are to preserve the crops as they are grown by natural rainfall.

Coming to the recent developments I would like to introduce to you some of the financial aspects of the irrigation projects in the East Pakistan. At the moment, projects costing up to Rs. 50,000 are considered the concern of the Divisional Development Boards which are presided over by the Commissioner. Projects costing up to Rs. 10 lakhs (1,000,000 Rupees) are handled by the Irrigation Department. Actually before 1959 all the major projects were handled by the Irrigation Department but recently with the formation of the Water and Power Development Authority in East Pakistan on the same lines as in West Pakistan the projects costing Rs. 10 lakhs or so are now the concern of this Authority.

The author has mentioned in his paper those projects which are costing Rs. 10 lakhs or so, but the position has now changed because the Government has very recently merged the Irrigation Department with the Authority. The Authority now has a very ambitious program of extending irrigation during the winter season, which is the dry season in East Pakistan and at the same moment there are about 22 million acres of cultivable area and our program is to extend irrigation during the dry weather to the entire area. Another reason is that in the early and later months of the monsoon when the rain fails we should have irrigation facilities in order to save the monsoon crops in the plains.

I would like to give you a general idea of the crops, because they are materially different than we find in arid parts of the world. Apart from jute, for which East Pakistan is very famous, the main food grain is rice, and there are mainly three crops—one is aus, as it is called in the local dialect, and then aman, and the third is boro. Aus is generally cultivated in a certain zone in the month of May and it is reaped in the month of August. The second crop, aman, is planted in the month of July and August and is reaped in the months of December to January. These crops have been designed according to the periods in which they are harvested. Therefore aman rice is known as winter rice. Boro rice is planted in the month of December in the low-lying areas where water is available and the soil has not dried and then it is harvested in the month of April. Therefore boro rice would be more appropriately called the spring rice or the summer rice.

Among the projects taken up by the Water and Power Development Authority are coastal embankments constructed to prevent the ingress of the saline water. Our observations during the last two years has been that where coastal dykes have been constructed the out turn of rice in those areas has doubled from about 20 maunds to about 40 maunds. We treat this areas on the same lines as the Dutch have done in Holland. The intention is to divide the area of Surma and Sona area of the Khulna District into ditch polders. The area covered by these polders will be about 27 lakh acres.

The first irrigation project to which I made a reference on Saturday lies in the north of Khulna, where irrigation facilities from canals will be available. North of Khulna there is an area of 150,000 acres which will be brought under irrigation by pumping water from the Ganges. Irrigation water will start flowing to these fields by November next year.

The irrigation project known as the Teesta Barrage Project, taken up as a pre-independence project, has been modified considering the changes involved in the river and a barrage is to be constructed on the Teesta River which is a tributary of the Brahmaputra. To maximum flow of the Teesta River is 4 lakh cusecs, and it is planned to divert about 10,000 cusecs into the Teesta canal which will irrigate the districts of Bogra, Mymensing and Rangpur.

Further north and north-west in the districts of Rangpur and Dinajpur outside the commandable area of the Teesta Barrage, there are a large number of streams and rivulets which are adjacent to farm lands. At the same time ground water resources of the Dinajpur area are considered to be potentially very hopeful and it is planned to install tubewells to pump the subsurface water for irrigation.

Rangpur and Dinajpur districts are well known for producing cash crops like potatoes, tobacco and sugarcane, and it is due to high costs that private irrigation is not possible. Good crops have been reported on the basis of the results of the tubewells which have been installed during the last two or three years. Another important project which is engaging our attention is the Brahmaputra Multipurpose Project.

I now divert your attention a little and tell you that most of these projects which I mentioned, although they are primarily irrigation projects, are also multipurpose since they are also meant to control the floods and to facilitate navigation which is an essential feature of all the water areas of East Pakistan. The large rivers of East Pakistan are inter-connected by natural streams which are like big rivers, like the Ravi, which you might have seen, and although in the local parlance they are known as khals which means a small stream, the flow varies from 60,000 to 200,000 cusecs.

The Brahmaputra Multipurpose Project received the attention of the Brigg Mission which visited Pakistan in 1956. Just before that the floods of 1954 and 1955 played great havoc with people and crops.

Pakistan made an appeal to the Indian Government that in order to harness or control the floods we should be associated, as regards practical information, with India. The response was very encouraging and the Flood Commission of East Pakistan happened to have some meetings with its counterpart in India, but is a sad story that not very much has happened yet. I think that if visits were possible and there were exchange of relations, we could proceed satisfactorily on the planning of such projects.

The Brahmaputra River in the Brahmaputra Project anywhere in East Pakistan is from 5-10 miles wide and the construction of a barrage has always baffled the imagination of the engineers. There is no bridge in East Pakistan over the Brahmaputra River and water-crossing is done by ferrying.

ADMINISTRATION AND OPERATION OF IRRIGATION IN THE LITANI PROJECT

By
HALIM NAJJAR*

Introdution

The Litani River originates in the interior valley of Lebanon near Ballbeck and runs a course of 170 kms. to empty its water near Tyre on the Mediterranean Sea with an annual average dischage of about 700 million cubic meters. Its course runs in the Bekaa Valley for a distance of some 80 kms. where its water, along with other springs or tributaries, is completely used in summer for the irrigation of the fertile plain of the Bekaa. The remainder of the course is a deep gorge permitting little or no irrigation until it reaches the narrow coastal plain at Kassmyie where a diversion dam and irrigation canals built during World War II allow for the irrigation of 6,000 ha. between the cities of Saida and Tyre.

