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IRRIGATION

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PREFACE

This bibliography was prepared by the Center for Development Information and Evaluation (CDIE) to provide a listing of major, current AID-funded technical reports and evaluations on the subject of irrigation. Topics covered include many of the wide range of variables involved in AID irrigation strategies such as appropriate technology, irrigation system construction and maintenance, water management for agricultural and non-agricultural users, local involvement, host country participation, and social and economic considerations. The bibliography also spans a wide variety of geographic locations with varying requirements and potential for the development of irrigation systems.

Items cited are limited to those with content of general interest and application to the broad spectrum of people involved in the irrigation sector. Included are evaluations of irrigation efforts within specific countries as well as within specific AID projects. Project papers and other project-specific documents not intended for broad dissemination have been excluded in order to make this bibliography available to as wide an audience as possible; these documents, as well as project-specific documents on other topics, are available to AID staff, who are encouraged to communicate their specific literature needs to CDIE.

Assistance in compiling this bibliography was provided by Dr. Worth Fitzgerald in the Bureau for Science and Technology's Office of Agriculture. Additional guidance was provided by the Water for Sanitation and Health (WASH) and the Water Management Synthesis (WMS) project staffs, and by Jim Cotter of the Bureau for Program and Policy Coordination who is preparing a document in the Program Manager's Reference Series on irrigation.

This bibliography is the first of a series of planned special bibliographies to be prepared by CDIE on AID's experience in various areas of development. Annual revised editions of this bibliography are also planned. Comments and suggestions on ways to improve the bibliography are encouraged. In addition, your cooperation is requested in providing CDIE with copies of all AID-supported documents so that future bibliographies, as well as other CDIE information products, can be as complete as possible.

1 PN-AAM-392

Agricultural expansion planning : incorporating water reuse
Allam, Mohamed N.; Marks, David H.
Cairo University
Massachusetts Institute of Technology. Technology Adaptation Program
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Technology adaptation program report, no.82-2, May 1982, xiii, 232p., En. Report no.269; Report no.R82-10
References: p.122-124
Project numbers: 2630013
Contract numbers: AID/NE-C-1291

The presence of salt in irrigation water causes an increase in irrigation water requirements and a decrease in plant growth and thus crop yield. This report develops a planning system for a large-scale agricultural expansion project where some or all irrigation water resources are saline.

First, a simple procedure is outlined to determine the amount of water necessary to leach salt out of the root zone of an irrigated field and thus maintain an acceptable level of production with the available saline water supply. Next, a mathematical model is presented to guide decisions in a project where irrigation sources have different salinities. These decisions - crop selection, quantities and locations of all resource inputs, the mixing ratio between different waters (if mixing is possible), irrigation network design, required enlargement of the existing irrigation system, and crop pattern distribution - are based on the maximum net benefit criterion and are carried out in a mathematical optimization framework. The model is then applied to an Egyptian case study, agricultural expansion in the Nile Delta and the Sinai. Alternative irrigation schemes are discussed, an economic approach for analyzing the alternatives is presented, and equity concerns in scheduling and cost allocation are considered.

Appendices provide tabulated data from the case study on seasonal discharges and salinities of the irrigation water sources, the model's output, and the model's input. (Author abstract, modified)

2 PN-AAR-197

Wheat production with supplementary irrigation in two Hama villages
Bailey, Elizabeth
International Center for Agricultural Research in the Dry Areas
ICARDA discussion paper, no.8, Jul 1982, 48p., En
Project numbers: 936411112

The International Center for Agricultural Research in the Dry Areas's (ICARDA's) Farming Systems Program monitored 33 farmers in 2 villages of Hama Province, Syria, during 1978-80 to determine if supplementary irrigation could eliminate fluctuation in wheat yield caused by variable annual rainfall.

Results show that use of irrigation during a dry year did not fully compensate for - but did substantially reduce - the decrease in wheat yields caused by insufficient

rainfall. In 1978/79, a dry year, the overall average output of irrigated wheat was more than double that of rainfed wheat, but in 1979/80 (a good year, in which wheat was mainly rainfed), rainfed yields alone were higher than were combined yields during the dry year. A mathematical model is developed to show how fluctuating yields affect both wheat output and its various uses as a commodity. The analysis indicates that even if the area under irrigation and the level of irrigated yields were significantly increased, wheat yields of 1978/79 could not have exceeded those of 1979/80 in either village. Detailed data on wheat production in both villages may be found in the appendices.

