ANNUAL TECHNICAL REPORT
1970-71

IMPROVING CAPACITY OF CUSUSWASH UNIVERSITIES
FOR WATER MANAGEMENT
FOR AGRICULTURE

REPORT NUMBER II
VOLUME II

APPENDIX C
UTAH STATE UNIVERSITY

Contract No. AID/csd 2459

August 31, 1971

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UTAH STATE UNIVERSITY LIBRARY - 211d

ON-FARM WATER MANAGEMENT

by

William I. Palmer

August 1, 1971

UTAH STATE UNIVERSITY LIBRARY - 211d

ON-FARM WATER MANAGEMENT

Introduction

In 1969 a five year AID supported program to augment and strengthen library holdings on world irrigation and drainage practice with emphasis on "On-Farm Water Management" was initiated. It envisioned a four-prong program to include:

1. Acquisition of library materials.
2. Development of information.
    a. Reference bibliographic collection.
    b. Computer system for retrieval of information.
    c. Cooperative networks for knowledge.
3. Developing of a special history of irrigation.
4. Cooperation with related disciples to Agricultural and Irrigation Engineering to build the total collection on Irrigation and Hydrology.

To fund this program a budget was adopted which provided for purchase:

1st year	$ 7,000
2nd year	7,750
3rd year	3,000
4th year	1,000
Total	$18,750

*For Publishing

(continued next page)

*Possibly some of the money budgeted for this purpose could be used for acquisition.

For organizing the library, developing information systems and pay for computer use: $48,000

I. Acquisition of Library Materials

Criteria for Purchases

At the start of the program a review of the library card catalog and a list of standard subjects as carried by the Library of Congress was made. From this review a "list of Subject Headings Used in Book Selection" was prepared to be used in guiding the search through the many bibliographic, indexing and offering sources received regularly by the library.

Procedure

A procedure was developed which involved the following steps:

1. Project staff assistants (Mrs. Loller, Mrs. Russell, Mrs. Lindberg and Mrs. Tassainer) assigned to the library and working under the direction of Karlo Mustonen conducted systematic reviews of all offered titles. For those titles thought to qualify under the "List of Subject Headings," a card was made. See List of Subject Headings, Appendix 1 and card sample, Appendix 2.

2. The cards thus prepared (several thousand in all) were checked against the card catalog to see if the publications were already available. Those cards and notices of publications, announcements, or sales promotion offerings covering titles not included in the library's "On-Farm Water Management" collection were circulated through the designated Ag and Irrigation Engineering staff members for "acquire" or "not acquire" decision.

3. All cards or other listing were returned to the library with the decision regarding acquisition recorded. The "do not purchase" cards have

been held by the project staff assistants assigned to the library. These will be discussed later under recommendations. The titles designated for purchase were placed in the procurement process.

Added Constraints

It soon developed that the offered works were so numerous and so costly that additional constraints had to be devised other than those imposed by the "List of Subjects" or those reflected by "interest profiles" of staff members who assisted in review.

It was concluded that the preference would be given to acquisition of:

1. Current works, primarily those published since 1960. Frequent exceptions to this guide have been made.

2. In any field there are certain "bench mark" works - When any of these were identified that were not already in the library they were acquired.

3. Titles needed to balance the library's holdings. For example, "Fluid Mechanics" is on the "List of Subject Headings for Book Selection" and properly so, yet all of the total budget could have been spent for publications treating with this single subject. Care has been given to try to develop a balanced "on-farm" water library.

4. Titles needed to balance international holdings. In the international purchase program care has been given lest too many publications from one country or one section of the world and too few from others might eventuate. All of the budget could have been spent on publications originating in one country, India, for example.

5. The purchase of books in preference to periodicals. This in recognizing: a) the library subscribes annually to all major periodicals bearing directly on on-farm water management, b) the difficulty to file and to set up data retrieval systems to handle magazine articles and c) the feeling that significant contributions to the subject that appear originally in various magazines and journals are subsequently picked up and made available in book form. Nonetheless some of the funds available have been used to subscribe to periodicals and journals.

6. Constant vigil has been exercised to see that publications not related to "On-Farm Water" did not find their way "under the tent" simply because of fund availability. For example: a request came in to acquire a sizable list of books on cryogenics. This subject obviously did not qualify and the request was rejected. A healthy recognition of possible value of offerings in a rather long list of approved subjects, however, has been maintained.

Acquisitions

From a long list of from 3,000 to 5,000 publications considered for addition to the library's On-Farm Water Management holdings 1350 were designated for purchase and have been ordered. Many of these have been received, cataloged, and are already in use. In addition to the titles listed for purchase several hundred gratis publications have been ordered and received. This gratis list includes many significant titles. Included in the gratis list are many publications of state and local governments, of trade associations and of manufacturing firms.

Each year in recent times the document room receives and processes

30,000 - 50,000 documents. These are covered by a special index maintained at the second floor entrance to the documents room. Many of these are relevant to On-Farm Water Management and are indexed and available to the researcher through the documents room librarian.

In addition to project purchases the library subscribed to or renewed its subscription to 1066 periodicals. Many of these came to the University by gift, exchange, or otherwise. The cost of serials paid for by the University aggregated over $6,600.

To summarize:	Number	Cost
Project Funds:		
Publications purchased	1,350	$6,144.57 [1]
secured by gift	300-500	-0-
Library Funds:		
Serials purchased or received by gift or device	1,066	$6,635.60
Federal Documents	300-500	Free

II. Development of Information

A. Reference Bibliographic Collection

An assignment of extremely high priority in terms of the On-Farm Water Management program was to secure an accurate listing of publications already available in the library. The problem at Utah State was complicated by: 1) a large collection of publications in the regular lending library that had accumulated over time, but which had never been organized or inventoried as an "On-Farm Water Management" library, 2) the

[1] Through May 1971.

maintenance in the library of several "special collections" which comprised private libraries of former faculty members, prominent alumni or others given to the University, but not cataloged, 3) an archives collection comprising writings and publications originating on campus and 4) a very extensive document room in which federal books, reports, legislative matters, technical papers and other items are housed. Most of the holdings in the special collections and archives were not generally or readily accessible to the patrons of the library. Federal documents were readily accessible through the index. A few of the federal items had also been added to the card catalog although apparently on a hit or miss basis and some second copies of archives titles were on the shelves. However, there was no easy way of checking exactly what "On-Farm Water Management" publications were available in the library and thus no meaningful guides were at hand to guide purchases.

One of the first needs obviously was to find out what we had. A second task of equally high priority was to make whatever we had readily identifiable and usable. Everyone believed that our library holdings on the subject were extensive. A start was made to produce a computerized bibliography and in June 1970 the first "On-Farm Water Management" printout was secured. It listed approximately 750 titles and was immediately recognized as covering only a small part of the total holdings. After further checking additional punch carding and other work a second run by standard library of Congress subjects became available in February 1971. It indicated that around 1400 publications dealing with On-Farm Water Management were held by the library. A BATAB history of purchases which became available at that time listed around 1050 books being purchased with project funds. These publications as received were being added to the pre-program library thus swelling total On-Farm holdings.

Guided by a strong suspicion that the total holdings of the library were still considerably larger than the printout indicated a comparison of printout titles with the card index titles was made for selected subjects. The results of this comparison invited the conclusion that less than half of the library's total On-Farm holdings were included on the tapes from which the computer printouts were made.

A meeting was held on February 11 which was attended by Karlo Mustonen, Mary Jo Lindberg, Velyn Tassainer, Richard Jensen and William I. Palmer during which the problem was discussed and a program for its solution was decided upon. The program adopted and responsibilities for its execution are briefed as follows:

1. Richard Jensen would supply Mrs. Lindberg and Mrs. Tassainer with a printout arrayed by standard library subjects.

2. This printout was to be checked with the card catalog by Mrs. Tassainer and Mrs. Lindberg. Wherever cards were found that had not been picked up on the printout they were to be listed by call number and returned to Mr. Jensen.

3. Mr. Jensen then was to check these call numbers against the "shelf lists" to see if the books had been lost or stolen or otherwise disposed of.

4. Mr. Jensen was to send back numbers that were missing from the shelf list for decision on possible re-order, or other disposition of the card.

5. Publications included in the catalog and on the shelves, but not on the computer tape would be added to the latter.

6. Cards covering new acquisitions were to be incorporated in the record system.

7. A new printout by standard Library of Congress subjects was to be processed by June 30.

This program resulted in finding over 3000 books listed in the card catalog that were, in fact, on the shelves, but were not on the computer tapes. This review also isolated some 50 to 100 books that were no longer on the shelves, but cards covering them were still in the catalog. Decisions are yet to be made on these.

In mid-June 1971 a computer printout was secured. This time the results are gratifying and more nearly in line with expectation. Based on this printout -- which incidentally, will be supplemented by a periodical and archives printout -- we have over 5000 books in our On-Farm Library. A gross subject grouping of these books is added as Appendix 3.

Problems Remaining

Documents Room

While the problem of completeness of the printout of On-Farm Water Management holdings appears to be solved many problems still remain. There is, for example, what to do about the several hundred thousand individual books and documents on file in the document room. Within the realm of the existing budget it appeared infeasible to attempt a search of the federal publications that have accumulated in the documents room since 1909 and before. The library receives around 40,000 individual federal publications each year with only a small percentage of these directly concerned with On-Farm Water Management. All federal documents are covered by an index that is on file at the entrance to the documents room and it was concluded that the search of this welter of material would not justify the cost. An alternate program for intermediate application was suggested which would include two basic steps.

1. Use of "see cards" under each selected subject in the card catalog. A liberal sprinkling of see cards would be inserted advising the user that other titles treating with the subject could be found in the index to federal publications located at the 2nd floor entrance to the documents room.

2. The documents librarian would attempt to call the attention of appropriate library staff to current titles thought to be applicable and cards would be prepared for inclusion in the card catalog. (Since January 1, 1971 these documents room titles are carded.) The publication would remain in the documents room.

These two steps may be all that is necessary. Use of the "see cards" alone may suffice. It is <u>not</u> recommended that a search of the accumulation of over a half century in the documents library be attempted with the thought of cataloging every relevant title until the program described above has been tried and evaluated. You simply start with the recognition that the library resource dealing with On-Farm Water Management involves titles covered in the card catalog plus titles listed in the federal index. The aim should be to make sure that additional bibliographies do not emerge to confound the user.

The Archives

Past practice at the University has been to house all of the writings and publications originating on campus in an archives section of the library. These holdings were more or less "locked up". They were not included in the card catalog and not generally available for check out or use. The Archives holdings have now been inventoried and are now being carded. The basic problem, however, remains unsolved. Copies of publications originating on campus should be preserved and their content should also be available for use as needed.

Prevailing practice has taken care of only the first of these requirements. It is now suggested that:

1. Every college, department and faculty member should be advised of the rules governing the Archives.

2. Each time a document is originated on campus three copies of it should be made available to the library. One copy should be permanently assigned to the Archives, one copy should be added to the lending library with the third copy held in reserve in the Archives until needed in the lending library.

Computer System for Retrieval of Information

With the completion of the inventory of "On-Farm Water Management" publications and the reduction of inventoried titles for computer use, a computerized bibliography is available. The University library has thus arrived at a base point essential in the establishment of any system of rapid information retrieval. To go beyond this point will require much additional work. The nature of work will depend on the services to be provided, but in any event all of the works included in the "data bank" now established will have to be given "key word" and subject designations.

Inquiry concerning any subject on which the patron is working could be handled either on a weekly computer batch cycle or preferably from a direct access terminal. The terminal could be at a convenient location and would afford the researcher direct access to and instant response on all information in the data bank.

This system could also be extended to include an index to periodical articles that appear in the professional journals and to the contents of the documents room. Key words that would identify general subject areas of specific interest would have to be assigned to these publications. Key words could then be correlated with the book index and a complete list of all available information on any appropriate subject would be available to the researcher immediately on call.

This system would require the assignment of specified key words to the title of books or periodicals and complete bibliographic citations of those works. This would require some degree of competence in the field of water management. Use of a graduate student with the necessary competence in this field is desirable.

The adoption of a direct access method of inquiry would also impose requirements for certain hardware and personnel not currently available. It would also require a great deal of cooperation and interfacing with the computer center. The computer center now plans to purchase a control unit and macro program to handle direct access techniques. A major portion of the equipment acquisition problem will be solved.

In addition to existing or planned hardware acquisitions, this system would require the leasing of some sort of terminal that would provide inquiry and output ability. An agreement with the computer center for central processing unit time and disc storage space would be required. These arrangements would also have to include the programming of the system since the programs must be written in assembler language. This could also be done by providing the library with the additional competence and assistance needed.

The "direct access" means as discussed above impose requirements for both technicians and equipment that could be reduced if a batch process mode were deemed adequate.

<u>Cooperative Networks for Knowledge</u>

Two possible meanings are attached to this heading. If it is directed to cooperative use of the "On-Farm Water Management" library collection by everyone coming to the library, the use would appear to be assured in steps that have been taken, or those now being recommended. If the intent is to develop cooperative networks of knowledge among the CUSUSWASH universities then the assignment becomes something else.