The Government of Lebanon had on hand a plan for the development of the Litani water resources. The U.S. Bureau of Reclamation Investigation Staff made a full study and developed detailed plans for this river. In 1954, the Litani River Authority was set up by the Government to execute this plan.

The overall plan includes briefly the Karaoun Dam at the end of the Bekaa Valley, a tunnel of about 16 kms. cutting across the Lebanon Mountain with some 10 more kilometers of tunelling and with canals leading the water down to Saida and north along the coast to Beirut. This plan involves:

(*a*) the development of 182,000 kws. of hydro-electric power at three plants;
(*b*) the irrigation of some 18,000 ha. of land.
(*c*) the supply of water to villages in Southern Lebanon and to the city of Beirut.

The main irrigation area will be in Southern Bekaa above the Karaoun Dam where some 8000 ha. of fertile land will be put under the scheme. The Saida-Damour coastal strip will also provide some 1,300 ha. of land. Southern Lebanon, a mountainous region, will receive a network of canals to provide for village water supply and for limited irrigation in each village.

Land ownership in all areas covered by the project is of the small type. Even in the Bekaa Valley where big ownership is more common than in other areas, 97% of the land is in properties of less than 10 hectares. In this region 20% of the land is operated by tenants, the rest by the owners. The crops of the non-irrigated sections include the usual winter cereals, sorghum, olive, and fig trees as well as vineyards. Irrigation will result in diversification, and hopefully, in the development of a mixed-farming system. The soils of the region are mostly of silt-loam fairly well drained and do not show evidence of salinity or other serious problems. The available water will not be enough to irrigate all the land. A crop rotation will be followed that will leave in mid-summer adequate supplies for the land under irrigation during that season.

The criterion of successful accomplishment in an irrigation scheme does not lie in the proper engineering and construction of dams and canals. It is rather a measure of the proper application of water on the land and of the amount of prosperity and welfare that may take place in the region after the introduction of an irrigated system of farming. The quantity of water made available, the proper distribution of that water at guaranteed intervals, its proper application to crops, proper cropping system and management, and the measure of prosperity and welfare that the water brings to the community are all factors to be considered in the planning of an irrigation project. General experience in this respect points to the pitfalls of an irrigation project. The usurpation of water right by the strong and quarrelling over water rights, the misuse of water and the over-production of

*Agricultural Advisor to the Litani Authority, Lebanon.

perishable vegetables without due regard to crop economy, are among the problems of irrigation farming.

The Litani River Authority is aware of these problems and has developed plans for the proper management of water distribution with due thought to agricultural considerations.

Water Management and Distribution

The management of small springs in the villages of Lebanon, as well as the river Barada which irrigates the vast gardens of Damascus indicates the reliance of the system on "*customary practice*". Custom is developed by the people over the centuries and to them it is a law that they defend.

A new irrigation project should develop its law in the spirit of "customary practice". A basic element of this "practice" is that its rules are developed by the people and are thus defended by the people. In other words, a cooperative enterprise among water users, making of themselves masters of the water, will throw the responsibility of water management and security on the people who benefit from the water. The organization envisaged for this type of management is as follows:

The Irrigation Service of the LRA.—A special Irrigation Service will be constituted within the permanent cadre of the LRA. It will have the personnel necessary to perform the functions mentioned below. This Service will attend to the administration of water for irrigation according to a special law enacted for this purpose and containing the principles and procedure of water management. The Service will pro-rate the water among the villages on the basis of area under irrigation. Each village will have its independent system of laterals within its boundary. The Service will supervise activities at village level through local agencies and will manage welfare programs on regional or district levels.

The Irrigation Cooperatives or Mutuals.—Water-users of a village will constitute among themselves an irrigation cooperative whose function will be to receive its share of the water in the canal, distribute it among its members on pro-rata basis and according to a detailed schedule. It will construct, supervise and maintain the laterals and collect tolls and charges. The cooperative is open to all owners of irrigable property in the village. Non-members are not entitled to water-rights. Each member will be issued a "*water-stock*" for each 1000 square meters of land he owns in the village. This stock entitles him to a certain portion of the water available for irrigation. The cooperative administers the distribution of water and performs all its functions under the guidance of the Irrigation Service.

District Irrigation Board.—The chairman of the various cooperatives in a district constitute an Irrigation Board. This Board, chaired by a representative of the Irrigation Office, coordinates activities between the cooperatives and shares in the programming of advisory and welfare activities in the district. There will be three such boards in the Litani Project.

Water Delivery.—The water flow in canals will vary from season to season. There will be no guaranteed liters-per-second delivery to any farm. Farmers will be given a portion of the water based on the number of "water-stocks" they own. This portion will be delivered at determined intervals and for a known period of time. Farmers will have to adjust their cropping area to their own estimate of the water available at various periods of the year. Since water will rarely be enough for the whole area, farmers will find it necessary to follow practices that lead to high water efficiency.

Tolls and Charges

Capital expenses of the Litani scheme will be shared by the irrigation and hydroelectric sectors of the project. The capital for irrigation constructions and administration will be pro-rated among the different irrigation districts. In a similar manner the share of each irrigation cooperative and each "water-stock" of that cooperative will be determined.