3 PN-AAT-154

Barriers to expanding irrigated agriculture in Subsahara Africa imposed by pumping costs
Arthur D. Little, Inc.
U.S. Agency for International Development. Bureau for Science and Technology. Office of Energy (Sponsor)
[1985], v.p., En

The costs associated with irrigation pumping, in particular the cost of energy, are assessed in relation to their potential impact on irrigation expansion plans, agricultural economics, and the energy sector. In the Sahel, where the percentage of irrigated agricultural land requiring pumping will range between 90% (Senegal) and 50% (Mali), energy costs will impose restrictions on the depth of pumping, double cropping potential, crop selection, and irrigation system design and management. The case of Senegal is used to compare two systems for powering pumps - direct diesel drive and grid electricity - with regard to fuel use, capital costs, crop selection, and related water requirements. The costs of irrigation pumping (fuel, operations and maintenance, and capital costs) are then discussed more generally; in the case of diesel drive pumps, the impact of pumping costs on crop economics (in particular, rice production) is assessed. An overview of policy issues related to expanding pumped irrigation is presented in conclusion. Appended is an 18-item list of references (1979-85).

4 PN-AAR-832

Broad - crested weir : a simple - accurate flow measuring device for irrigation channels, Lam Nam Oon, Sakon, Nakhon, Thailand
Bell, William C.
Louis Berger International, Inc. Center for Rural Development
Thailand. Ministry of Agriculture and Cooperatives
U.S. Agency for International Development. Bureau for Asia. Thailand (Sponsor)
Mar 1983, 14p. + 3 appendices, En. Technical note no.7
Project numbers: 4930272

The broad-crested wier (BCW) is an easily built device which measures the flow of water in irrigation canals much more accurately than traditional devices such as sharp-crested weirs and cutthroat flumes. BCW design and construction are described in this technical report. The key design criterion is to ensure that the sill, which controls water levels and emergence, rises high enough out of the water to obstruct the flow, yet without causing an overflow. In building BCW's, it is necessary to choose sites where

bottom and side slope irregularities are at a minimum. BCW's are made of concrete or of rock fill with a concrete cap; additional layers of concrete may be added if needed to keep the device from being too submerged, and tubes can be installed for canal drainage. A final section of the report describes BCW performance at Lam Nam Oon, Thailand, where two were built in about a day's time, and where their effectiveness was found to be satisfactory. BCW's recently installed in Arizona and Idaho have also performed satisfactorily. Appended are a description of a computer program for calculating water flow using the BCW; a sample computer printout; and a computer program of the mathematical model for the BCW.

5 PN-AAJ-610

Sudan : the Rahad irrigation project
Benedict, Peter; Ahmed, Ahmed H.; et al.
U.S. Agency for International Development. Bureau for Program and Policy Coordination. Office of Evaluation
A.I.D. project impact evaluation report, no.31, Mar 1982, vii, 19p. + attachments, En
Project numbers: 6500100

Although the Rahad Irrigation Project in Sudan, partly AID-funded and nearly complete, has been operating for only four seasons, it faces problems which threaten its viability. This report assesses these problems, the project's impact, and the lessons learned.

Designed to maximize use of government investments in Nile water management, to upgrade the living standards of 100,000 herders and farmers, and to produce cotton and groundnuts for export, the project is pursuing full mechanization and 100% intensive rotation of crops. Production is supervised by the Rahad Corporation which controls pricing, marketing, and most decision-making.

The Corporation has not coped well with management of a mechanized operation, erroneously perceived labor shortages, and tenant dissatisfaction. Faced with little incentive to grow cotton, farmers have produced less and are working as day laborers and raising livestock, sorghum, and groundnuts. Mechanization has further reduced project-generated income and threatens to displace labor. In addition, limitations on local currency have resulted in the inadequate and unequal provision of educational, health, and other promised services.

Among the lessons taught by the project are that: a policy of 100% mechanization needs more analysis; farmers must be given a role in the decision-making process and be allowed choices; harvest-time labor shortages must be viewed in relation to prevailing wage rates; environmental analyses must be conducted and used in designing and implementing irrigation projects; programs to control water-borne diseases should be designed and funded in irrigation projects; and crop protection techniques should be reviewed prior to project implementation and coordinated with public health officials.