At the July 9 and 10 meetings of CUSUSWASH at Logan a Library Committee was appointed comprised of Garth Jones of Colorado State, Chairman; James Officer of Arizona and William I. Palmer of Utah State as members. All three universities have made a start and the means of developing cooperation among the CUSUSWASH universities is now being explored and expanded.

III. Develop a Special History of Irrigation

This phase of the assignment has not been initiated as yet. If such a history is to be prepared here we should be getting on with it. Assuming that we will develop such a special history, three suggestions are offered.

1. The staff of Agriculture and Irrigation Engineering prepare an outline for the "History of Irrigation". (The Fact Finding Report of 1924 would possibly be a good place to start.)

2. A graduate student who has demonstrated writing ability be selected to prepare the manuscript based on the outline, for review of Agriculture and Irrigation Engineering.

3. The reviewed manuscript be processed through editing reproduction and publication.

IV. Cooperation with Related Disciplines to Agriculture and Irrigation Engineering to Build a Total Collection on Irrigation and Hydrology

The exact meaning of the phase of the assignment is not clear. Cooperation has existed in the designation of titles to be acquired. The On-Farm Water Management library as now constituted includes several hundred titles on hydrology and closely related subjects and in itself might pass as a good "Hydrology" library. As the program continues we should see that University hydrologists a) continue to be brought into the selection of materials to be acquired, b) are consulted in the development of cooperative networks for knowledge and otherwise be pressed into the 211-d library program.

V. Recommendations

In terms of the On-Farm Water Management program the following recommendations are made.

1. Continue the purchase program. Up to this time we have spent less than half of the $18,500 acquisition budget. The purchase effort got off to a slow start in 1970, but has gathered momentum since. In this connection project and regular library staff should:

a) Continue searching the current sources for new material.

b) Likely titles should be carded and placed in the review process for "purchase" or "not purchase" decision as has been done in the past.

c) Rejected order cards should be reviewed for possible purchase selections. Many cards were rejected on the basis of borderline decisions; some titles probably should be acquired.

2. The 50 to 100 titles now on catalog cards that were not found on the shelf list should be reviewed and brought to a state where decision on missing titles can be taken (an unforeseen omission in the checking process described on page 8 will entail extra effort now, but it must be done.) After the titles are again found and listed the missing publications should be reordered or if the decision is not to replace, the cards should be removed from the catalog.

3. A program should be undertaken by the project library assistant to verify the accuracy and completeness of the June 1971 printout. The selected checking of card catalog titles against printout titles should be continued. After enough subjects have been checked decision can be taken on:

a) how to be sure the printout remains accurate, or

b) how to overcome inaccuracies observed.

At this time the program should proceed on the assumption that the printout is accurate enough for present uses. It must be recognized that the printout can never be 100% accurate or current. New books are constantly arriving and some books are lost to the library from a variety of actions.

4. Project personnel should work with regular library people to see that new titles are picked up on library records and added to the computerized bibliography to keep it as up to date and accurate as possible. Unless this is done the printout will soon become obsolete and the effort that has gone into getting a computerized bibliography will be of little value.

5. Project personnel should work with catalogers in the library in securing and filing "see cards" for the card catalog referring patrons of the library to the index of federal documents.

6. Now that a computerized bibliography is available covering "On-Farm Water Management" a start can be made to develop programs through which rapid sorts of bibliographic material can be made for faculty members, graduate students or others. This will involve the development of "key word" and Dewey decimal system designations for all "On-Farm Water Management" library holdings, but would make possible the rapid retrieval of subject matter for any special interest.

7. A number of publications designated for purchase have not been acquired because the acquisition section was not given complete or accurate titles, authors, or addresses of vendors. These data should be searched out so that the acquisition processes can be completed.

8. Some publications have been designated for purchase that subsequently were found to be out of print. These cases should be reviewed and steps taken to microfilm or otherwise reproduce those documents deemed essential for our library.

9. The computer printout of the "On-Farm Water Management" library is a thick, heavy, unwieldy document. Consideration should be given to binding it in some more readily manageable fashion so that copies of it can be available for use in the library and possibly in the College of Engineering.

10. The "On-Farm Water Management" library should be written up and published in a concise form so that it can be distributed to persons interested in On-Farm Water studies at Utah State.

11. Decision should be reached on the propriety and desirability of filing copies of the On-Farm Water Management printout with the other CUSUSWASH universities. It is the view of the writer that filing copies of the descriptive bulletin should be preferred over any procedure that might lead to extensive request for inter-library loans.

12. Throughout the year much time was spent in considering purchase of back issues of periodicals. This activity was not pressed to a conclusion. It should be. Some missing periodicals should be acquired, but the list should be a highly selective one.

13. Consideration has been given to incorporating use of an "Approval Buying Plan" into our acquisition program which plan presumably would be continued after the 211d program has phased out. Since several such programs are available it would appear that decision as to which plan should be subscribed to and whether any plan is adopted should be matters for the library to decide.

14. The Library should issue a set of instructions governing its archives collection and disseminate it widely on campus.

15. The operations of the Documents library should be reviewed. If a rapid retrieval system is adopted several man years of work would be required to extend the system to governmental documents.

V. Contributions of the Library

Over the year the library staff has worked efficiently, cooperatively, and tirelessly in inventorying and organizing the library's "On-Farm Water Management" holdings and in the acquisition of designated new material. Regular library staff input has been at a far greater level than obtained in the previous year as evidenced by Dr. Abrams June 29 memo which appears as Appendix 4.

APPENDIX

Appendix 1

Part V Definition -- A GUIDE FOR SUBJECT SELECTION

A. SCIENTIFIC DISCIPLINES AND ACADEMIC SPECIALTIES

AGRICULTURE as related to
- conservation of water
- crop response
- cultivation of irrigated lands
- erosion
- farming irrigated lands
- irrigation efficiencies
- rates of application
- soil-water-plant relationships
- strip cropping
- supply and best use of water
- water delivery
- water requirements
- water utilization
- watershed protection
- weed control

AGRICULTURAL ENGINEERING as related to
- contour farming
- drainage
- irrigation
- land reclamation
- soil conservation
- water storage
- water supply

AGRONOMY as related to
- desalination
- erosion control
- salination
- water movement in soils
- water use practices

BACTERIOLOGY as related to
- effects of pollution
- identification of pollutants
- pollutants
- sources of pollution
- use of waste water
- waste treatment
- water quality control
- water treatment

BIOLOGY as related to
- conservation of water in agriculture
- ecological impact of water development
- pollutants
- waste treatment
- water treatment
- watershed protection

BOTANY as related to
- adsorption
- consumptive use of water
- efficiencies
- growth in relation to irrigation
- root zone
- soil-water-plant relationship
- water utilization
- weeds
- wilting

CHEMISTRY as related to
- absorption
- adsorption
- aqueous solutions
- desalinization
- filtration and separation
- identification of pollutants
- marine geochemistry
- pesticide kinetics in water
- pollutants
- saline water conversion
- use of waste water
- waste treatment processes
- water and waste chemistry
- water pollution
- water quality control
- water treatment

CIVIL ENGINEERING as it applies to the design, construction, operation, and maintenance of works useful to water management. Also, as it relates to (See structures, Section C)
- channeling
- concrete
- drainage engineering
- drilling
- erosion
- flood control
- linings
- porous media
- surveys

ECOLOGY of fresh water bodies; irrigation ditches, canals borders; and estuaries as it applies to

- amphibians
- aquatic plants
- birds
- fish
- invertebrates
- mammals
- phytoplankton
- reptiles
- zooplankton

ECONOMICS as related to

- alternative costs
- construction and operation of water management facilities
- control of surface water
- effects of water based recreation on water resources management
- erosion
- estimating
- financing water resource development
- flood prevention and control
- ground water management
- impact of water development
- institutions
- land appraisal
- land tenure
- land use
- need for water research
- sedimentation
- training of water management personnel
- water data acquisition and distribution
- water demand
- water quality standards and management
- water rates
- water resource planning
- water yield improvement

FORESTRY (including Range Management) as related to

- erosion
- irrigation of forests
- water conservation
- water pollution
- watershed protection

GEOGRAPHY as it applies to the distribution and characteristics of water and water features.

GEOLOGY as it applies to

- engineering for water management projects
- geochemistry

geohydrology
ground water management
marine geology (shore and near shore)
sedimentation
sediments
settling velocity
suspended load
topography

HYDRAULIC ENGINEERING as it applies to
aquifer characteristics
flow
fluid mechanics
hydraulic design
intake gates
pumping
return flow
roughness
seepage
sluice gates
water control
water spreading

HYDRAULICS as it relates to mechanics of irrigation

HYDROLOGY as it applies to
consumptive use
erosion
evaporation
flow
ground water
infiltration
movement
porous media
precipitation
quality control
quality of water
roughness
runoff
sedimentation
seepage
snow
soil moisture
stream flow
surface-groundwater relationships
surface waters
surges
Thiems equation
transpiration
unsteady flow

water conservation
water table
water yield

ICHTHYOLOGY as it applies to the ecology of fresh water bodies, farm ponds, and estuaries; also, water management.

INSTRUMENTATION as it applies to
- earth resources observation satellites
- hydrology
- limnology
- measurement
  - current meter
  - flow measurement
  - flow meters
  - gravemetric method
  - hydrographs
  - rates
  - streamflow
  - surveys
  - water measurement
- oceanography
- venturi flumes
- water quality monitoring, including
  - chlorine and other agents
  - dissolved oxygen pH
  - solar radiation
  - turbidity
  - water/air temperatures
  - weirs

LAW as it applies to
- conjunctive use of surface and ground water
- control of surface water
- Desert Land Act
- government regulation
- grants and contracts for water related research
- impact of water development programs
- land tenure
- legislation
- public lands
- right of way
- riparian rights
- sub-surface disposal of contaminated waters
- water and waste treatment
- water conservation
- water institutions
- water law
- water pollution
- water rights

LIMNOLOGY as it applies to
- estuarine problems
- lakes
- ponds
- rivers
- springs
- streams
- wells

MATHEMATICS
- equations
  - Darcy-Weibach
  - energy
  - Mannings
  - Thiems

METEOROLOGY as related to
- cloud structure
- forecasting
- hydrometeorology
- marine meteorology
- precipitation dynamics
- rainfall
- seasonal
- weather modifications

MINE AND QUARRY ENGINEERING as related to
- erosion
- sedimentation
- water pollution
- watershed protection

OCEANOGRAPHY as related to estuaries and shore and near shore areas.

OPERATIONS RESEARCH as related to policy modelling in water resources management.

ORNITHOLOGY as it applies to the ecology of fresh water bodies.

PEDOLOGY as related to
- flood flow frequency studies
- ground water
- precipitation-runoff relationships
- river sedimentation

PHOTOGRAMMETRY as it applies to the interpretation of remote sensings of geographic water features and thermal pollution.
- color and near infrared photography studies of water bodies
- ultraviolet reflectance and luminescence studies of water bodies

PHYSICS as related to
- bed-load movement
- capillary fringe
- conductivity
- dynamics
- fluid dynamics
- marine geophysics
- mechanics
- optical image evaluation
- physical properties of water
- precipitation
- pollutants
- radioactive material (pollutants)
- runoff
- sediment transport
- soil dynamics

POLITICAL SCIENCE as related to water resources management

SANITARY ENGINEERING as it applies to
- ground water reservoirs
- irrigation
- pollutants
- return flow
- sources of pollution
- ultimated disposal of waste
- waste
- waste treatment processes
- waste water
- water quality control
- water treatment and supply

SOCIOLOGY as related to
- alternate source of water (e.g., wells vs. river) and public preference
- impact of water development programs
- river basin demography
- water conservation
- water demand
- water pollution
- water quality
- water use

SOILS
- absorption
- consumptive use
- corrosion
- evaporation
- excess water
- fertilization vs. irrigation
- field capacity
- infiltration

leaching
moisture
moisture availability
percolation
permeability
porosity
root zone
runoff
saline soils
salinity
salt balance
salts
saturation
seepage
silt
soil classification
soil conservation
soil erosion
soil moisture
soil moisture meter
soil physical properties
soil physics
soil profiles
soil properties
soil reclamation
soil structure
soil surveys
soil texture
soil-water-plant relationships
tension
water conservation

B. USES AND APPLICATIONS:

HUMAN CONSUMPTION

IRRIGATION
border irrigation
flood irrigation
furrow irrigation
mist irrigation
sprinkler irrigation
subsurface irrigation
surface irrigation
surface drainage
supplemental irrigation

FLOODING
pest control
weed control

RECREATION only as it applies to water conservation, water use, and water pollution control.

FISH AND WILDLIFE only as related to water pollution, potential water use, and the ecology of fresh water bodies and estuaries.

INDUSTRIAL PROCESSES only as related to water demand and pollution.

ORE TREATMENT PROCESSES only as related to water demand and pollution.

TRANSPORTATION only as related to water polllution.

COOLING TOWERS AND AIR CONDITIONING as related to water and supply and pollution.

FIRE CONTROL only as related to water supply and watershed protection.