Irrigation capital expenses will remain a debt, interest free, paid in annual instalments over a certain number of years. Each irrigation cooperative will collect annual charges on capital expenses according to the number of water-stocks held by the water user. These charges will be paid to a government fund reserved for use in some other development project.

Current annual expenses for operation and management of water distribution in a village will similarly be levied on water-stocks (irrigated area). These tolls, determined annually by the general assembly of the cooperative, will be the revenues of the cooperative of payment of costs to be used for the supervision of water distribution, maintenance of lateral canals and contribution of the cooperative to the general fund of the district for the provision of agricultural research and advisory facilities.

Tolls and charges are paid one year in advance. Failure to pay dues will discharge the cooperative of its obligation to deliver water to a delinquent member.

Supporting Activities

The introduction of irrigation into a region places the farmers face to face with new farming

problems. The crops are new. His old inherited methods are no more applicable. His re-adjustment to the new situation may be very costly to himself and to the general economy of the irrigation project if he is to be left to struggle for himself without support from outside. It is therefore considered imperative that water distribution on new land go hand in hand with research, extension and other welfare activities.

Irrigation Studies.—Farmers at their best make inefficient use of water on the farm. This is particularly true with farmers who have no previous experience with irrigation. It is necessary therefore that they be trained in the proper use of water. In newly irrigated areas local studies on the best methods of applying water to the land, on consumptive use of water by crops under local conditions and on rates and intervals of applications must be made. These studies are needed so that farmers can be properly advised on how to use water on their land.

Studies in Farm Management.—The introduction of new crops on a farm raises many questions of management and economy. What crops to plant? Which ones are more suitable than others? What type of a rotation to use? What system of agriculture to follow? These and similar questions are pertinent and need to be investigated by qualified farm management specialists. In the region falling under the Litani irrigation project there is need for investigating the possibility of shifting from common vegetable and fruit production to a mixed system of farming where animals for meat, milk and egg production will be raised. One cannot increase the irrigation area of a country by 30% without giving serious and well-considered thought to what sort of agriculture one should follow on the new land. This is particularly true in the case under study because of the shortage of livestock in Lebanon. Another problem requiring investigation arises from the fact that in Southern Lebanon water will be used in limited quantities on small subsistance farms.

Crop Management.—Field trials to determine soil fertility and the proper use of fertilizers will be needed on the newly-irrigated land. Varieties of seeds will have to be tested to discover those most suited among them for local soil and climatic conditions. Planting dates, cultivation and other farm practices will also need to be investigated. In short, research will be necessary to assist operations to find the answers to questions raised by farmers and to solve problems met by them.

Farm Advisory Services.—Farmers will be at the mercy of their own ignorance if they are not given guidance and advice in the new practices they are performing. The results of research work cannot be known to farmers except through an extension organization that keeps farmers well informed. Field demonstrations, posters, movies and other extension methods will have to be used to induce farmers to acquire new methods of farming. Extension personnel are needed to educate the farmers and to train them in methods of irrigation farming.

Cooperative Organization.—A good system of cooperation among the farmers in the district will solve many of their problems. Cooperation is an essential activity in the economic and social development of any community. The farmers receiving water from an irrigation cooperative will have some experience in cooperation. This experience should be extended to other fields of work. Cooperatives will be promoted in such fields as farm machinery, marketing credit, consumers and farm supplies. In this manner the economic side of farming may be set on a sound basis.

Briefly stated, the Litani River Authority through its Irrigation Service intends to organize and administer the use of water on the land with the cooperation and participation of the water users themselves. Furthermore, its plans include local studies in irrigation and farm and crop management so as to find out facts to give to enquiring farmers through an agricultural extension organization. The economic and social problems of the communities will be tackled by a series of cooperative associations. All these supporting activities of LRA will be conducted by its special personnel and in close cooperation with the departments of government concerned. Farm communities benefiting from these various services will contribute to their upkeep and will take part in the development of programs.

Discussion

Mr. Najjar discussed the question of how costs were to be allocated. He was particularly concerned whether or not lands at greater distances from the canal should be assessed additional costs due to longer laterals. He was also concerned about the question of procuring rights of way for distribution systems through the existing pattern of land holdings. The decision regarding the responsibility of farmer cooperatives for the construction, maintenance and operation of laterals and farm ditches has yet to be resolved.

In response to a question by Dr. Ahi regarding how the various projects costs are to be allocated among the various elements of the multi-purpose project, Mr. Najjar replied that the Authority would decide on this matter. The entire basis of cost allocation is still under discussion; however, more than one-half of the cost is for hydroelectric power. Furthermore, three cubics meters per second are furnished Beirut for domestic use, for which the city of Beirut will pay. After the irriga-

tion share of the costs have been determined, the Authority will then allocate this sum among the various regions. Repayment will be based on the period of twenty or thirty years interest free.

Mr. Natour asked whether each cooperative will be provided enough water for an adequate water supply for the land under the cooperative. He further asked if the Authority had means of requiring that the farmer use his water supply efficiently, if inadequate for all of his land, on part of his land rather than spreading too thin.

Mr. Najjar replied that the farmer will know that he gets a certain proportion of the available water. He may apply this to his crops as he sees fit, based on his experience. The Authority will try to get him to do this most effectively voluntarily through its program of education and extension rather than by regulation.

Mr. Ismail pointed out that where the distribution of water has been placed in the hands of cooperatives there is a tendency for the leaders to take more than their share of the water. He inquired as to how this was to be prevented. He further commented that he had a great deal of valuable information to carry home with him; but that he was quite concerned as to how he could condense and simplify this so that it could be placed in the hands of farmers.