Appended are photographs; a list of contacts; a 56-item bibliography (1968-81); and reports on: the institutional and social effects of controlled resettlement, micro-level management of technical resources, economic analysis of agricultural enterprises, labor/tenant relations, and Sudan's environment and natural resources.

6 PN-AAP-297

Irrigation in Syria
Bergsrud, Fred; Shabab, Said S.
Louis Berger International, Inc.
South Dakota State University. Remote Sensing Institute
Syria. Ministry of Agriculture and Agrarian Reform. Directorate of Soils
U.S. Agency for International Development. Bureau for Near East. Syria (Sponsor)
Oct 1982, x, 66p., En. SDSU-RSI-83-08
Land classification / soil survey project of the Syrian Arab Republic, v.7
Project numbers: 2760020
Contract numbers: AID/NE-C-1644

Presented here is an interpretive classification system for evaluating the soils of the Syrian Arab Republic with regard to their suitability for three different irrigation methods - surface irrigation, and high and low application sprinkler methods. In this system, the following soil properties are used to assess irrigation potential: depth, surface texture (to indicate water intake rate), available water holding capacity, surface fragments (stones and rocks), profile fragments (percentage of soil occupied by gravel, stones, and rocks), gypsum level, salinity, alkalinity, depth to water table, depth to unconsolidated layer, flooding, drainage class, permeability, and slope. Standards for these qualities are described for each of three irrigation methods. The initial application of the classification system in Syria will be computer-assisted preparation of thematic maps showing irrigation suitability by irrigation method. Seven recommendations address water requirements and water management issues. Drip irrigation (for which irrigability standards have not yet been set) is briefly discussed.

7 PN-AAL-861

Irrigation system management research and selected methodological issues
Bhuiyan, Sadiqul I.
International Rice Research Institute
IRRI research paper series, no.81, Oct 1982, 9p., En
References: p.8-9
Project numbers: 936411102

Recent field research findings indicate there is great potential to improve the performance of existing irrigation systems in Asian rice growing regions. Crop yield, water use efficiency, irrigation efficiency, water adequacy, relative water supply, and water distribution equity criteria can be used to assess irrigation system performance. This paper discusses the requirement for using these criteria and their relative merits and demerits. Methodological options available for evaluating field research on irrigation system management improvement are analyzed. Critical hydrologic and hydraulic factors which enable the determination of water-related criteria for irrigation system performance evaluation are then examined in relation to field considerations and applicability requirements. (Author abstract, modified)

8 PN-AAN-403

Allocative efficiency and equity of alternative methods of charging for irrigation water : a case study in Egypt
Bowen, Richard L.; Young, Robert A.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.37, Mar 1983, viii, 74p., En
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Systems of charging for irrigation water are of important concern, both as a source of revenue and because of their potential impacts on resource allocation and income distribution. In this study, five area-based methods of charging for irrigation water and four volumetric pricing instruments are evaluated with regard to their institutional cost, allocative efficiency, and equity. Linear programming models were used to estimate the response of representative farmers in Egypt's lower Nile valley to different water supply scenarios and pricing instruments; charges were set to recover the full operating costs of providing irrigation water.

Findings show that area-based pricing instruments, in particular the flat land tax, are an inexpensive and efficient means of recovering costs, as long as water supply is adequate and given Egypt's unique system for rationing water. Volumetric pricing is more equitable than area taxes when water is limited, but more efficient only in the case of severe shortages. It is noted that imposition of water charges should be undertaken cautiously, if at all, due to the high taxation already faced by Egyptian farmers. Five figures, 13 tables, and a 38-item (1953-1982) bibliography are included.

9 PN-AAR-289

Irrigation water pumping technologies : a brief overview
Briscoe, John
Camp Dresser and McKee, Inc.
Aug 1982, v.p., En
Project numbers: 9311176 * Microfiche not available 7

Various published sources are collated to present a description of 12 technologies used for pumping irrigation water. The pump technologies are grouped under three categories: (1) human powered (simple hand, pendulum, rower, diaphragm, bellows, and chain/bucket pumps, the archimedean screw, and the water ladder); (2) animal powered (the Persian wheel); and (3) those powered by other energy sources (wind, solar power, and biogas).