C. ENGINEERING STRUCTURES

aqueducts
barrages
canals -- design and linings
check structures
chutes
conduits
conveyance structures
culverts
dams
dikes
diversion structures
drainage systems
drains
drops
embankments
filters
flumes
gates
intakes
irrigation canals
laterals
levees
orifices
outlets
pipelines
pipes
pumping
pumps
reservoirs -- design
retaining walls

sewers
sluices
spillways
venturi flumes
weirs
wells

D. GEOGRAPHIC FEATURES

alluvial channel
arid lands and zones as related to water conservation, demand, use, and supply augmentation.
bays
beaches and shores
estuaries
ground water
lakes and ponds
oceans-near shore only
ports, harbors, and docks as related to water pollution and optimum use of water
rivers and streams
river basins and valleys
swamps and marshes
tides, surfs, currents as related to shore and beach preservation and estuary problems
waterfalls
watersheds
wetlands

E. WATER CONTROL CONSERVATION

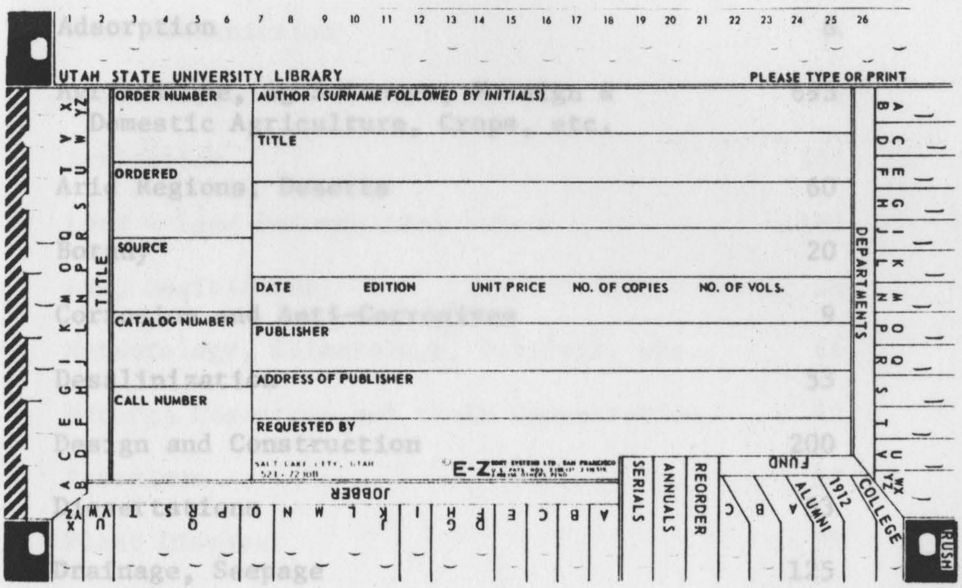
flood control and prevention
water pollution prevention
government regularion of water bodies
  water law
  riparian rights
natural resource conservation as it applies to water conservation
water diversion and direction (including drainage and channelization)
water collection and storage
watershed management
water treatment and purification
waste treatment as related to water pollution
water analysis and measurement
water data acquisition and analysis
artificial seeding and precipitation of water vapors
education in water management technologies
research and research facilities as related to water control and processes

F. SPECIAL PROBLEM AREAS:

eutrophication
thermal water pollution
acid mine drainage
waste water reclamation
stream vs. effluent standards
saline water conversion
saline water intrusion
recreational use of municipal watersheds
automation as related to water management, supply and treatment
water resources planning

Appendix 2

Card Sample



Appendix 3

Distribution of On-Farm Water Management

Under Generalized Subjects

Adsorption	8
Agriculture, Ag Sciences, Foreign & Domestic Agriculture, Crops, etc.	693
Arid Regions, Deserts	60
Botany	20
Corrosion and Anti-Corrosives	9
Desalinization	53
Design and Construction	200
Dissertations	53
Drainage, Seepage	125
Ecology	10
Economic Development	16
Electric Power	11
Erosion	60
Evaporation	37
Farm Equipment	12
Farms and Farm Management	72
Fertilizers	78
Floods	22
Fluids, Fluid Mechanics & Dynamics	121
F.A.O.	10
Food Supply	26
Forests - (products, soils, law)	14

Fresh Water Biology	9
Fungacides, Herbicides, Pesticides	34
Geography - Economic & Physical	11
Geology	17
Heat Transmission	14
Hydro-Sciences	322
Irrigation	347
Land - Land Reform, Land Tenure	165
Law, Legislation	18
Meteorology, Climatology, Rainfall, etc.	64
Natural Resources and their Conservation	42
Petroleum	12
Plant Disease	75
Reclamation of Land	50
Regional Planning	7
Rivers	35
Runoff	16
Saline Water - Salinity	23
Silt, Sedimentation	33
Sewage	35
Soil	674
Thermodynamics	7
Theses	272
Undeveloped Areas	14
Water, Groundwater, all subjects	855
Watersheds	14

Weeds		36
Wells		12
Miscellaneous		114
	Total	5,037

Appendix 4

June 29, 1971

Dean D. F. Peterson
Dr. Alvin Bishop

Gentlemen:

The attached report was prepared by our staff in an effort to summarize our accomplishments in the On-Farm Water project. In the main we have been pleased with the results of the program thus far and we request that on the receipt of this letter and the report you will discuss with us any further plans which ought to be undertaken between the University Library and the On-Farm Water Program.

Sincerely yours,

Milton C. Abrams, Director
Learning Resources Program
and University Librarian

MCA/mc
Enclosure
cc: William Palmer
D. L. Chappell

A SUMMARY REPORT OF THE UNIVERSITY LIBRARY IN SUPPORT OF THE ON-FARM WATER MANAGEMENT PROGRAM 1970-71

We believe that significant progress has been made this year toward the achievement of the main objective of the Program which is to increase the Library's holdings in the area of On-Farm Water Management. A decision was made to give the acquisition of current material first priority and our efforts have been directed toward the purchase of materials and the search of bibliography from 1950 to date.

At this point we believe the Library has an adequate historical collection and our continuing efforts ought to be toward updating. Most of the sources which were used in the development of the collection have been thoroughly searched. From the search approximately 2600 titles were submitted to Mr. William Palmer for his selection. Based on his judgment, 1350 of the titles were purchased. In addition to the searching and ordering of new material we report progress in the following areas:

1. The development of a comprehensive bibliography of library holdings related to On-Farm Water Management. This bibliography, which is reported in author, title and subject sequence, contains what we feel is a complete list of all material held by this library related to the project.

2. The card catalog was searched thoroughly under selected subject headings for books applicable to the project. These titles were submitted to be included in the On-Farm Water bibliography. Nearly 3000 titles were added from this search.

3. The U. S. Government documents whose call numbers are included in the card catalog were submitted to be included on the printout Five hundred documents have been added.

4. Archives - An attempt was made to organize and classify archives material to make it more accessible to the patron. Many publications housed in archives are very pertinent to our project especially publications from the Utah Water Research Laboratory and U.S.U. Agricultural Experiment Station. The publications from these two departments have now been cataloged and are accessible through Special Collections. These will also be included in the next printed bibliography.

5. Complete survey of the U.S.U. Library Catalog of S rials was made. A list of all serials, state publications and journals relevant to the project will be included on the bibliography soon.

6. Out-of-print Material - Material deemed to be out of print and thought to be especially pertinent to the project has been borrowed from other libraries and microfiled.

1. Library materials purchased from regular library budget	
A. Serials renewals	$6,635.60
2. Personnel	
A. Organizing historical collection	
Contractual	2,150.00
Payroll	400.00
B. Orders processing	
Contractual	2,400.00
Payroll	1,600.00
C. Fund accounting	
Contractual	1,000.00
Payroll	900.00
D. Computer programming	
Contractual	3,200.00
E. Key punching and verifying (30,000 cards)	
Contractual	1,200.00
Payroll	1,165.00
F. Cataloging	
Contractual	2,400.00
Payroll	2,000.00
TOTAL PERSONNEL	$18,415.00
3. Supplies	
A. IBM cards (16 cases at 11.50 per case)	184.00
B. Ordering forms (BATAB)	121.50
C. Miscellaneous	87.38
TOTAL SUPPLIES	$ 392.88
4. Processing costs	
A. Binding serials and books	2,931.50
5. Computer time	
A. Ordering and processing	1,100.00
TOTAL EXPENDED BY LIBRARY	$29,474.98

SECTION II

AGRICULTURE, FOOD AND IRRIGATION

by

Dean F. Peterson

AGRICULTURE, FOOD AND IRRIGATION[1]

Dean F. Peterson
Utah State University
Logan, Utah

"The man who farms as his forefathers did cannot produce much food no matter how rich the land or how hard he works."
--Theodore W. Schultz in Transforming Traditional Agriculture.

INTRODUCTION

The theme of this Congress stresses development and proposes an interdisciplinary approach. Consistent with that theme, this paper will center on problems of the developing countries related to agriculture, food and irrigation; these countries will be defined essentially as proposed in the "Provisional Indicative World Plan for Agricultural Development," (Indicative World Plan) developed by FAO.[2] They consist of most of Africa; Latin America; the Near East and Asia except mainland China and USSR. Their total population in 1962 was 1,394,181,000 according to FAO; the populations of the countries having developed market economies was given as 698,964,000 and those with centrally planned economies, 1,066,833,000 for a world total of 3,159,978,000.

According to Charles E. Kellogg[3] seventy percent of the world's people still live in the country. In the developing countries this percentage usually is much higher and a major share of national income is generated from the agricultural sector of the economy. On the Indian-Pakistan subcontinent, just short of 500 million people are "agricultural" according to

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1/ Prepared for presentation to the Second World Congress of Engineers and Architects, Tel Aviv, Israel. December 15, 1970.

2/ Food and Agricultural Organization of the United Nations. Provisional Indicative World Plan for Agricultural Development. Rome, 1970. The Indicative World Plan is an assessment in broad detail of what might realistically be accomplished in agriculture by the developing countries between 1970 and 1985.

3/ Kellogg, Charles E. The World Soil Potential in Getting Agriculture Moving. Raymond E. Borton, Editor. The Agricultural Development Council, Inc. New York, 1966.

FAO. The Indicative World Plan[4/] states:

> The overwhelming fact of the developing world is the number of people in it, and the staggering rate at which these numbers are increasing. Secondly, the greater part are rural and are apt to remain so, the majority live at a poverty level of subsistence, most are illiterate or very poorly educated, and around 50 percent of the total populations of these countries are under 20 years of age.

Table 1 shows agricultural and non-agricultural populations and population projections for the developing countries included in the Indicative World Plan studies.

Drastic reduction of population growth, and soon, is an essential objective if widespread disaster is to be avoided. This has been stated many times. Beyond this, population control will not be treated in this paper, rather the hard reality that the social change necessary to accomplish significant leveling-off of population growth is at least a couple of decades away will be accepted.

As stressed by the Indicative World Plan, the unit of production in agriculture is "less the tiny fragmented farm than the farmer himself, or more accurately, the farmer and his family." It is to the input needs of this human "unit of production" that agricultural development, by and large, must be addressed, even though some large corporate farming operations will doubtless emerge. That this "production unit" is responsive to adequate incentives and "investment opportunities" in the form of new inputs has been demonstrated throughout the world.[5/]

Food, of course, is the principal, but by no means the only product of agriculture. FAO[6/] states that for the base year of their study "calorie intake averages exceed requirements by 15 percent in the developed countries, but fall short of them in the developing countries by 6 percent." There is no

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4/ FAO op cit. Ch. 13. p.424.

5/ See, for example, Schultz, Theodore W. Transforming Traditional Agriculture. Yale University Press. New Haven. 1964.

6/ FAO, op cit. Ch. 13.

Table 1. Agriculutral and Non-agricultural Population in Developing Countries. [1]

Region	Estimated Agricultural Population			Estimated Non-agricultural Population	
	1962	1975	1985	1962	1985
		('000)		('000)	
Asia and Far East	470,206	602,907	721,534	250,000	591,000
Near East	74,188	88,206	94,836	47,000 [a]	140,000 [a]
South America	66,775	81,586	95,790	127,000 [b]	289,000 [b]
Africa	140,625	178,963	216,060	36,000 [c]	140,000 [c]

1/ Source: FAO, Provisional Indicative World Plan for Agricultural Development. Rome, 1970.

a/ Includes also Northwest Africa

b/ Latin America

c/ Africa South of the Sahara

apparent global shortage of food, but according to the President's Science Advisory Committee[7/] "in the developing countries . . . . there is overwhelming clinical evidence of undernutrition (too few calories) and malnutrition (particularly lack of protein) among the people." The difficulty is primarily in protein deficiency at this time. According to FAO, deficiencies in national averages arise as much or more from ecological and cultural conditions that have determined food choices than from differences in income. Accordingly, improving quality of diet may be more difficult to accomplish than simply caloric content. In many countries, strenuous efforts will have to be exerted if even caloric requirements are to be met. In East Pakistan, where there will be six persons per cultivated acre in 1985, food production will need to be doubled.[8/]

There are still large areas of unused land suitable for agriculture in the world and, to a lesser extent, water supplies are available. Unfortunately, this land is not located where population pressures are greatest. In many areas, new farming methods will have to be developed to utilize these lands effectively. According to the report on the World Food Problem[9/] about 24 percent of the earth's surface, or 3.14 billion hectares, is potentially arable. This is more than twice the area that has ever been cultivated and more than three times the area harvested in any single year; more than half, over 1.6 billion hectares lies in the tropics. In contrast to these vast global reserves of usable land, the potential for increasing net cultivated areas in Asia and Europe is very small and relatively small in USSR. In East Pakistan, for example, 75 million people live on a land area of 22.5 million cultivated acres. The vast land reserves of South

7/ President's Science Advisory Committee. The World Food Problem. Report of the Panel on World Food Supply. The White House. Washington, D. C. 1967.