Mr. Najjar replied that the water turns will be based on measured streams distributed on the basis of a time schedule (developed by the cooperative). This will be supervised by a water master which should make it practically impossible for one man to steal another man's water.

Mr. Mohan commented that the Litani set up was quite ideal. He asked if the cooperatives were already operating and if so what efficiency had been obtained. He pointed out that geographical considerations might make it desirable for two or more laterals to serve a single cooperative; or conversely, two or more cooperatives might use the same canal. He asked how these factors were reconciled.

Mr. Najjar replied that in Bekaa Valley it so happened that each village was provided its own lateral. In some of the other locations the situation posed by Mr. Mohan could occur. In that event each cooperative would simply be delivered its proportionate share of the water from each canal. He further stated that although the water was originally supposed to be available this summer, it now appeared that this would not happen until 1961; therefore, the Authority has not yet had actual operating experience.

IRRIGATION AND FARM PLANNING ON THE EAST GHOR CANAL PROJECT

By

SWEILEM M. HADDAD, PROJECT ENG.

AND

FAHED S. NATOUR, IRRIGATION ENG.

General

A general description of the Jordan Valley is an essential introduction to this paper. The Jordan Valley is a long and deep valley between two mountainous ridges. It is about 200 meters below sea level in the north and about 400 meters below sea level in the south. It is about 100 km. long and 16-30 km. wide. It has two distinct terraces, the Ghor and the Zor.

The Zor is the flood plane of the Jordan River, 1-3 km. wide and relatively flat. The Ghor is about 20-50 meters higher than the Zor, with a pronounced steep and badly erroded badland area, called the Katar, separating the two terraces. The East Ghor is the part that lies east of the Jordan River. It has a westward general slope of 2-3% and a milder southward slope.

The climate of the valley is of the subtropical, semi-arid type. The average maximum temperature is 45° centigrade, the average minimum, 5° centigrade. The average summer relative humidity is less than 50%. Rainfall varies from about 500 mm. in the north to about 100 mm. in the south.

Some irrigation is done from the perennial-flow side tributaries of the Jordan River, using simple diversion works on these tributaries. But the lands in the Ghor, which are registered at present as irrigated lands, are not enjoying full efficient irrigation. Since 1938 several schemes have been proposed for the utilization of the water of the Jordan and Yarmouk Rivers for the development of the Jordan Valley. The Jordan Government had proposed several times to take water from the Yarmouk River without any storage and without any diversion dams, in the form of a pilot scheme.

Among the half a dozen schemes proposed so far for the development of the Jordan Valley, the East Ghor Main Canal is a common factor. Therefore, the East Ghor main canal scheme could be considered as a self-contained unit, or as a segment or first stage for any further development that might be agreed upon in the future for the utilization of the lands and waters of the Jordan Valley. As matters stand at present the scheme is considered as a first stage of the Yarmouk-Jordan Valley Project set forth in the master plan report of 1955.

This scheme was submitted to USOM/J at the end of 1957 to be financed by the 20 million dollar technical assistance money to Jordan. At the same time the Jordan Development Board proceeded with its plans by forming the East Ghor Canal technical team for preparing the final designs and construction drawings by using the funds set forth for the scheme by the Jordan Government in the fiscal year of 1957-58. A three-man team of Baker and Harza Consultant Engineers from the United States, working with Jordanian Engineers and technicians, prepared the plans for the scheme.

This project is a very important project for the people of Jordan. 120,000 donums (or 30,000 acres) are to be developed for intensive irrigated agriculture. A large number of farmers would be able to attain a decent standard of living. This will reduce population pressure in other areas. Quite a number of laborers will be employed and that will reduce the number of unemployed laborers. The farmers, with a good standard of living, will be able to support other business both inside and outside the project area. The Government will save some hard currency by reducing imports, and will bring in more hard currency than it is bringing in now by increasing exports. The completion of the project will add to the national income and to the government revenue.

The realization of the importance of this undertaking necessitated a strong authority for the planning and execution of the East Ghor Scheme. This is particularly true in this area. As we read the history of the area we get the impression that irrigation and agriculture flourished in the area when there was a strong ruler or a strong and proper legislature. Having this requirement in mind, as East Ghor Canal Authority was organized last year to care for the development of the scheme, with the old technical team as the backbone of this authority. A group of experts from Harza Engineering Company International are providing technical assistance. The Authority has the stable structure necessary to complete its task.

The Main Canal

The East Ghor Main Canal is intended to draw off a part of the normal flow of the Yarmouk River by simple diversion near Adasiya at the northern end of the valley. This water, together with water diverted from the perennial-flowing east side tributaries of the Jordan River, will be used for controlled irrigation of about 120,000 donums (or 30,000 acres) in the East Ghor and Zor lands, which lie between the Syrian border in the north and the Zarqa River in the south.