An introductory section notes that human powered pumps are the easiest to build, although they last a relatively short time, must be located directly above the water source, and are of limited pumping capacity; use of leg power somewhat increases their capacity. Some human powered pumps can be modified to use animal power. The Persian

wheel can be constructed of local materials and has a fairly long lifetime, although it too must be located directly above the water source. Pumps operated by solar power, wind, or biogas consist of a separate pumping unit attached to a power generator. These pumps have a long lifetime and, except for the biogas digester, a low maintenance requirement. They also have a high initial cost and require a preliminary assessment of feasibility and appropriate type of system.

10 PN-AAP-607

Environmental assessment : small farmer pilot irrigation project; Swaziland
Buzdugan, Stefan; Carroll, Frank
RONCO Consulting Corp.
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Feb 1983, v.p., En. Work order no.11
Project numbers: 936140601; 6450217
Contract numbers: PDC-1406-I-00-1138-00

The potential adverse environmental effects of an A.I.D. irrigation project in Swaziland are assessed using a "worst-case" approach, and measures for minimizing their negative impact are presented. The planned project will develop pilot irrigation schemes using various designs, technologies, and management and financing arrangements and will involve interventions ranging from dredging, dam construction, and water diversions to land clearing/forming, fencing, and access road construction. In the absence of environmental protection measures, major physical environmental impacts would include increased soil erosion and salinity and changes in water surface quality; health impacts would include a potentially dangerous increase in transmission of schistosomiasis in certain areas, increased transmission of other enteric parasites, and acute and chronic effects of pesticide and herbicide exposure. However, the incorporation of soil and water conservation measures, improved domestic water supplies and sanitation, and regulation of pesticide use can minimize these impacts. Environmental guidelines for project design, implementation, monitoring, evaluation, and training conclude the assessment; a 74-item bibliography (1958-82) is provided.

11 PN-AAT-155

Report of three - week study in Bangladesh for the Cornell/ USAID water management synthesis II project
Campbell, J.K.
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
14 Jul 1983, 38p. + 4 appendices, En
Project numbers: 9364127

A study of ground water irrigation equipment was conducted as part of an effort to double the amount of irrigated land in Bangladesh by 1985. A description of the types of irrigation equipment - deep tube wells, shallow tube wells, hand tube wells, low lift pumps, and traditional manual water lifting devices (especially the treadle pump) - is presented; next, the report evaluates the performance of each in the Bangladeshi setting

with particular attention to potential water pumping capacity. The importance of indigenous manufacture of pumps, small diesel engines, and spare parts in Bangladesh is discussed, and constraints thereto (especially the lack of a reliable supply of raw materials) are noted. The report recommends, inter alia, that the Bangladesh irrigation program include locally-manufactured shallow tube wells operated with manual treadle pumps (and emphasize these in the privatization program); training and promotion programs for mechanics, and funding for private repair shops; and further research into pump performance characteristics, depth to water during the dry season, and the manufacturing capacities of the five companies with permission to build diesel engines in Bangladesh. Appendices include a 19-item bibliography (1974-83), and lists of pertinent publications and agencies involved in irrigation.

12 PN-AAT-845

Irrigation pricing and management
Carruthers, Ian D.; Peabody, N.S. III; et al.
Devres, Inc.
U.S. Agency for International Development. Bureau for Program and Policy Coordination. Office of Policy Development and Program Review (Sponsor)
30 Sep 1985, xix, 106p. + 8 annexes : Statistical tables, En
Project numbers: 9300091
Contract numbers: OTR-0091-C-00-4466-00

Case studies from Morocco, the Philippines, Indonesia, Peru, and the Dominican Republic are the basis of this analysis of irrigation system financing and management. The following issues were examined in depth: (1) the feasibility of cost recovery through direct and indirect charges; (2) whether farmer participation in and control of system management improves cost recovery and operation and maintenance; (4) the degree to which cost recovery depends on reliable and adequate water supply, water delivery, and measurement technology; and (5) whether increased water charges are a necessary and sufficient condition for improved operation and maintenance and the extent to which efficiency of water use varies with the cost of water. Concluding overall that the resources for maintaining irrigation inputs must come from the direct beneficiaries, the study details, for each of the five issues, conclusions and recommendations adaptable to specific technical, economic, and political situations. A 58-page annotated bibliography is included.