8/ Revelle, Roger and Harold A. Thomas, Jr., Population and Food in East Pakistan. Paper presented at a seminar. Harvard Center for Population Studies, May 13, 1970.

9/ President's Science Advisory Committee. op cit., Vol. II. Ch. 7.

America and Africa have little bearing on the land problems of this crowded province. Water supply and climate are constraining on world land reserves; however, for 480 million hectares, year around cropping without irrigation is, theoretically, possible.

Irrigation provides the means for bringing strictly arid or sub-arid lands into production and of lengthening the growing season on lands subject to annual cycles of wet and dry months. It is, of course, only one of the inputs to production. It does permit close control of the water environment during the dry seasons so that highly efficient cropping practices are possible. In many crowded areas, Asia and to a large degree in the Middle East, irrigation is essentially the only way that effective cropped areas [10/] can be increased, therefore, it is an essential factor as far as 70 percent of the people living in the underdeveloped countries are concerned. Implementation of irrigated agriculture is not easy. Capital costs are very high and the period for development is long. Engineers are able to design reasonably efficient storage and diversion works, but the systems for distributing the water to farmers when they need it and supplying other inputs, seeds, fertilizer, etc., have received far too little attention in most project development.

In concluding this introduction, there appears to be no insurmountable technical reasons why agricultural production could not be increased substantially, even multiplied several times; however, increasing industrialization and extraction and processing of metals and fuels produce waste material at an exponentially growing rate. Highly industrialized urban areas already suffer from serious air pollution; water supplies are becoming increasingly polluted and their use for power plant cooling will add substantial thermal waste loads to them. The new Malthusianism may not be based on technological limitations for food production, but on the capacity of the general environment to absorb burgeoning waste loads. Much can be done

10/ Area under cultivation times number of crops per year.

to reduce this burden by changes in technology, but this usually raises the direct costs of production. The economic and technological limits of waste management at an acceptable level are still unexplored.

AGRICULTURE

Agriculture as Part of a Social System

The "production-unit," i.e., the individual farmer, can either single-handedly wrest input resources from his environment or society can help him gain access to these kinds of resources. The extent to which the latter happens measures the extent to which he has a capacity to change. He may be essentially illiterate, but he is not stupid and he can count. Schultz[11] believes that traditional farmers are highly efficient in the way they allocate those resources available to them as long as the nature and distribution of these resources does not change at a pace too fast for them to adapt.

Agricultural development, therefore, requires a pervasive social change if it is to be successful. Society must now provide a host of new supplies, equipment and services. Credit must be available and the farmer must know how to use these new resources with confidence that he will not only not fail, but will also profit in terms of returns that he values. Society provides his logistic support system, this system is complex and often extends beyond the boundaries of his country. If it does not work, production does not increase. Here, then, is the interdisciplinary problem for those who would generate development. It includes understanding individual incentives in different cultures and ranges through highly complex socio-economic and political problems as well as technological ones. That development occasionally works has been more a matter of luck than of understanding the complex system.

Incentives.--The report on the World Food Problem[12] says that "to

11/ Schultz, Theodore W., op cit., Ch. 3.

12/ President's Science Advisory Committee, op cit., Vol. I, p. 16.

induce farmers to change, the potential payoff must be high; not 5 or 10 percent but 50 to 100 percent." The Indicative World Plan devotes a chapter to economic incentives. Essentially the approach proposed is "to assure producers of a market at prices that are remunerative in relation to costs of production and the cost of consumer goods." Price stabilization schemes are an essential part of an incentive package. Subsidies may be provided for various inputs such as seed, fertilizer and water, but the most effective implementation depends on the efficiency of the marketing system. Taxation policies can have adverse effects on incentives.

Technological know-how.--Part of the logistic is to assure that the farmer learns how to use most effectively the expensive new inputs of seed, fertilizer, pesticide and water that are made available to him. The process of transferring agricultural technology has been discussed at length in many publications and no attempt will be made to summarize these discussions. Clearly, adaptive research and demonstrations are vital elements. Soil, climatic and cultural factors change rapidly with location so that fairly large numbers of adaptive experiments are needed. Transferring technological know-how is constrained by low availability of technical and professional manpower in agriculture.

Credit, Supply and Marketing.--One of the discouraging problems faced by developing countries is the scarcity of credit at reasonable rates of interest. Institutionalized credit traditionally has been used as a relief measure. Its use by farmers is not well understood and the history of repayments and collections has been very discouraging. The Indicative World Plan estimates 1975 annual credit needs in the developing countries at $25 billion for annual operations credit and $40 billion for medium and long-term credits. Much of this credit can only come from savings in the agricultural sector itself. Institutional systems which provide competition with private high-interest sources and at the same time manage millions of small loans somehow much be developed.

While agricultural production must more than double by 1985, the Indicative World Plan points out that the volume of goods passing through the marketing system will have to increase by three or four times. Governments need to create favorable environments for market development through research and planning services and in most cases they will also need to provide supplementary marketing services alongside private ones. The tendency, however, is for government to compete preferentially with private enterprise. This not only destroys the private market but encourages inefficiency in the government one. Marketing facilities are estimated by the Indicative World Plan to need an investment of $30 billion over the next fifteen years.

Farmer cooperatives are a means for mobilizing and providing credit, marketing functions, and equipment needed to take advantage of economics of scale. Generally speaking, the effectiveness and efficiency of cooperatives needs to be increased greatly by providing financial resources, management training and implementing democratic processes in their formation.[13/]

Training.--Advantages of a high level of general education as a basis for agricultural change are self-evident. Substantially raising present educational levels in most developing countries will take time, too long to meet the pressing demands for food. In the shorter term, availability of trained professional and technical manpower will limit the speed and effectiveness with which agricultural change can take place. Unfortunately, most developing countries have tended to spend their educational resources on traditional academic subjects rather than on those relating to food and agriculture.[14/]

13/ The work of the Pakistan Academy for Rural Development, Comilla, is a case in point. See, for example, High Population Regions Already Under Cultivation by David Hapgood in Selected Readings to Accompany Getting Agriculture Moving, edited by Raymond E. Borton. Agricultural Development Council, Inc. Sowers Printing Company, Lebanon, Penn. 1966.

14/ President's Science Advisory Committee, op cit., Vol. II, p. 596.

Particularly short are the numbers of personnel trained at intermediate levels. Improving the situation will require not only higher priorities for educational programs related to agriculture but improved employment opportunities, status, and incentives as well. Unless reasonably adequate numbers of professional and technical personnel can be mobilized, major changes in agricultural economy hardly can be expected to occur.

The Indicative World Plan [15/] projects professional and technical manpower at 0.26 percent of the (assumed) agricultural labor force in developing countries by 1975 and 0.4 percent by 1985. In contrast, the proportion of professional and technical workers in most highly developed economies is 5.0 percent; none of the developing countries appears to have more than two percent in these categories.

Research.--Adaptive research has been mentioned as essential to the process of technological transfer. But more basic agricultural research is also required. A stream of new strains and varieties of crops for regional adaptation is necessary in order to optimize changing mixes of inputs and to provide resistance to disease. Research on marketing is very important as is research in agricultural sociology and rural development. As will be mentioned later, many crops that are selected because of ecological adaptability or custom may be quite deficient in protein; new protein sources, including livestock, will have to be developed. A basic agricultural research program at some minimum level is essential to continuing agricultural development in any country. This is a fact not well appreciated by political leaders in most developing countries. Agricultural research needs a long lead-time. The new wheats along with the new rice varieties that may have gained society two or more decades in the battle against hunger, have been under development for a quarter of a century.

15/ FOA, op cit., Ch. 12.

Agriculture as Part of a National Economy

The relatively high importance of the agricultural sector in the economies of developing countries has been mentioned already. Besides providing employment for 60 to 75 percent of the labor force, much of the savings for investment in other sectors must be formed in agriculture. While agriculture must compete with other sectors for available capital, its viability depends on the health of the general economy. Agriculture provides markets for industrial production and industry provides income for the purchase of agricultural products. Developing countries have the problem of allocating their development resources among the various sectors of the economy in a balanced way. Employment potential is a major factor in these allocations.

Another important aspect of the national economy is foreign exchange. In some countries, specialized agricultural products as jute in East Pakistan, coffee in Brazil, and tea, cocoa and rubber in several other countries, are important sources of foreign exchange. Many countries will subsidize new industry at heavy local currency cost as a substitution for imports, thus drawing on resources otherwise available for agricultural development.

The Indicative World Plan summarizes the role of the agricultural sector. This is so important that it is repeated here:

(a) Providing the future food supply, with population typically growing at 2.5 to 3 percent a year.

(b) Adjusting to the still more rapid increase in the number of people who can only be reached through marketed output, as well as the changes in the composition of the diet that accompany urbanization and rising incomes per caput.

(c) Adjusting to the specific requirements in food policy, which emerge from the analysis of the main dietary deficiencies (especially protein quality) inherent in the present composition of food intake under the major dietary patterns.

(d) Assuring the raw material base for the processing industries (food and non-food), which are usually dominant in the early stages of industrialization.

(e) Earning and saving foreign exchange. Shortage of the latter is one of the most serious bottlenecks to economic growth in most developing countries and most of them depend mainly on agricultural products to earn it. On the other hand, in a great many countries the agricultural sector offers considerable scope for economic import substitution. In more general terms the agricultural sector has a significant part to play in the mutual enrichment of all countries through expansion of international trade based as far as possible on comparative advantage.

(f) Providing a large part of the additional employment that will be needed over the period up to 1985; and at the same time permitting some of the increase in the labour force to become available for non-agricultural occupations through an increase in labour productivity on farms.

(g) Contributing to the savings needed to finance development.

(h) Helping in the diffusion of wealth, which alone can provide a mass market for industry, not to speak of an adequate effective market for agricultural products. The greater part of the population in most developing regions is still agricultural, so that without prosperity here, the whole process of economic development is thwarted.

(i) Providing a market for "producer goods" industries, that is farm machinery and equipment, fertilizers, chemicals for control of pests and diseases.

Demand for Agricultural Products.--Farmers need income to purchase new inputs. This comes from sale of produce generally outside of the agricultural sector. Total income outside of agriculture therefore limits the amount of money that farmers can pay for inputs produced by other sectors. As low incomes begin to rise, new increments are at first spent largely for food; but as incomes grow, the proportion spent for food decreases. Income elasticity for food may be 0.8 or higher in some developing countries, whereas in the highly developed market economies this may approach 0.1. By 1985, the non-agricultural population of the developing countries is expected by FAO[16/] to increase from a present 460 million to over 1100

16/ FAO op cit., p. 17.

million whereas farm population will increase from a present 752 million to 1128 million. Most of the increased demand for food will arise in the non-agricultural sector.

Rural Displacement and Unemployment. -- The foregoing figures imply generally that creation of new employment opportunities in the non-agricultural sector must exceed those in agriculture by about two to one. In many developing countries this may be extremely difficult. In East Pakistan, for example, population is expected to rise from a present 75 million to 125 million in 1985. Based on maintaining the present man-land ratio of 0.6 gross cultivated hectares per worker, Revelle and Thomas[17/] estimate that farm employment would be provided for about 24 million workers, leaving a non-agricultural work force of 18.5 million, more than three times the present 5.7 million non-farm workers. Estimated population in cities and towns would account for 7 million workers leaving 11.5 million non-farm workers seeking employment outside of agriculture in the countryside. Lowering the man-land ratio would ease the unemployment problem, but probably at the expense of decreased efficiency on the farm. East Pakistan may have trouble providing employment for the increased number of urban workers as well, considering that nearly all of its known natural resources are agricultural. The conclusion is that every effort needs to be made to develop new industries outside of agriculture. The problem is extremely difficult in countries that have few resources beyond agricultural ones. Future farm population is apt to be influenced largely by inheritance customs and land tenure policies on one hand and non-agricultural employment opportunities on the other. Man-land ratio cannot be taken as a "given" but will evolve as a result of a balancing of economic opportunity and social custom. Rural works programs are an important conjunctive activity for agricultural development.

Although agricultural productivity might increase faster if enough people could move from agriculture to other forms of activity so that large-scale farming could be implemented, generally this will not be possible. Iran is attempting to move in this direction, but this country has resources

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17/ Revelle, Roger and Harold E. Thomas. op. cit.

of capital and manpower not usually available to developing countries. On the other hand, there is good evidence that small farms can be highly efficient, as in Japan, for example.