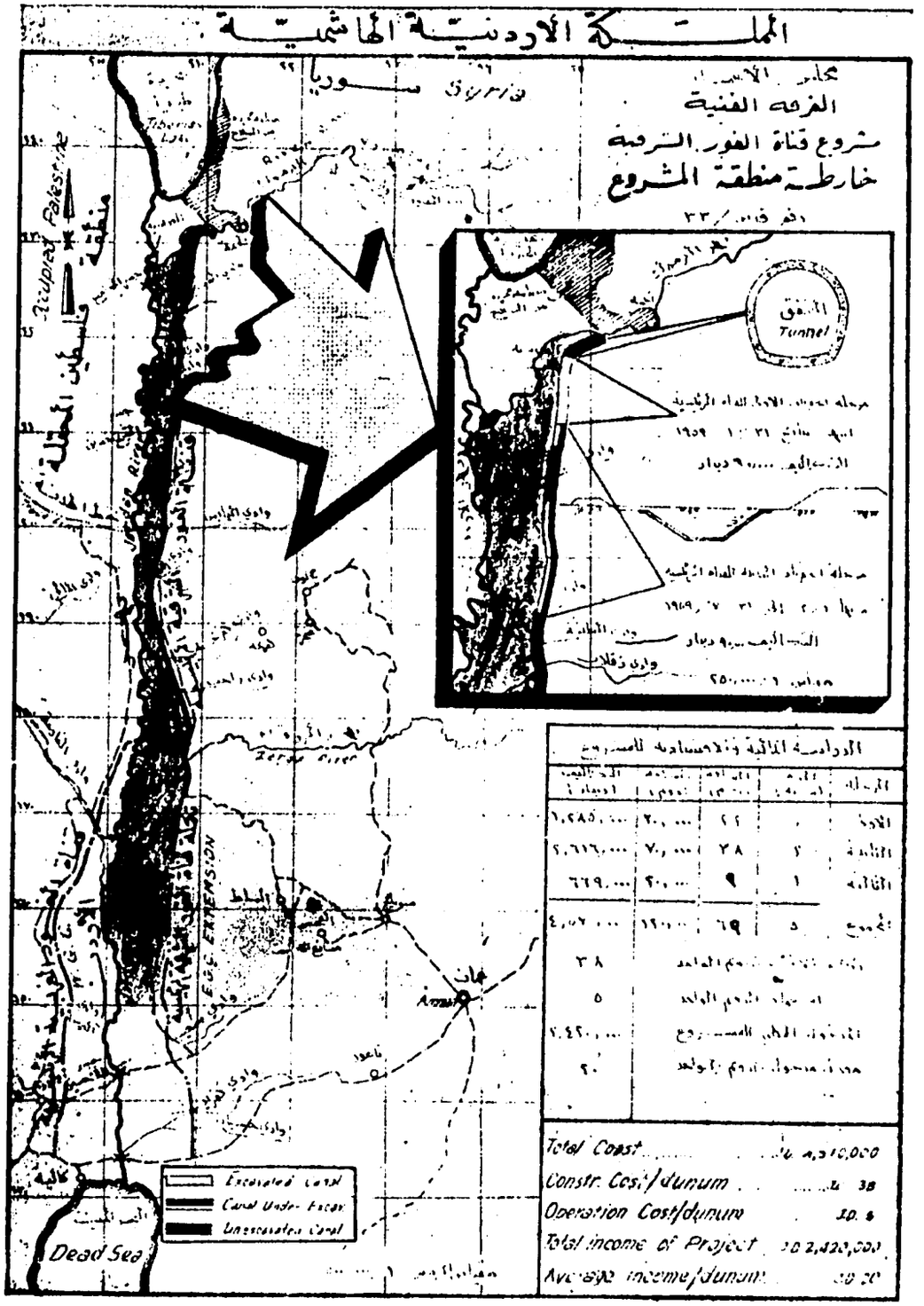
The Yarmouk water will be diverted through a horse-shoe tunnel 3 meters in diameter, 950 meters long, and with a slope of 2 meters in a thousand meters. This tunnel is designed to carry a flow of 20 cubic meters per second.

The canal itself is 69 km. long with a concrete-lined trapezoidal section of 2.97 meters bottom width, side slopes of 1½ to 1 and 2 meters depth including a 0.30 meters free board. The berm is 1 meter wide and the operating road is 5 meters wide with a minimum height of 0.53 meters above the berm. The slope in the canal is 18 meters in 100,000 meters. The canal is designed to carry a flow of 10 cubic meters per second with allowances for a 30% overload. It will draw off a total of 155 million cubic meters annually. This capacity was selected with a view of conveying extra water in off season periods to the thirstier southern Ghor land where an additional earth canal is envisioned, and because of other technical and economic reasons. The over-design of the tunnel, the syphons and the flumes, together with a planned raising of the canal lining, is to take care of the future development when there is storage on the Yarmouk River making more water available and a 20-cubic meter per second flow would then be diverted from the Yarmouk. With the full utilization of the Yarmouk River and the Jordan River waters 36-cubic meter per second would be available. The extra 16 cubic meters per second would be diverted in a feeder canal parallel to the present canal and without structures down to a point where a similar amount had been drawn off the old canal.

Water of the side tributaries would be used for the irrigation of lands above the main canal, and some of it would be taken into the main canal through lateral irrigation inlets.

The main canal has the following structures on it:

82	reinforced concrete	pipe culverts
6	,, ,,	box culverts
16	lateral irrigation	inlets
77	lateral turnouts	
26	checks	
1	drop structure	
11	waste ways	
6	reinforced concrete	syphons
10	,, ,,	rectangular flumes
12	,, ,,	foot bridges
23	,, ,,	highway bridges



East Ghor Project

The contract has already been signed for the construction of the first stage of the three-stage project. This stage includes the tunnel and 22 km. of canal with appurtenant structures.