13 PN-AAL-029

On - farm water management in Aegean Turkey, 1968 - 1974
Casstevens, Thomas W.; Kolars, John F.; Wilson, James D., Jr.
U.S. Agency for International Development. Bureau for Program and Policy Coordination. Office of Evaluation
A.I.D. project impact evaluation report, no.50, Dec 1983, ix, 18p. + 17 annexes, En
Project numbers: 2770426

The impact of the On-Farm Water Development Project, jointly undertaken from 1968-74 by A.I.D. and Turkey's General Directorate of Soils and Water (TOPRAKSU) in the fertile Aydin region, is reviewed. Implementation stressed the concepts of the "farmer as

planner" and of "learning by doing" and focused on various forms of training designed to help farmers level, drain, and otherwise improve their land; promote local manufacture of farm machinery; and encourage private contractors to do land leveling.

Overall, the project was very successful. A 1971 study of four project farms showed an average increase of 1,500 kg/ha in cotton yields and an average decrease of TRL 1,000/ha in production costs - a return on investment of over 200% in the first season. Land improvement not only doubled yields in the traditional season, but also created a second season for a second crop, leading to a boom in fruit and vegetable production. The project also stimulated local production of farm machinery, which is now well established, and a growth in the number of private contractors conducting land leveling activities. TOPRAKSU engineers trained under the project (74 in the United States, 219 in-country) carried the spirit of the project with them throughout Turkey. Indirect benefits included widespread electrification, improved nutrition, and upgraded women's roles. Negatively, increased distribution of water led to deterioration of the fig crop (due to fig sensitivity to moisture) and a spread in crop diseases, while occasional overproduction has led to still unmet needs in crop forecasting, packaging, and marketing.

The project taught that: demonstration projects are more likely to succeed (and thus be replicated) when designed in close cooperation with the farmer/manufacturer/contractor; farmers are more apt to experiment if risks are limited; a complex project should be modularized and decisionmaking delegated to the lowest practical level, with a simple evaluation and feedback system; technology must be easily adaptable and repairable locally; and help may be rendered more effectively by increasing employment and demand for goods than by direct intervention. Appendices offer further treatment of individual points.

14 PN-AAL-028

Helmand Valley project in Afghanistan
Clapp-Wincek, Cynthia; Baldwin, Emily
U.S. Agency for International Development. Bureau for Program and Policy Coordination. Office of Evaluation
A.I.D. evaluation special study, no.18, Dec 1983, xiii, 29p. + 2 appendices, En
Project numbers: 3060090

The Helmand Valley Development Project in Afghanistan, a complex effort - assisted by 25 A.I.D. and predecessor agency projects (1949-79) - to settle new farmers on desert lands reclaimed by irrigation, is herein reviewed.

Although often accounted a failure, the project did spur impressive growth in agricultural productivity and income. The amount of land under cultivation increased from 77,000 to 145,000 ha, 5,500 new families were settled in the valley, fertilizers and high-yield varieties were brought into widespread use, and double cropping increased dramatically. Average farm income increased by as much as ten times. By 1975, however, inadequate attention to drainage and salinization and failure to adequately train farmers in water management (as more settlers arrived and the project focus shifted from irrigation to integrated rural development) began to slow income increases. Long-time residents dealt with these problems better than did new settlers. Still, even in areas

where salinity was severe, income remained well above pre-project levels.

Nonetheless, the increased crop yields were not enough to significantly improve Afghanistan's export situation. Social services (some of which the United States was responsible for) failed to mitigate the negative impacts of severe salinization and waterlogging - impoverishment, illness, and outmigration.

The project taught that: mixing export production and resettlement goals makes achievement of either unlikely; social services must be given high priority and integrated with other activities, but crop production gains must be consolidated before positive social impacts can be sustained; successful nomadic settlement programs must provide strong economic incentives, adequate social services, and effectively communicated agricultural information; and close integration of donor and host country activities and goals is essential. The success of A.I.D. activities in such a project depends on the success of the effort as a whole. Thus, provision must be made from the outset for all essential elements.

Appendices include an analysis of four farm economic surveys conducted in the Valley between 1963 and 1978 and a 41-item bibliography (1955-1980).