Agricultural Policy.--Besides allocation of its development resources among various economic sectors, forming the necessary governmental organization, defining responsibility, and encouraging institutional development there are many other matters of agricultural policy which developing nations face. These include subsidies, price support and control, management of institutional credit, land tenure and reform, allocation of foreign exchange for import of inputs such as seed, machinery and fertilizer, development of cooperatives, water rights, education and training, extension and taxation are examples. Often policies may be inconsistent or even in conflict; they actually may be inhibitive of development.

Policy, of course, is the business and responsibility of the developing nation itself. Aid donors can, however, help identify inconsistencies and persuade officials to change. Frequently policy inconsistencies may stem from political realities which cannot be overcome easily and this must be recognized.

Developing Agriculture as a World System

As earlier stated, while there is estimated to be nearly three times as much potentially arable land in the world as is now annually cropped, most of this land is not where the large numbers of people are. Table 2 shows estimated potentially arable land by continents and by climatic zones. In Asia, where there is already only 0.7 acres (0.28 hectares) of cultivated land per person, nearly 85 percent of all potentially arable land is already cultivated. While cultivated land per person is low in South America, only 1.0 acre (0.4 Has), only about 13 percent of the potentially arable land is cultivated.[18]

Climate may limit productivity of these either by lack of moisture or low temperature or both. Of the potentially arable land in the world, about 850 million acres (344 million Has), or 11 percent, would require irrigation

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18/ President's Science Advisory Committee. op cit., Vol. II, Ch. 7.

Table 2. --Potentially Arable and Cultivated Land.[1]

		Area in Millions of Hectares						
Continent	Population 1965 (000, 000)	Cold-Temperate Boreal	Cool Temperate	Warm Temperate Subtropical	Tropical	Total	Cultivated	Hectares Cultivated Per Person
Africa	310	-	-	68.7	664	732	158	0.53
Asia[2]	185	1.6	142	150	336	627	517	0.28
Australia	14	-	1.6	105	44.5	150	16	1.17
Europe[2]	445	4.1	125	36.4	-	178	154	0.36
North America	255	24	277	108	52.6	465	239	0.93
South America	197	-	20	85	574	680	76.8	0.4
USSR	234	24	332	-	-	354	227	0.97
Total	3,310	54	898	554	1,670	3,186	1,390	0.39

1/ Source: President's Science Advisory Committee. The World Food Problem. Vol II. The White House. 1967.

2/ Ommitting USSR.

to produce even one crop. At least one crop could be grown on the other 7 billion acres (2.8 billion Has) with no irrigation; by multiple cropping, this could be increased to 9.8 billion acres (3.96 billion Has) annually without irrigation. An additional 6.5 billion acres (2.63 billion Has) of cropping could be added if irrigation water were available, bringing the total annual crop area to 16.3 billion acres (6.59 billion Has) potential.

There doesn't seem to be any practical way to do very much about the disparity between people and land. Shipping food materials in the large quantities needed long distances and distributing these in developing countries appears to be out of the question. The economic difficulties are as difficult as the physical ones. Either non-agricultural income would have to generate in the recipient countries or the developed countries would have to finance the operation on a charity basis. The people-land disparity suggests possible large-scale migrations; but, under present circumstances, this doesn't seem likely either. However, the possibility should not be discarded considering the alternatives. For the near future at least, it appears that food will have to be grown pretty much where the people live, although, as has been the case for the last two and one-half decades, fairly large-scale transfers of basic cereals will probably continue in order to meet the more pressing shortages.

Technology and Capital.--In today's world, the entire globe is a source for technological transfer from one culture to another. Every effort needs to be made to identify technology which can be applied to specific problems of developing countries. The Mexican wheats have, in five years, found their way all around the world.

Clearly, by far the larger share of developmental capital will have to be formed in the developing countries themselves. Sources from the developed nations will provide only a minor share. But this is a very important share; for one reason, it is a source of foreign exchange. It also seems clear that without the stimulus of outside capital, prospects for development are virtually hopeless in many countries.

In spite of current disillusionments, the writer's prediction is that hard currency capital donor sources will increase substantially over the next few years. Much has been learned about capital management for development. President Nixon's decision[19/] to untie U. S. funds from domestic purchases and his appeal to the world for increased capital to be made available through the international organizations is gratifying. Sector loans rather than project loans will increase. These changes do not mean that the world has now learned how most effectively to manage the limited hard-currency capital available for international development. There is much more to be learned, but the prospects are encouraging.

Technical assistance is also an asset possessed by the world system. There is now a large corps of experienced and skilled personnel. Development will always involve reallocation of resources. This usually leads to political repercussions. Dealing with this problem is part of the art of development.

International Trade.--The complexities of international trade as it affects agricultural development are far too complicated to discuss here. Trade policies can have significant effects on the success of specific crops or for agriculture generally. The most pervasive difficulty is finding international markets for agricultural and industrial products of developing countries, especially where tariff barriers exist. In his message on Foreign Affairs, President Nixon appealed for lowered tariffs throughout the world as an encouragement to developing countries.

The Indicative World Plan implies that growth of agricultural exports of developed countries should rise from 2. 5 percent at present to 3. 3 percent and that imports should drop from 5. 0 percent currently to 2. 5 percent over the Plan period.

Agricultural Technology

Because of the interdisciplinary emphasis of this conference, to an

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19/ President's Message on Foreign Affairs. The White House. Sept. 15, 1970.

audience of engineers, little has been said about specific agricultural technology. Technology is the bailiwick of engineers. The essential nature of new inputs are known: seeds, fertilizer, pest control, tillage and harvesting, and water. Much may be transferred, but adaptive research is invariably necessary. The Green Revolution is a testimony to technological transfer backed initially by research.

Power. --Energy inputs into a traditional agricultural ecology are limited to those that can be produced locally by photosynthesis. New inputs of seeds and fertilizer can make that cycle more productive, but these inputs actually represent energy transfers from other sources.

More directly, power for timely tillage and harvesting can substantially increase production. This is especially critical for multiple cropping, but is also important where plantings have to correlate with monsoon rains or other climatic factors or where grain crops are subject to shatter and bird damage. Introduction of fossil fuels into the ecology permits more of the basic photosynthesis to go toward net agricultural production, but implies the need for properly adapted machines and tractors. For groundwater or other pumping, electricity is preferred if the developing areas are sufficiently concentrated that capital costs are not excessive. Electricity has the advantage that it provides the basis for development of small-scale industry, a business in which most peoples in developing countries have been unexpectedly innovative.

Futures. --Doubtless there will be new and unforeseen inventions and technological developments which could have tremendous impacts on agriculture in the future. It is useless to try to predict what forms these might take. By and large the future likely will be shaped mostly by adapting and refining much that is already understood. Breeding new crop varieties having desired ecological responses for production and disease proofing probably is only beginning.

Because of the large amounts of tropical land now unused for cropping, special attention needs to be given to systems of tropical agriculture.

FOOD

Two approaches could be taken in discussing food as related to needs and prospects of developing countries. Assuming various projections of population as "givens", estimates of needed food for various countries and regions can be made. Another, "econometric", approach could relate food production to projections of overall economic development. These approaches are complementary in examining the nature of the problem and its possible solutions. Basically, the President's Science Advisory Committee adopted the first approach. The second approach was used by FAO in preparing its provisional Indicative World Plan. At some point, the gap between the two approaches needs to be closed by a balance of population and available food.

Present nutritional problems arise because of uneven distribution of food supplies among countries and within countries among families of different income levels. Global surveys suggest no world-wide shortage of food.[20/] The Indicative World Plan[21/] states that food production by the developed countries averages 15 percent above requirements; but, by the underdeveloped ones, 6 percent below. Many of the underdeveloped countries have diets which are nutritionally inadequate. Broadly speaking, in these countries the poorest 25 percent of the people consume diets with caloric and protein contents that are only about three-fourths of the country average. Malnutrition is found particularly among the more susceptible--infants and small children, pregnant women and nursing mothers.

Nature of Food Deficiencies

Caloric intake needs of a population depend upon adult body size and age and sex distribution. There are wide racial variations in body size throughout the world. The West Pakistan adult weighs 20 percent more than his East Pakistan counterpart on the average, for example. Similar variations exist not only in Asia, but in South America and Africa also. Populations with large numbers of children require less food per caput than those having high proportions of adults.

20/ President's Science Advisory Committee. op cit., Vol. I, Ch. 3.
21/ FAO. op cit. Ch. 13.

Regional inequalities in protein intake are much more pronounced than for caloric. In the developed countries average protein supplies total 85 grams per day, more than half of which is animal protein. In the under-developed countries, the protein intake is 57 grams, but only 11 percent is animal protein. Protein nutrition is a complicated matter which will not be dwelt on here. Essential amino acid content varies among different sources. An important element is lysine, which is adequate in proteins from animals or pulses, but generally inadequate for cereals and roots and tubers. There are a number of possibilities for supplementing protein by additives. These include use of protein extracted from green leaves and use of fish protein concentrate (FPC) as well as a number of other enrichments. There are also some genetic possibilities for improving lysine content of cereals, particularly in the case of maize (U.S. corn) based on two new strains discovered by Purdue University in 1963.

Birth Rate and Food Production.--Malnutrition results in high infant mortality with the result that birth rates increase under conditions of malnutrition because of the need for more births to insure survival. Reduction or elimination of malnutrition is believed to be a first step in reducing birth rates. Paradoxically, it appears that inadequate food and high population growth go hand in hand.

Income Effects and Projections.--As incomes rise, increases are at first spent for staple foods, next for more diverse foods, depending on social custom, and then for things other than food. The Indicative World Plan postulates that 70 percent of the 140 percent increase in food production required by the developing countries during the period 1962-1985 will arise as a result of population increases whereas only 30 percent will result from increases in income. Demand for food is expected to grow by 154 percent in Asia and the Far East, but only 120 percent in Latin America. This is expected even though populations are projected to increase by 95 percent in Latin America and only by 80 percent in Asia and the Far East because of the particularly uneven distribution of income in Latin America.

The 140 percent projection implies an annual growth rate of 3.9 percent during the 1963-1985 period; however, the growth for the last six years has averaged only 2.4 percent. This has resulted in increased imports of cereals $980 million in 1955 to $2,500 million in 1965. If this rate is projected to 1985, imports to developing countries would reach the staggering, but obviously hypothetical, level of $26 billion annually; because of shortfall during the 1960's the growth rate in food production now needs to be increased to 4.3 percent instead of the 3.9 originally postulated.

Cultural Differences.--The regional differences in protein intake are believed to be essentially cultural, arising from use of ecologically adapted food crops. While total calories increase with income, protein content and quality is believed to be largely unrelated to income because of traditional food habits. Improving protein diet may thus be primarily a matter of cultural change. The Indicative World Plan notes seven regional groups according to the nature of their protein sources:

Group I	Source primarily animal includes U.S., Australia, New Zealand, the Rio Plate Countries of Latin America and Western Europe.
Group II	Primary source is wheat. Southeastern Europe, Middle East, Afghanistan and Chile.
Group III	Primary source is millet and sorghum. Central African countries.
Group IV	Primary source is maize. South Africa, Zambia, Malawi, Central America.
Group V	Primary source wheat, maize and rice. Northern countries of South America.
Group VI	Primary source rice. Southeast Asia, India and Pakistan.
Group VII	Primary source roots, tubers and plantains. Central Africa.

Generally, the protein deficiencies increase in the order shown. Little has been said in this paper about livestock. Increased livestock production could assist in improving low protein diets. Poultry is an efficient converter of vegetable sources to meat protein.

IRRIGATION

Through history, irrigation has been the means by which arid lands not otherwise arable could be made productive. Today, however, irrigation has additional new values for increasing intensity of land use and as a basis for systematic use of modern agricultural inputs.

Virtually the only way in which areas harvested can be increased in the heavily populated lands of South Asia is by multiple cropping using irrigation during the dry seasons. Just short of 500 million people on the Indian-Pakistan subcontinent live on 490 million acres of potentially arable land, 473 million of which have been placed under cultivation already. For Asia outside of USRR, 83 percent of the 1.55 billion acres of potentially arable land is under cultivation.[22/] A large share of this area suffers from drought for all or a large part of each year.

Artificially adding water in an arid climate is the best way to control the moisture environment. Under these controlled conditions, inputs of fertilizer, new seeds, tillage and harvesting can best be optimized. Thus, irrigation provides the ideal base for an efficient integrated crop production technology. Emphasis is bound to be placed on intensification of agriculture over the next few decades rather than extending it to new lands even though new lands may be available because greater returns on investment are more likely and the need for grazing on potentially arable cropped land continues to increase. Figure 1 shows production functions for a typical crop for various levels of moisture and fertilizer. Controlling these in combination, along with new seeds and pest protection can greatly multiply yields. Table 3 illustrates interaction of water and fertilizer. With no irrigation, 60 lbs of nitrogen per acre raised production of cotton seed by 600 lbs. The ceiling placed on fertilizer response by moisture is evident. With no irrigation, fertilizer in excess of 60 lbs per acre produced no increases. Use of irrigation in connection with traditional strains of cereals is very apt not to pay off even with with fertilizer; thus, successful irrigation implies modernization of the entire agricultural process.