Quality of the Water to be Used

Water quality is a very important aspect in any irrigation project planning. A brief discussion of the quality of the Yarmouk water and of the side tributaries water is not out of place. An average analysis of the Yarmouk water follows:

EcX10	=	681 microohms
Na	=	2.24 m.c/L
Ca	=	1.9 ,,
Mg	=	1.71 ,,
Cl	=	1.72 ,,
Co3	=	.03 ,,
Hco3	=	3.21 ,,
So4	=	0.83 ,,
No3	=	0.16 ,,
Ssp	=	38.3%
SAR	=	1.7

From this it follows that the Yarmouk water is of the type C2-S1. Salinity hazard is low and leaching requirements are mild. These leaching requirements are 17% for the most sensitive crops like citrus and stone fruits, 8.5% for moderately tolerant crops like grapes, olives, alfalfa and sorghum, and 5.7% for the tolerant crops like date-palms, sugar-beets, milo and cotton. Alkalinity (Sodium) hazard is also very low.

Water of all the side tributaries, except Zarqa River and Wadi Ziglab, is of the C2S1 class, and would have the same qualities as the Yarmouk water. Water of the Zarqa River and of Wadi Ziglab are of C3S1 class, but on the lower border of the C3 group. More leaching requirement should be accounted for and good drainage is needed.

Zarqa River also has 3.18 m.c/L chloridion concentration which is rather on the high side, and special care should be taken not to use it chloridion sensitive crops like stone fruits.

The Distribution System

The distribution system layout had to fit the land distribution and parceling layout of the area. A program of land distribution based on an extensive land classification study was made for the Jordan Valley prior to 1955.

The purpose of this study was to make a systematic appraisal of the soil, topographic, irrigation and drainage characteristics of the land in order to determine its degree of suitability for sustained irrigation agriculture. This will lead to an equitable redistribution of the land plus the formulation of the basic data necessary for the design of the distribution and drainage systems and the farm irrigation layout. This study was carried out according to U.S. Bureau of Reclamation Standards, modified to meet the local conditions. Factors taken into consideration in this study were:

Type of soil.
Parent material.
Soil texture.
Soil structure.
Degree of salinity.
Degree of alkalinity.
Hydraulic conductivity and infiltration rate.
Vegetative cover.
Presence of marl layers in the soil profile.

This last factor is particularly important in the Ghor area. This area was once under sea water when it was an arm of the Red Sea. During this period salt-laiden, highly calcareous silts and clays were deposited, making this an impermeable layer which is contributing to the salinity of the alluvial soil which covered it later.

In addition to soil classification, the following factors are taken into consideration in laying out the boundaries of the farm units:

1. Topographic conditions.
2. Expense for land levelling (Efficient irrigation should be attained with the minimum expense for land levelling).
3. Delivery of water by only one farm turnout for every farm unit.
4. Shape of the unit (Farm units are laid rectangular or with wide angle corners as much as possible, to permit efficient farm management).
5. The open drainage system planned. (Care is taken not to divide a farm unit by the open drainage ditches).
6. The permanent cropped areas, like orchards.
7. And, of course, the hydraulic and engineering considerations.

Farm ownership will range from 30 donums (or 7½ acres) to 500 donums (or 125 acres). Present ownerships range in size from less than a donum to over 4,000 donums.

This distribution was governed by many factors basic to land reform programs, such as economical, social, humanitarian and justice factors.

The size of the lateral turnouts depends on the total area to be served by that turnout. They range in capacity from 1/8 cu M/Sec serving about 500 donums to 1 cu M/s serving about 4,000 donums. Laterals leave the main canal at lateral turnouts and lead west towards the Jordan River. The section is planned to be concrete lined with a

minimum velocity of 2 ft/sec. and a maximum velocity of just below critical velocity. The steep slope 2 to 3% in the Ghor makes it possible to have a drop structure at each delivery point, and the remainder of the drop will be taken care of by stepped lining of the lateral. Long chutes are going to be used to deliver water from the Ghor to the Zor across the steep and rough Katar.

Submerged orifices are going to be used at farm delivery points to measure and control delivery to each farm. Each delivery point will have a controlled discharge of 0.75 cfs. as a minimum and 3.5 cfs. as a maximum. Water surface in the farm head ditch will be maintained 15Cm. above ground level at all flows. The decision on this capacity was governed by many factors, the most important of which is water requirement of the crops.

Water Requirements

Irrigation requirements are the basis for adequate design and efficient operation of any irrigation project. Knowing the consumprive use of a crop is a first step in knowing its irrigation requirements. Although there are several different methods of getting the consumprtive use of a crop, yet the Blaney Criddle method is by far the most commonly used during the planning stages. That is because in general climatic and physical records are available over a number of years for the area to be developed, while it is very rare that long Lysimeter, evaporation pan, or atmometer records are available for the area. To do these latter investigations is expensive and time consuming.

The Blaney-Criddle method uses the physical characteristics of the plant that determines its consumptive use coefficient, together with variations in mean monthly temperature, and the location or latitude of the area that determines the length of sunshine hours to get the consumptive use of the crop in that area. Then knowing the amount and distribution of precipitation or effective rainfall, and the winter soil-moisture carry-over the irrigation requirement is found from the consumptive use or evapo-transpiration. From this irrigation requirement the diversion requirement which is very important for design purposes is calculated, assuming a certain farm irrigation efficiency. This was the approach followed in the planning stage of the Ghor East Canal Project. The Ghor being divided into two latitude regions, and the present scheme lying completely in the northern region of the two. In the Master Plan a monthly diversion requirement was calculated for each crop, and then from a suggested cropping pattern a monthly and a seasonal diversion requirement was calculated for the whole project area.