15 PN-AAR-524

Comparative advantages of axial - flow pumps over centrifugal pumps for low - lift irrigation
Philippines. Bureau of Plant Industry
U.S. Agency for International Development. Bureau for Asia.
Regional Economic Development Services Office (Sponsor)
7 Feb 1983, 15p. : ill. tables, En. Report no. IEP-6
Project numbers: 4980265

Centrifugal pumps are commonly used in the Philippines for low-lift irrigation whereas axial-flow pumps have proven more acceptable in Thailand and Vietnam. This study compares centrifugal and axial-flow pumps in terms of performance and cost.

The pumping efficiency of the axial-flow pump is substantially higher than that of the centrifugal pump for lifts (static heads) of three meters or less. Therefore, the fuel required to pump a specified quantity of water is lower for the axial-flow pump than for the centrifugal pump. This, and the fact that the initial costs of the two pumping units are approximately equal, are considered in an economic analysis which demonstrates that axial-flow pumps have significantly lower total annual costs than centrifugal pumps for lifts of three meters or less.

It is recommended that a promotional campaign be carried out in the Philippines to inform farmers, manufacturers, and extension workers of the comparative advantages of axial-flow pumps relative to centrifugal pumps for low-lift irrigation. (Author abstract)

16 PN-AAQ-701

Improving policies and programs for the development of small - scale irrigation systems
Coward, E. Walter, Jr.
Cornell University
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.27, Sep 1984, iii, 16p., En
Project numbers: 9365942
Contract numbers: DAN-4127-C-00-2086-00

Small-scale irrigation projects often face serious programming problems such as escalating recurrent costs, inflexible design, nonfunctioning irrigation groups, inadequate agency capacity, and, most critically and ambiguously of all, the problem of determining the optimal mix of state and local responsibilities. Defining small-scale irrigation projects to include those that are managed either by the state or by local groups, this study analyzes key program choices regarding investment, design, local organization, and implementing agency and in so doing develops an initial strategy for overcoming existing problems. Major elements of the strategy include: (1) supporting local investment initiatives; (2) incorporating local input into project design; (3) forming local irrigation groups prior to system construction and giving them autonomy, attempting to understand the functions of existing local groups and the local structure of the ownership and distribution of land and water rights, and training agency staff to work with local groups; and (4) selecting the implementing agency (or agencies) on the basis of specific project needs, assigning this agency a service rather than a managerial role, and developing a support network which includes research and management institutions, other government agencies, and private voluntary organizations. The advantages of the proposed strategy are enumerated in a final section. A 40-item bibliography (1979-84) is appended.

17 PN-AAN-486

Socioeconomic issues in irrigation development and distribution
Easter, K.W.; Welsch, Delane E.
University of Minnesota. Institute of Agriculture, Forestry and Home Economics
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Apr 1983, ii, 64p., En. Economic report no.83-5
Project numbers: 931023609
Contract numbers: AID/TA-BMA-5

Socioeconomic problems facing irrigation planners and managers are examined in this review of the literature on irrigation in India, Pakistan, Thailand, and Egypt. Focus is on three critical areas: water allocation; institutional arrangements for irrigation management; and investment alternatives.

Section I, on water allocation, reviews research on a variety of issues, e.g., allocation of water over time and among users; conjunctive use of groundwater and surface water; system size; means of reducing water loss; the impact of allocation procedures on waterlogging and salinity; and differing perceptions of farmers and irrigation managers.

This last issue - the need to make individual and societal incentives compatible - recurs in Section II on institutional arrangements. Other institutional issues include: coordinating government involvement; financing water user associations; farmer participation; and the role of land tenure and water rights. Section III discusses two key investment questions - new projects vs. rehabilitation and small projects vs. large ones. Topics here include: frequency and type of maintenance and rehabilitation; preventing overuse of groundwater; communal- vs. government-operated systems; tank projects; the relationship between socioeconomic problems and system size; water application intensity; and drainage and terminal infrastructure.

18 PN-AAR-824

Baseline data for improvement of a distributary canal system
El-Sheikh, Kafr
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.72, Oct 1984, viii, 57p. : charts, statistical tables, En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351; NEB-0017-C-00-0022-00

In an effort to improve irrigation water management, the Egypt Water Use and Management Project conducted an irrigation research and development program during the period 1978-84 in the Abu Raya area served by the Daqalt Canal. Using an interdisciplinary approach, the program included the design, construction, and operation of a system to deliver water to all farms in sufficient quantity at appropriate times to meet all water needs; to deliver water at an adequate and equitable flow rate and head; and to minimize surface losses to drains. The original system was designed, built, and operated under certain physical and operational assumptions that would minimize water use while maximizing crop yields for all individual users.