22/ President's Science Advisory Committee. op cit. Vol. II. Ch. 7.

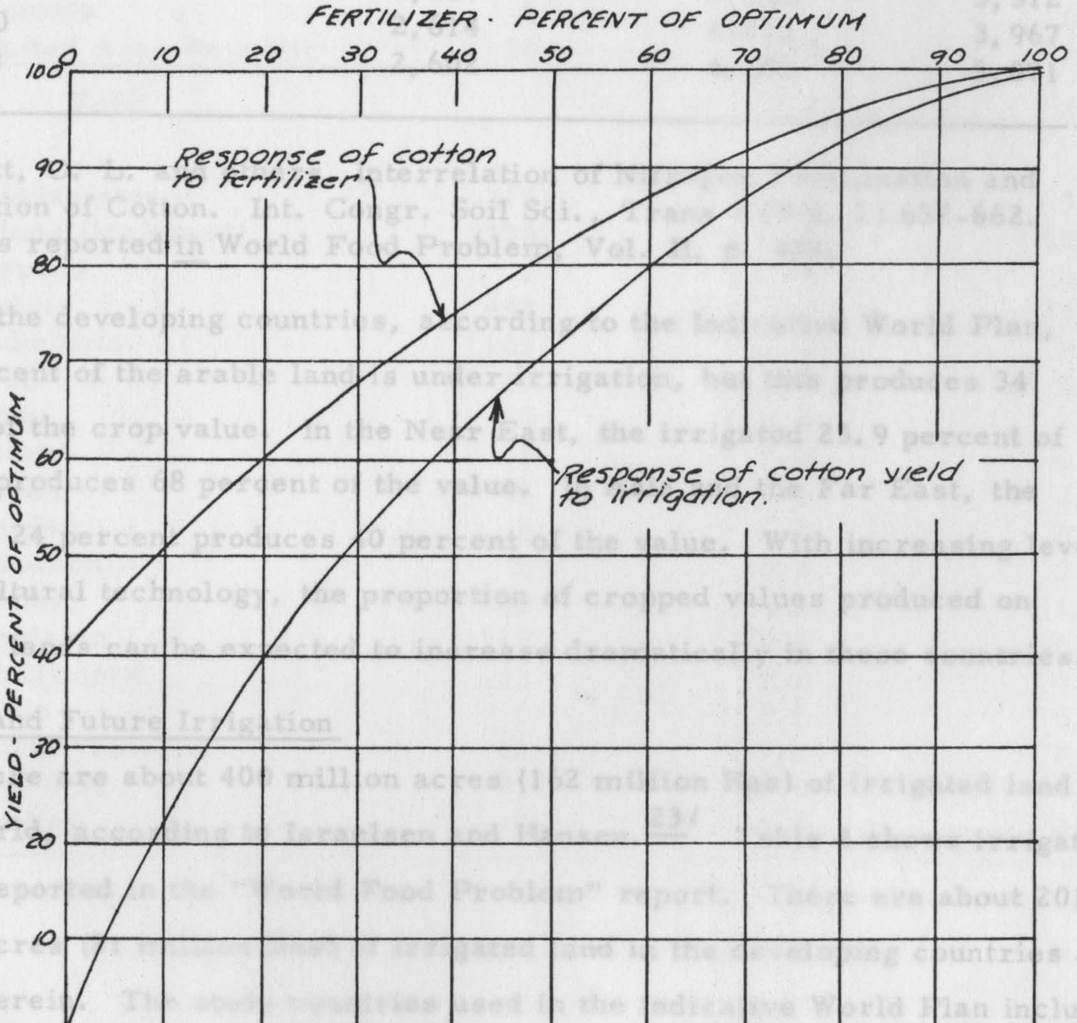

Fig. 1. Response of cotton to irrigation and fertilizer. (Adapted from Efficient Water Use and Farm Management Study. India. Ralph M. Parsons Company, Los Angeles. Prepared for U.S. Agency for International Development. January, 1970.)

Table 3. Interaction of Nitrogen Level and Irrigation on Cotton Seed Yield. Alabama, 1957[a/]

Nitrogen Pounds per acre	Irrigation level 0 inches	11 inches	13 inches
0	2,101	2,191	2,212
60	2,687	3,299	3,312
120	2,614	4,052	3,967
240	2,602	4,009	5,071

[a/] Bennett, O. L. and others, Interrelation of Nitrogen Fertilization and Irrigation of Cotton. Int. Congr. Soil Sci., Trans 7 (Vol. I) 657-662. 1960 as reported in World Food Problem, Vol. II, p. 458.

In the developing countries, according to the Indicative World Plan, 12.9 percent of the arable land is under irrigation, but this produces 34 percent of the crop value. In the Near East, the irrigated 23.9 percent of the land produces 68 percent of the value. In Asia and the Far East, the irrigated 24 percent produces 40 percent of the value. With increasing levels of agricultural technology, the proportion of cropped values produced on irrigated lands can be expected to increase dramatically in these countries.

Present and Future Irrigation

There are about 400 million acres (162 million Has) of irrigated land in the world, according to Israelsen and Hansen.[23/] Table 4 shows irrigated land as reported in the "World Food Problem" report. There are about 201 million acres (81 million Has) of irrigated land in the developing countries as defined herein. The study countries used in the Indicative World Plan include 182 million acres (73 million Has)[24/] or about 13 percent of the cropped land. This 13 percent provides 19 percent of the harvested land because of multiple cropping.

[23/] Israelsen, Orson W. and Vaughn E. Hansen. Irrigation Principles and Practices. John Wiley and Sons. 1962. p. 10.

[24/] FAO. op cit. p. 47.

Table 4. Estimated Irrigated Land [1/]

Continent and Country	1965 Population ('000, 000)	Area (Millions of Has) Cultivated	Irrigated
Africa:			
Sudan	14	17.2	1.6
Tunisia	5	4.8	0.1
United Arab Republic	30	2.8	2.8
Total		14.8	4.5
Asia:			
Afghanistan	(15)	14.8	3.6
China (Mainland)	(730)	200.0	52.8
Cyprus	1	0.4	0.1
India	483	161.0	27.6
Indonesia	105	17.6	5.6
Iran	23	16.8	4.8
Iraq	8	8.0	3.6
Israel	3	0.4	0.1
Japan	98	6.0	3.6
Jordan	2	1.2	0.0 *
Lebanon	2	0.4	0.0 *
Nepal	10	4.0	1.2
Pakistan	115	28.4	10.8
Phillipines	32	10.2	0.4
Syria	6	8.8	0.4
China (Taiwan)	12	1.2	0.4
Thailand	31	10.0	1.6
Turkey	32	25.6	2.4
Total		515.0	119.0
USSR	234	227.2	9.2
Australia	11	15.2	1.2
Europe:			
Greece	9	4.0	0.4
Poland	32	16.0	0.2
Spain	32	20.8	1.6
Yugoslavia	20	8.0	0.1
Total		48.8	2.3

Table (continued).

Continent and Country	1965 Population ('000, 000)	Area (Millions of Has) Cultivated	Irrigated
North America:			
Mexico	41	10.8	4.4
United States	195	183.2	15.2
Total		194.0	19.6
South America:			
Argentina	22	29.6	1.6
Brazil	81	18.8	0.4
Chile	9	5.6	1.2
Colombia	16	2.4	0.2
Dominican Republic	4	0.8	0.1
Ecuador	5	2.0	0.1
Peru	12	1.6	1.2
Uruguay	3	2.4	0.1
Venezuela	9	2.4	0.2
Total		65.6	5.1

1/ Adapted from President's Science Advisory Committee. The World Food Problem. The White House. 1967. Vol. II. Ch. 7.

In broad terms, the Indicative World Plan suggests targets as shown in Table 5. Under this plan by 1985, irrigation would be provided for 16.3 percent of the cultivated area in the study countries and for 26.8 percent of the cropped area.

Table 5. Proposed Irrigation Development[a]

Region	Irrigated Area, Millions of Has					
	Net Area			Harvested Area		
	1962	1975	1985	1962	1975	1985
Africa South of the Sahara	1.1	1.5	1.9	1.1	1.6	2.4
Asia and the Far East	44.1	55.5	68.1	49.5	75.0	102.7
Latin America	10.6	13.5	17.4	8.2	11.4	16.2
Near East and Northwest Africa	16.7	18.5	20.1	12.8	16.1	17.8
Total	72.5	89.0	107.5	71.6	104.1	138.8

a/ Adapted from FAO. Provisional Indicative World Plan. Rome, 1970.

Costs.--Costs of providing irrigation are high, but also vary widely. The World Food Problem Panel[25] made a fairly extensive study of costs. For bringing irrigation to presently cultivated lands these averaged $325 per acre ($815 per hectare) for projects ranging in size from 8,000 Has to 800,000 Has. Providing supplemental irrigation averaged $320 per acre ($800 per hectare). New lands in settled areas average $400 per acre ($1,000 per hectare). FAO's estimated cost for irrigating thirty five million hectares additional area indicated in Table 5 is $37 billion or about $1060 per hectare. The World Food Report[26] estimated the ultimate irrigation potential of Southwest, Southeast and South Asia to be 80 million hectares at an investment cost of $80 billion, 1965 price level. There is some

25/ President's Science Advisory Commission. op cit., Vol. II. Ch. 7.

26/ President's Science Advisory Committee. op cit., Vol. II, Ch. 7.

evidence that these costs may be low. In any case, irrigation development is expensive and the time required for planning, construction and settlement may range from 10 to 25 years.

In addition to irrigation works, some lands may require protection from floods and surface drainage; as, for example, in East Pakistan where about one-third of the cultivated land is flooded each year during the monsoon season to depths of up to six meters. Internal drainage and associated salinity is very commonly a serious problem. Introduction of tube wells into West Pakistan has stemmed the loss of 40,000 hectares of land annually to waterlogging and salinity. In many other areas, drainage problems on existing irrigated lands have not been solved.

The Indicative World Plan envisions regional differences in irrigation development strategy because of differing economic and ecological conditions. In the East African Savanna, limited (one percent of the land area) irrigation is seen mainly as a support for rice and sugar cane production. In this region the forest zone is seen as the principal area of expansion of agriculture without using irrigation. In South Asia, emphasis is given to irrigation development as a means for rapidly increasing cropping intensities and yields. Combined use of surface and groundwater and drainage will be a prominent feature in the Indus and Ganges Basins of this region. In Southeast Asia irrigation and flood control will develop primarily around existing settlements as a means of increasing intensities. In the Far East every effort will be made to extend irrigation to its maximum on all usable land including tidal land developments and bench terracing on slopes up to 35 degrees.

In Chile and Argentina the need is to improve use of existing systems to produce higher value crops on irrigated lands used for grazing. While not contiguous, Mexico and Peru have similar ecological situations. Expensive irrigation projects to bring water to low rainfall areas and modernizing traditional irrigation systems are visualized. In the remainder of South America, irrigation is expected to serve mainly as a means to permit intensification of agriculture near areas of high population pressure; in this area more attention needs to be given to better utilization of existing facilities.

In Afghanistan and Iran, irrigation will be concentrated on large-scale schemes relying on storage and modernization of existing traditional systems. Water availability from Aswan High Dam dominates irrigation considerations in UAR. The water will be used in areas previously intermittently served by basin flooding and on new areas in the lower delta region. In the remainder of the Middle East, new systems could provide more intensive irrigation, as could modernizing traditional systems. A large portion of these lands will require effective drainage before modern agriculture can be successful.

Irrigation Technology and Economics

Because of the high cost of irrigation development, intensive cropping practices should be favored over extensive development. Irrigation will not generally be profitable unless other inputs of fertilizer, seeds and pest control are amply available. With these inputs, significant increases in the efficiency of water use under present systems should be expected.

One of the principal reasons for disappointment and even failure of irrigation projects has been the common failure to include tertiary and farm-level distribution systems and land development needs as part of the engineering plan. Civil engineers, generally, have been particularly shortsighted in their strong conviction that "this is the farmer's responsibility -- the responsibility of the irrigation division ends at the farmers lateral!" After several decades of failure and short fall, it is surprising that this old tune continues to be played. New distribution technologies using underground pipe, sprinklers and trickle irrigation may be profitable under conditions of highly intensive irrigated agriculture.

Another attitude whose continued prevalence remains beyond understanding is the tendency to ignore drainage in planning and designing irrigation projects. While some drainage investments may be deferred, these ought to be anticipated, not only in the physical plans, but in the financial ones as well. Equally bad is the inclusion of poorer lands in the projects even when better lands are available. With the shortage of capital and the need for rapid and high rates of returns, the best soils should be given priority for irrigation. Another pervasive shortcoming is the difficulty of maintaining irrigation works and keeping them in good operating condition.