Water delivery to farm units depends also on the physical characteristics of the soil such as field capacity and permanent wilting point and hence the available moisture storage of the soil, and also on the level of available moisture at which the soil profile is planned to be refilled. These detailed studies are planned to be done by the Authority in cooperation with the Scientific Research Department in Jordan.

The rate at water is applied will depend on the infiltration rate of the soil. Studies on this factor were made for the master plan report and more studies are planned. The rate will also depend on the irrigation method used. With a basin or a border method of irrigation, quite a large flow of water could be handled and ponded on the land; but with a furrow system the farmer can only handle 1 cfs. on the average.

Farm Irrigation System

A basin irrigation system was suggested in the Master Plan. A basin system for the area is a very good system due to low infiltration rates of the soil and due to the fact that some areas have salts and have to be leached. In these areas with a furrow system, crown salinization of the furrow might result. Although the farm units are laid to follow the contour lines as much as possible, there is a need for a big and expensive land levelling program if basin irrigation is going to be used for the whole area. So it will be better for us to begin with more than one gravity farm irrigation system; like using the basin system on the flatter areas and using the contour furrow system on the rougher lands. In the future, with more returns coming to the farmer land, levelling may be done by the farmer for a more efficient use of water. Some land levelling might be done by the Authority at the start.

Distribution System Operation

A strict rotation schedule of delivery by which each individual farm unit receives water for a 4-hour period every fifth day was recommended in the Master Plan. The problem was that a strict rotation system would not be the most eff e set-up, because of the great variations in crop requirements, root system depths, soil textures, available moisture storage capacities, and infiltration rates on different farms.

Because of these difficulties we have been working on having a better system and we are convinced that a controlled demand system is better. In this system the demand of different crops on different soils could be taken care of within a somewhat flexible rotation. The system is built to deliver a variable head of water through variable lengths of time in multiples of a minimum unit time of 6 or 12 hours. By this system the Authority would control the demand of the farmers for many reasons, one reason is that the system is not built for a completely free demand system which is more

expensive. A second reason is that the Authority technicians are in a better position than the farmers to know the crop and the soild requirements.

The system is planned to work as follows: The ditch rider will take orders from the farmers for 3 days and will tabulate them by lateral and give them to the water clerk. The water clerk consolidates all water orders and transmits them daily to the water master's office. Orders have to be checked by the farm development section, and then processed and returned to the water master. The water master schedules the water in the main canal to meet the orders and arranges for the diversion of the required quantity, taking into consideration inflow into the canal from the side wadies. The water master advises the hydrographer of the scheduled water for each reach of the canal and for turning water into each lateral. The hydrographer turns the water into the laterals and passes the control of the water to the ditch riders who will make deliveries to farm units.

The Drainage System

Agricultural land drainage is a corner stone in most cases for the success of an irrigation project. It serves to keep a good deep root-zone relatively free of water and salts.

1. *Surface Drainage:*

This system consists of open channels to take the surface runoff out of the area to the Jordan River or to side wadies crossing the Ghor and serving as natural outlets. An open channel is excavated east of the main canal as a protection for the canal. This drain will intercept the runoff from the hills and thus relieve the area of much of the water which otherwise would have to be drained.

In the project area itself, the precipitation is not very high, westward and southward slopes are not very steep; consequently there is no problem of surface drainage except in some localized areas where the area is a closed contour area or a very rough area. This happens mostly where the alluvial fans of the side wadies meet. In thess cases a network of open channels are planned.

Another open ditch may be necessary at the foot of the Katar to intercept both surface and subsurface water that is flowing from the Ghor to the Zor.

2. *Subsurface Drainage:*

Because of the size of the farm unit, the need for the fullest land utilization, and the topography, subsurface land drainage was chosen for most of the areas to be drained.

Subsurface drainage systems are needed in about 7% of the present project area, either to leach the salts out of some local spots of saline land, or to lower the water-table in some other specific areas.

Leaching

As discussed before the alluvial soil of the Ghor is underlain by a salt-laden impervious marl layer. The depth to this layer varies in different areas, but it is quite shallow in a small total area. In this case it might act as a barrier and a source of salt. With a high water-table or with a static or artesian pressure, water carrying desolved salts, is forced near the surface where it evaporates and leaves a salt crust.

Previous experiments in test plots have shown that these soils need leaching to turn them into productive soils. A subsurface drainage system is needed for such a leaching program. Leaching trials were made for the Master Plan report. An interesting finding was that it was advisable to leach the soil partially before installing the drainage system. The reason for this was that the soil did not have enough stability when leached. During this primary leaching, shallow rooted crops are used to keep the water-table down at about 90 Cm.; then the leaching is completed after the drainage system is installed. In was found that leaching the soil with 80-100 Cm. of water will reduce the salt level in the root zone for shallow rooted crops. Additional water has to be applied to leach the salts further down.

The High Water-tables

There are several reasons for the high water-table in some parts of the area, the most important of which are the following:

1. Inefficient use of the irrigation water.
2. Uncontrolled streams.
3. Seepage from the higher hill-lands.
4. Static pressure of ground water in some areas.
5. Barriers.