In terms of strategy, other things being reasonably equal, priority should be given to smaller projects in areas where agriculture already exists and agricultural institutions are already developed. Use of groundwater and pumping from rivers and drainage channels permits investments to be made in small increments under rather simple and established institutional arrangements. Exploiting these kinds of opportunities first while complex, multiple-use plans are being developed and experience is being gained, greatly increases the chances for success of the overall strategy. Large schemes should be phased if at all possible, both in order to gain earlier returns on capital and to develop experienced manpower and better institutional arrangements. Extensive adaptive crop and fertilizer research should be initiated reasonably well in advance of project implementation, especially for large schemes. The new high-producing varieties are especially sensitive to ecological variations occurring over even short distances. Adaptive research is almost never started far enough in advance; a scheme moving with the rapidity of the Indicative World Plan, for example, will be hard put to procure the adaptive information needed to make the plans effective. Investment of scarce aid or local capital in large projects taking a decade or more to construct in areas where population pressure on the land is not very high and single-crop, rain-fed farming during the wet season is well established and reasonably profitable makes little sense, even though attractive water and land resources and reservoir sites are available.

Desalting has been proposed as a means for agricultural development and easing the food problem. The global problem is not primarily one of available resources of land and water which are still quite plentiful in the world and a high-level irrigation technology that could be applied to desalted water could be applied equally well to water provided by a dam or a well. There may be areas within specific national boundaries where constraints on water supplies, high population pressure, existing capital infrastructure as, for example, Israel, could justify investment in desalting as an important part of a national development strategy even at the high cost. Desalting technology in modules of the size needed has not yet been tested. The United States is just now beginning a test program for an intermediate size module vertical tube evaporator (VTE), a concept which will almost certainly replace present flash distillation evaporators in any large-scale project. The relative place of nuclear dual-purpose plants and fossil-fueled dual- or single-purpose plants in a desalting strategy is still an open question.

FAO's projections for irrigation development under its Indicative World Plan will place a very heavy load on the relatively small corps of experienced planners, engineers and other scientists specializing in irrigation in the underdeveloped countries as well as in the developed ones. Expertise from developed countries is not immediately responsive without experience to the needs of developing ones even in the same technology, and there are limits to what "foreign" specialists can do in a different culture as well as to how many the culture will tolerate. This is especially true for the agricultural phase of project implementation. If FAO's plans, which are modest in terms of need, are implemented, the best efforts of the world's stock of irrigation engineers and their associates from other relevant disciplines will be needed. Particularly short are experienced professional talents for water management at the farm level.

International Problems of Irrigation.--Besides the international aspects of agriculture, which have been outlined earlier, the allocation of the water supplies of international rivers is a major problem in irrigation development. Almost all major rivers are international in character. The Jordan, Nile, Euphrates and Tigris, Indus, Bhramaputra and Ganges, and the Helmand are only a few that are important to irrigation. International boundaries usually prevent optimal planning and management of these resources. This does not seem to be something that can be corrected soon; however, every effort should be made to do so. Perhaps the United Nations agencies, particularly the World Bank, and regional agencies can find means to improve international cooperation in utilizing these international streams.

SECTION III

EXTRA CONTRACTUAL SERVICES

SUBJECT: Extra Contractual Services (Continued)

(4) Faculty members and administrators are permitted a limited amount of time away from campus during regular working hours under his University contract for performing professional off-campus work for which compensation is paid with funds not managed by the University under the following provisions:

(a) Professional work is defined as work involving the training and skills associated with a faculty member's assignment in the University. Such off-campus work should contribute to the faculty member's professional experience and competence.

(b) Arrangements should be made with the department head and dean or the provost, in the case of deans, when the work is to be done during the period of contracted employment and when time is to be taken during regular work days.

(c) The total amount of time permitted away from campus during regular working days by the faculty member engaging in outside professional activities for payment may not exceed an aggregate of two working days per month. Absence from the University for more than six (6) consecutive working days will ordinarily be considered a violation of the consulting privilege.

(d) The work must be consistent with the ethics of the faculty member's profession, it must not unduly interfere with the scheduled University work, and must not impair his efficiency in discharging his obligations to the University.

(e) The work must not involve the use of University facilities, equipment, supplies, or personnel being paid concurrently by the University, except when specific arrangements are made to compensate the University.

(f) The work must not be of such nature that it may be reasonably construed by the public to be an official act of the University.

(g) The work must not involve the use of official information of the University not available to the public.

(h) The work cannot be done while on duty or be considered as part of his regular duties for the University.

(i) The work must not create a conflict of interest.

A "conflict of interst" situation may be defined as one in which an administrative staff or faculty member's private interest, usually of an economic nature, conflicts or raises a reasonable question of conflict with his duties and responsibilities under his contract with the University, with any State agency, or with any Federal agency if a substantial part of his salary is paid from Federal funds. The potential conflict is of concern whether it is real or only apparent. The appropriate dean, director, or provost will report periodically to the President regarding faculty members who are engaged in off campus work, the time required and whether he considers that the off campus work conforms to the University policy of off campus work.

SECTION IV

JAPAN TRIP

Alvin A. Bishop

JAPAN TRIP

Contract AID/2459 - Foreign Travel
A. A. Bishop - Japan Trip, August 30 - September 12

Dr. A. A. Bishop, Head of the Department of Agricultural and Irrigation Engineering at USU, has been organizer and technical leader for the Near East-South Asia Irrigation Seminars since 1965. Enroute to conduct the Eighth NESA Irrigation Seminar in Kabul, Afghanistan in September of 1970, Dr. Bishop stopped for two weeks in Japan to study the progress of irrigated farming in Japan. The stop in Japan was under sponsorship of 211(d) funds, Contract AID/2459. Dr. Bishop kept a diary of his activities in Japan and collected a number of technical books, reports and brochures concerned with irrigation in Japan. This material is available in the library, a list of the materials is appended to the report.

The following is the diary and account of his activities in Japan.

<u>Monday, August 31</u>

I arrived at the Tokyo airport at about 4:30 p.m. and was met by Mr. Seki of the Nippon Koei Engineering Consulting Firm. Travel and hotel arrangements in Japan had been made by the Nippon Koei Company. Mr. Seki of the company had been assigned to act as my interpreter and guide during my stay in Japan. We journeyed to the hotel and discussed my itinerary in Japan and arranged to meet the next morning.

<u>Tuesday, September 1</u>

Mr. Seki and I left the hotel about 8:30 a.m. and traveled to the Ministry of Agriculture where several officials of the Irrigation Division of the Ministry of Agriculture were assembled to discuss irrigation in Japan. After a meeting of about an hour we went on to the headquarters of the Nippon Koei Consulting Firm and met with the President and members of the staff there.

At 2:00 p.m. we boarded the new fast train "Beam" and traveled to Nagoya for an inspection of the Aichi project. The train journey took only two hours where previously it had taken about five. A large number of the Aichi Corporation staff were on hand to greet me at the station, and a party had been arranged for me that evening.

Wednesday, September 2

We visited the offices of the Aichi Irrigation Corporation now called the "Water Resources Development Corporation of Japan" where we discussed the present status of the project. I was told that originally it had been planned to develop about 25,000 hectares of new land, but due to the great industrial upsurge in the Aichi prefecture, the planned new land development had decreased to about 10,000 hectares or about 40% of what had been originally planned. After a visit of about one hour in the headquarters, we proceeded to the field where we observed the irrigation practices now being carried out. Since about 1961, Japan has been able to export rice; therefore, paddy land is not getting the same emphasis that it was at the time the Aichi project was being planned. Near Nagoya, a city of more than 2 million people, Aichi farming lands had been converted to vegetable crops, and there are extensive acres of glass and vinyl houses used for the cultivation of vegetables, especially melons for the early market in winter time. As we traveled into the field, I was told that there were 300 hectares of vinyl houses and 100 hectares of glass houses in the Aichi Project. Several pictures were taken of the vinyl houses assembled at one of the farms showing the furrow irrigation being used in the house and the filter outside the house that was used to clean the water so that the flow would not clog the nozzles. (See photographs 18, 19, 23; see also slides 18-23) Pictures, prints in black and white, and colored slides were also taken of the turnout facilities of the farms and some of the cultivation practices along the Miyosi Lateral (photographs 3-5; slides 2,3). The dairy industry and the beef industry is also growing. We visited the largest beef and dairy farm in Japan where approximately 1,000 animals are managed on 50 hectares of land. Much of the feed (about 90%) for finishing off the beef is especially imported from the United States.

We then visited the experimental farm which had been one of the pilot farms for the Aichi Project. The very competent staff were experimenting with the various methods of irrigation as well as water requirements of crops, transpiration rate, and other factors. A humidity chamber, consisting of a hood which is placed over the crop, had been developed by a member of the research staff. By pumping air through the system and measuring the difference of the incoming and outgoing humidity, they are able to measure the actual transpiration of the crops within the chamber (photographs 6-9).

There has been a great change with more emphasis to sprinkler irrigation since the Aichi Project was conceived due to the topography of the project and the great change in the availability of labor due to the industrialization. Most of the U flumes built when the project was constructed have been replaced by pipe line systems, and sprinkler irrigation has been adopted on a major part of the land. It is believed by the Japanese that they will also tend to build more and more vinyl houses for agricultural production because the yield within the glass houses is reported to be as much as eight times the yield outside the shelter. It was mentioned that the glass house requires more water because it is not able to take advantage of the natural precipitation, and the temperatures within the enclosures are usually higher. However, the intensity of cropping is greatly increased.

Thursday, September 3

I visited the Toyokawa Irrigation Project southeast of Nagoya, along with members of the Aichi corporation, which is now the "Water Resources Development Planning Corporation of Japan." We traveled by car to the vicinity of Gamagori where we inspected the sprinkler irrigation of the Toyokawa project. Cropping in this area is very intense. At the present time, they are shifting from their summer crops: watermelons, tomatoes, and other vegetables; to cabbages, raddishes, and other similar winter crops. The transplanting is all done under sprinkler irrigation conditions, and the intensity is similar to most truck farms of the United States, although the farming methods are different (photographs 10-14; slides 10, 13, 14, 17).

The maximum size of the farm in the Toyokawa Project is about 1 to 2 hectares. The delivery of water is from a farm outlet to a flexible hose serving three or four sprinkler stands. The sprinklers are of Rainbird design or of similar types.

Later in the afternoon, the sprinkler irrigation systems for the mandrin orange groves near Gamagori City were inspected (photograph 26; slides 26, 27). Almost all of the area in the Toyokawa Project was sprinkler irrigated from hand held nozzles, individual sprinkler stands, and solid set irrigation systems (photographs 15-17, 20, 21, 23-25, 27; slides 24, 25, 28, 29). The area contains over 1,000 acres of greenhouses, and there has been a 23% increase in vinyl house construction in the past year (photographs 18, 19; slides 18-23).

Friday, September 4

Traveled from Nagoya to Kyoto and inspected the Kyoto Water Development Project.

Saturday, September 5

Traveled from Kyoto to Matsue.

Sunday, September 6

We traveled by car from Matsue to Tottori, about a two hour journey. We looked at the sand dune development in the vicinity of Tottori. Here, the irrigation development is by solid set, using Rainbird type irrigation nozzles. The nozzle spacings, I understand, are on eight by twelve meters. Water application is reported to be an average of six and one half milimeters being applied every three days. At the time of the visit, they were harvesting yams and had just completed the harvest of tobacco. The method of irrigation reminds one of the irrigation in the USA (photographs 27-29, 31-35; slides 30-35). Each unit is only about 0.4 hectares (about one acre) and is tended about the same way we would tend our home gardens. In Tottori, as elsewhere in Japan, a small tractor is doing much of the labor, but still a tremendous amount of hand labor is required with the intensive vegetable, vineyard, and orchard cropping practices (slide 28).

Unfortunately, one problem has developed in Tottori. The farm system, comprised of several farms and different ownerships, is to be irrigated all at one time. Because each farmer produces a different crop, the blanket irrigation of all the crops at the same time does cause some problems. For example, one farmer may be planning to harvest but cannot because the sprinkler is running.

On the north coast of Japan, winds are a tremendous problem, and wind protection in the Tottori area is difficult to achieve. Shelter belt plantings are used quite extensively, although with the new land reclamation projects, many of the shelter belt trees are being removed. Land reclamation in Japan means changing from forests to agricultural land or changing from lake land or seep and inundated land to agricultural land. In the shelter belt plantings, they have found that the height of the trees protects a strip the width of which is seven times the height of the tree. This requires spacings fairly close together where shelter belt strips have been provided.

Although the irrigation layout is highly sophisticated, the operation seems less than what might be desired. At many places, sprinklers were operating at high pressures on land that had just been harvested.

A farmer association packing plant was also visited at Tottori. The packing plant was processing yams at the time of the visit, but it is used for all of the crops including yams, tobacco, peaches, pears, and others. The farmers have a cooperative organization for marketing their products. The intensive cropping patterns supply much of the vegetable and fresh fruit market for Osaki and Tokyo (photograph 30).

Monday, September 7

After returning to Matsue from Tottori, we visited the development projects in Matsue. There are two semi-fresh water lakes that are fairly shallow, and a large land reclamation project is being developed to take land away from the lake area. Further south and west in the project area, again in very sandy land, irrigation systems of the type seen at Tottori were again viewed. (See again photographs 27-35; slides 30-35)

I talked to farmers at both Tottori and Matsue, and they seem anxious to use the water and report that with the use of irrigation water on their upland lands,they have been able to change their dryland cropping practices (sweet potatoes and other crops which can survive drought periods) to very intensive vegetable and high yielding varieties that increase their incomes tremendously. When I was in Japan in 1956, the average value of farm land was something like $2,000 to $5,000 per acre, but it has now increased to almost 10 times this figure. I am surprised that there has been no surface irrigation in the projects that I have visited, but I have been told that the high labor requirements, and the extreme labor shortage now in Japan has generated a move towards solid set and semi-automatic types of systems.