The alluvial fans deposited the coarser material up near the hills and the finer silt and clay materials down at the lower fringes of the fans. With time, some sort of a vertical barrier was formed. Also connected with that is the fact that the impervious marl layer gets shallower at the lower reaches of the Ghor.

Old Water Works.

The Romans developed some water by tunnelling at the foot of the hills and collecting some water from acquifers along the length of the

tunnels. Some of these tunnels had been clogged, thus creating a high water-table and salinity problems.

The drainage system to be put in any area will depend on the reason for the high water-table. Irrigation efficiency will be controlled so that there is no more than 10% of the irrigation water going as deep percolation. Interceptor ditches, a network of underground drains, and making outlets in the vertical barriers discussed above, will take care of the drainage in the problem areas. A drainage investigation was done for the Master Plan report and a more intensive study is planned to be started using piezometers and observation wells in the drainage problem areas.

The Zor has a different source of water-table. The water-table here seems to be affected by the level of water in the Jordan River. Water level recorders will be installed on the River and observation wells and piezometers will be installed in the Zor to study the relation of water-table in the Zor with the river water.

The observation wells will be installed initially on a grid of 2 km. and the piezometers on a grid of 1 km. The grid will be of shorter distances in specific problem areas. Piezometers will be 3/8-in. pipes, 5-10 ft. deep. Observation wells will be 3 in. pipe gravel packed 10 ft. deep.

Because the drainage water is high in salts and sulfates, concrete tile drains are not suitable. Since clay pipes or fiber pipes are not produced in Jordan in quantities sufficient for the project, it was decided that stone or French drains should be used. These will not need more maintenance and have the advantages that the materials are available, labour is cheap, and these drains need less exacting excavation.

Cropping Pattern

A great variety of crops can be grown in the Jordan Valley. The choice of the crops to be grown in the project area and the percentages of land to be assigned to each crop will depend on many factors some of which are the following:

1. Economical policy for the project farmers; whether they are to operate on self-sufficient basis or to stress cash crops more.

2. Economic policy of the government; whether the government wants to produce products which are usually imported and thus cut down imports, or produce products wanted by others and thus increase exports, both of these operations would save hard currency for the government.

3. The agricultural-industry policy of the government for production of processed agricultural products.

4. Local and foreign markets as to needs, competition and ease of transportation to them.

5. Size of farmer units.

6. Water requirements of different crops.

Since 1954 six different cropping patterns have been proposed by different agencies because of different opinions or the factors involved, especially the economic factors. The last one of them was proposed by the technical team with a view of having a sugar factory in Jordan and of allocating 18.5% of the land for sugar-beets annually. Double cropping was around 50% in this pattern. Some of the considerations taken into account in preparing that cropping pattern were the following:

1. To have the maximum double cropping possible as allowed by the water availability. This is so because the Ghor has a practically frost free year.

2. To utilize the special subtropical climate of the valley and stress subtropical fruits like bananas and citrus and stress early vegetable production also, because these will have a good market price.

3. To have a small area under crops which are not intensive crops.

4. To have adequate amounts of forage and food crops.

At present the problem is that some of the project lands are going to be cropped before there will be a sugar factory set up in Jordan. For this, a new cropping pattern is being developed eliminating the sugar-beets and utilizing more production and market information collected this year.

Extension Service

The farmers in the project area are going to be professional farmers and although they are expected to have a fairly well working knowledge in agriculture, yet they are not expected to understand fully all the problems intensive irrigated agriculture. They might even carry over with them precedents and practices. To have a very efficient use of the water the farmers need technical help and direction in the form of an extension program or an advisory system.

This advisory system would consist of advisors with a chief advisor. These are to be graduates in general agriculture. They would carry infor-

mation and directions to the farmers from the farm development section of the authority and the scientific research centers and work with the farmers on improved methods to get the best possible results. In addition to irrigation advice they would give advice as to fertilizers, seed stock, plant protection and other things.

In addition, agricultural cooperatives are planned. Due to the small size of farm units the farmer will not be able to do many of the farm operations alone such as mechanical deep tillage, mechanical harvesting, marketing and grading of the products.

The farmers would be grouped in cooperatives that will have machine pools, marketing and grading facilities and other services for the farmers. Cooperatives, and some farmers will need some financial aid to get started, and provisions should be made to meet this requirement. Plans on this subject are not drawn yet, but much thought has been given to it. The help of the agricultural credit bank of Jordan would be required.

Community development and social and health extension services are needed.

All of this work is to be done in cooperation between the East Ghor Canal Authority, the Ministry of Agriculture, Ministry of Social Welfare and the Ministry of Public Health without duplication of any services present now in the area.

Discussion

In reply to an inquiry by Engineer Ayasi, Mr. Natour stated that farm units varies from 7.5 to 125 acres. The landholdings are planned subsequent to location of the irrigation and drainage system so that holdings are not bisected by canals or drains. In order to accomplish this, previous use of water and land is ignored and the plan is based on what is best for the area. The Ghor system will be integrated with systems providing water from other sources including wadi supplies above the canal. Canal water will replace wadi supplies now used on lands below the canal so that wadis may water more fully lands above the canal. Two ditch riders will be provided for each of about 25 laterals and the remaining staff will include two to four water clerks, one water master and one or two hydrographers. An intercepting drainage ditch is provided above the main canal to protect the canal from floods due to rain in the mountains.

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