Tuesday, September 8

All day was spent in travel from Kyoto to Niigata. We arrived at Niigata by special express train at about 8:30 p.m., tired out even though the train was air conditioned.

Wednesday, September 9

We were met at the hotel by members of the Niigata Prefectual Government and went immediately to the field to inspect the developments in the Niigata area. One of the largest rivers in Japan emptys into the Japan Sea on the north coast of Japan near Niigata. The low gradiant of the river has caused rather serious drainage problems to the land inland for a number of miles, and much of the development work concerns the natural drainage improvement of these rivers. In one large tract of land, a pumping plant of about 1,600 cubic feet per second had been installed to pump water from the low lying land and, thus, reclaim it. The land ranges from 1 meter above sea level to about 1 1/2 meters below sea level, so the embankments are built up between the sea and the pumping plant. The pumping plant removes all the rainfall and excess irrigation water of the area (photograph 38; slides 29-44).

Niigata presents one of the most highly mechanized areas of Japan. Small rice combines have been developed especially for Japan (photographs 36,37; slides 36-38). A two-row combine harvester is used extensively, and they are experimenting with a large three meter international harvester of the type we use in the United States. In order to mechanize, they are trying out experiments of mechanization on the land reform project. The Prefectual Government is experimenting with about 100 acres of land in four blocks, 280 meters by 100 meters each. In this experiment, they are using automatic irrigation and completely mechanized operations with absolutely no hand labor being done at all in order to search out the possibilities of mechanization (photograph 39). Although this is one of the first experiments, the rice looks very beautiful. It compares favorably with the rice that has been hand-transplanted and grown in the adjacent fields. It is expected that the yields will be about 10% less because of the differences in plant population. In order to mechanize this particular section, they have irrigated the entire plot or each plot by sub-irrigation. They have installed permanent 25 milimeter diameter, perforated pipes similar to drains at five meter spacings and at a depth of 40 centimeters. These particular installations serve as both irrigation and drainage outlets for the field. The field is being sub-irrigated from this source of supply, which is connected to the head ditch parallel to the 280 meter side of the field. Transverse to these combination supply pipes and drains and parallel to the head ditch, unlined moles are constructed to a depth of 30 centimeters to facilitate water infiltration from the permanently installed plastic pipes.

From the appearance of the crop and from observations by the Japanese during the entire season, this system provides excellent water distribution. The moles are at 5 meter spacings, and there is also a grid of moles at thirty centimeters depth, and perpendicular to the moles are the permanently installed perforated pipe lines at a depth of 40 centimeters. While irrigation water is being supplied, the supply ditch is filled with water, and the water surface is maintained almost at ground level, although there is a slope in the field. If heavy rains occur, surface drainage back into the ditch is provided. In order to use the mechanized equipment for weeding the land or fertilizer application, the land must be drained in order to provide enough soil strength to support the equipment. According to the Japanese researchers, this is possible by removing water from the supply ditch and allowing the perforated pipe and mole system to function as a drainage system. After 48 hours, the soil will support a farm tractor of the International or John Deare type. The cost of the combination irrigation and drainage system is about $1,500 per acre.

Later in the day, we visited the large pumping plant and after lunch inspected a pumping plant still under construction. The plant will have a 1,600 cubic meter per second capacity and will take one of the main branches of the river and dump it into the sea. This particular plant is being installed primarily as a drainage facility for the land which is subsiding, due to the removal of natural gas (photograph 38; slides 44-47). The paddy land comprises a large number of fertile acres, and the pumping plants will remove the water even though the land has subsided to near sea level at the present time. The cost of the facility will be about $500 per acre for the land benefited.

On the dune sections west of Niigata, sprinkler irrigation is being applied on several large areas. One tract visited is a completely automatic system with solonoid operated valves and all of the necessary hardware to make the system automatic. In this area, watermelons, radishes, and other vegetable crops are produced. It was reported that the farmers gross about $6,000 per acre per year on this particular tract. The automatic sprinkler system costs about $500 per acre per year.

Since agricultural land for all of Japan is at a high premium, the government subsidizes the land reclamation projects by 40%. The Prefectual Government subsidizes the area by another 40%, and 20% is expected to be paid by the benefiting land owners. The same is true with regard to the operating cost of the system. The subsidization of agricultural land in Japan far outstretches anything that we have ever done through the Bureau of Reclamation in the United States. It is interesting to note that Japan, with an area twice the size of the state of Utah and an agricultural area of only 15% of its total area, is still self-sufficient as far as food is concerned.

Thursday, September 10

Traveled from Niigata to Tokyo.

Friday, September 11

Traveled from Tokyo to Hong Kong in order to depart for Irrigation Seminars in Kabul, Afghanistan.

Saturday, September 12; Sunday, September 13

Departure to Kabul delayed due to Typhoon Georgia. Two-day layover in Hong Kong.

Monday, September 14

Traveled from Hong Kong to Karachi.

PHOTOGRAPHS OF JAPAN TRIP

2. Field evaporation pan with guard to prevent birds from drinking water- Mioyshi

* 3. Tensionometer installation- Mioyshi lateral

4. Farm distribution turnout for sprinkler irrigation - Mioyshi

5. Vegetable and rice crops, lateral distribution - Mioyshi

6. Glasshoods to measure transpiration - Mioyshi Experiment Station

7. Same as #6 - Mioyshi Experiment Station

8. Root chamber - measure root growth Aichi Experiment Station - Mioyshi Experiment Station

9. Soil erosion measure Aichi Experiment Station - Mioyshi Experiment Station

*10. Cabbage transplanting and irrigation - Toyokawa

11. Cabbage sprinkler irrigation - Toyokawa

12. Small farm cultivator - Toyokawa

*13. Watermelon crop to be converted to another vegetable crop - Toyokawa

*14. Transplanting vegetable crops - Toyokawa

15. Setting sprinkler head for irrigating cabbage - Toyokawa

16. Small farm tractor with roto tiller - Toyokawa

*17. Irrigation of cabbage with hand held nozzle - Toyokawa

*18. Vinyl houses - Toyokawa

*19. Vinyl houses - Toyokawa

*20. Pumping plant for sprinkler irrigation project - Toyokawa

21. Tomato plant - Toyokawa

*23. Vinyl houses - Toyokawa

*24. Sprinkler irrigation of cabbage - Toyokawa

*25. Turnout for sprinkler irrigation - Toyokawa

*26. Mandrin oranges - Gamagori on Toyokawa

27. Intake to pump plant - Toyokawa

*28. Sprinkler riser - Tottori

29. Sprinkler irrigation risers and grape vineyard in background - Tottori

30. Packing plant - Tottori

31. Vegetable farms, sprinkler irrigated - Tottori

32. Sprinkler irrigated farms - Tottori

33. Sprinkler irrigated farms - Tottori

34. Valve control boxes and sprinkler connection lines in background - Tottori

35. Control structures in vineyards - Tottori

36. Rice combine - Niigata

37. Rice combine - Niigata

38. Inlet to pumping plant - Niigata

39. Full automatic solid set system near Niigata

* Indicates color slide also available

COLOR SLIDES OF JAPAN TRIP

2. Irrigated lands - Mioyshi lateral
* 3. Tensionmeter - Mioyshi lateral
*10. Transplanting and irrigation of cabbage - Toyokawa
*13. Watermelon field ready for harvest - Toyokawa
*14. Transplanting of vegetable crops - Toyokawa
*17. Irrigation of transplanted cabbage with hand held nozzles - Toyokawa
*18. Vinyl houses - Toyokawa
*19. Vinyl houses - Toyokawa
*20. Vinyl houses - Toyokawa
21. Vinyl houses - Toyokawa
22. Vinyl houses - Toyokawa
*23. Vinyl houses - Toyokawa
*24. Sprinkler gun - Toyokawa
*25. Turnout for sprinkler irrigation #24 - Toyokawa
*26. High rise sprinkler - mandrin orange - Toyokawa
27. High rise sprinkler - mandrin orange - Toyokawa
28. Small farm tractor - Toyokawa
29. Sprinkler irrigation of planted crops - Toyokawa
30. Pump house - Tottori
31. Head tank for sprinkler irrigation - Tottori
32. Sprinkler irrigation - Tottori
33. Sprinkler irrigation - Tottori
34. Sprinkler irrigation - Tottori
35. Sprinkler irrigation - Tottori
36. Rice harvest - Niigata
37. Small rice harvesting equipment - Niigata
38. Small equipment - Niigata
39. Drainage irrigation - Niigata
40. Drainage canal intakes - Niigata

41. Intake to drainage pump - Niigata

42. Sprinkler irrigation - Niigata

43. Sprinkler irrigation - Niigata

44. Pump plant - Niigata

45. Pump plant - Niigata

46. Drainage pump - Niigata

47. Small pump plant for sprinkler irrigation near Niigata

* Indicates black and white photograph available

List of Technical Books, Brochures, and Reports Collected in Japan

Alphabetical listing according to titles.

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   Niigata Agricultural Experiment Station
   (Written in Japanese)

2. Daishia Aichi Agricultural Irrigation Project-Summary
   Shimane Prefecture
   Izumo District Agricultural Engineering Office
   (Written in Japanese)

3. Drainage Facilities at Kanbara Plain (Mainly Kameda-go Area)
   Tajin Suzuki, Tsu Shigemi, Shunichi Yamase
   International Commission on Irrigation and Drainage
   Seventh Congress, R #18

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   Field Agriculture Division
   Ministry of Agriculture
   (Written in Japanese)

5. Improving the Field Crop Irrigation (1)
   An Irrigation Timing Warning Device
   Ichiro Kato, Kimio Sakata, Fukuya Kamota, Risaku Taniguchi
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   No. 19
   March 1970

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   Tokai - Kinki Agricultural Experiment Station
   Field Agriculture Division
   (Written in Japanese)

7. IRC Working Party on Rice Soils, Water and Fertilizer Practices
   Eleventh Session
   Kandy, Ceylon, 2-5 September, 1968
   by Ichiro Kato
   Upland Farming Division, Tokai-Kinki
   Ag. Experiment Station, Taketoyo, Chita-Gun, Aichi, Japan

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Upland Farming Division
Tokai - Kinki National Agricultural Experiment Station
Taketoyo-cho, Aichi-Ken, Japan, 1967

9. Irrigation and Agricultural Management
Aichi Prefecture
(Written in Japanese)

10. Measurement of Evapotranspiration by Chamber Method and its Application
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Reprinted from Jarq: Japan Agricultural Research Quarterly
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The Agriculture, Forestry and Fisheries Research Council, the Ministry of Agriculture and Forestry

11. Nakanoumi (Central Lake) Reclamation Project - Summary
Ministry of Agriculture
Nakanoumi Reclamation Office
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12. Observations of Evaporation, Percolation and Storage of Rain Water by Lysimeters
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Masateru Mizunoe, Toshiya Furuki
Reprinted from the Miscellaneous Publications of the National Institute of Ag. Sci.
Series F. (Agricultural Engineering), No. 2, March 1954.
(Written in Japanese)

13. Ogura Pond Reclamation Handbook
Ogura District Land Improvement Organization
Revised Edition Nov., 1959, Supplemental Nov. 1968
(Written in Japanese)

14. Oyamatsic Drainage Plant (Station)
Niigata Prefecture
(Written in Japanese)

15. Present Status and Trends in Inland Water Fishery
by Yoshikazu Shiraishi
Freshwater Fisheries Research Laboratory
Nikko Branch
November 1969

16. Promotion of Horticulture by Toyokawa Irrigation Canal
    by Ichiro Kato
    Reprinted from Farming Japan Vol. 3, March 1969

17. Shinkawa (New River) Agricultural Water Resource Project
    Ministry of Agriculture
    Hokuriku Agriculture
    Administration Bureau
    Agriculture Water Resource Office
    (Written in Japanese)

18. Sprinkling Infiltrometer
    H. Kawauo
    September 1, 1970
    (No other information available)

19. Studies of the Transpiration and Evapotranspiration Amount by the Chamber Method
    Upland Farming Division
    Tokai-Kinki National Agricultural Experiment Station
    Taketoyo-cho, Aichi Ken, Japan
    June 1967

20. Summarized Results of Research Work
    December 1966
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21. This is Matsue - An International Sightseeing City
    Published by Sightseeing Section, Matsue City Office
    by Yasuyuki Kajitani and Ro Iqawa

22. Toyokawa (Toyo River) Irrigation Project
    Design Data
    Aichi Prefecture
    (Written in Japanese)

23. Toyokawa Yosui (Toyo River Irrigation Project)
    Technical Design Data
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    Aichi Prefecture and Shizuolca Prefecture
    (Written in Japanese)

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    Water Resource Development Public Corporation
    5-3-6, Alaska, Minato-ku, Tokyo, Japan

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