This technical report describes the physical characteristics of the existing system, including water supply, canal structures, canal and <<mesqa>> surveys, soil conditions, crop patterns, water table levels, on-farm irrigation, and water delivery requirements. The socioeconomic characteristics of the existing system are also evaluated to assist in developing an equitable water user management program.

The Daqalt Canal does not meet its original objectives due to water shortages, inadequate and inequitable flow rates and heads, and large surface losses to drains. These problems are caused by ineffective physical structures operation, conflicts with irrigation timing preferences, and poor canal maintenance. As a result, the system falls short of desired performance due to incorrect assumptions and improper management. The entire water delivery system requires renovation within the context of the larger irrigation system.

The report recommends that a complete hydraulic model of the existing Daqalt system be developed in accordance with available water levels in the Mit Yazid Canal, and that the design be re-evaluated in light of this model. The renovation process should continue, and water users should participate in the design and operation of the water management plan. (Author abstract)

19 PN-AAT-992

Small farm self - help irrigation projects
Embry, Bertis L.; Adams, Nancy L.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Colorado State University. Engineering Research Center
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Handbook / Water Management Synthesis Project, no.4, Dec 1983, iii, 45p. + appendix, En
Project numbers: 9364127
Contract numbers: AID/DSAN-C-0058

Nine principles for irrigation water management drawn from A.I.D.'s successful Small Farm, Self-Help Irrigation program in Guatemala are presented and discussed. (1-2) Identify site suitability and benefit potential and locate farmers willing to participate in a self-help project. (3) Determine a funding source prior to the project. (4) Prepare a preliminary plan, including cost estimates, and present it to funding agencies and participating farmers. (5-6) Identify a sponsoring organization committed to working with farmers to improve agricultural production and marketing and work with that organization to provide farmers with technical assistance. (7) Locate or train personnel willing to work with farmers in the field. (8) Carry out seven basic field tasks - form and legally organize farmer groups, conduct basic survey design activities, help farmers arrange financing for the project, supervise and train farmers to build their system, operate and maintain it, and to use agricultural and marketing methods needed for new crops. (9) Extend the program to other areas and regions as appropriate.

20 PN-AAT-156

Evaluating the technical and economic performance of photovoltaic pumping systems : a methodology, final draft
IT Power Inc.
Laboratoire de l'Energie Solaire
U.S. Agency for International Development. Bureau for Africa. Office of Regional Affairs (Sponsor)
May 1985, v, 108p., En
Project numbers: 6980510
Contract numbers: AFR-0510-C-00-4042-00

A methodology for testing, monitoring, and evaluating small-scale photovoltaic pumping systems is presented. The methodology consists of three performance tests - the photovoltaic array rating test, and long- and short-term performance tests - and a procedure to calculate the unit water cost. Instrumentation requirements and detailed procedures for carrying out the tests are specified, as are formats for evaluating and

presenting results.

The methodology was field-tested on five photovoltaic water pumps in Mali, of which three were performing well (producing water at unit costs of $0.20-0.35 per cubic meter). It was noted that villagers are unaware of the potential output of the pumps, and therefore may not realize if a fault develops. It is recommended that all photovoltaic pumps in Mali be tested, that the methodology and the sample results from Mali be circulated to organizations installing/operating solar pumps, and that a workshop and network of experts be organized to further improve and apply the methodology. Data obtained in Mali and references are appended.

21 PN-AAT-153

Expanded economic analyses of Senegal River : irrigation pumping alternatives
Energy / Development International
U.S. Agency for International Development. Bureau for Africa.
Office of Regional Affairs (Sponsor)
Aug 1985, 29p., En

To make a 1984 cost-benefit analysis of irrigation pumping options in the Senegal River Valley accessible to a wider audience, this draft report expands the study's economic analysis section by including data on national costs and farmer and project benefits. The analysis, results of which are presented in a series of statistical tables, was based on a large number of variables, including differing sites, pumping options, and crop choices. Both variable (fuel) and fixed (investment, depreciation, and operation and maintenance) cost are reviewed. Included is a Bakel area case study which, it is argued, demonstrates the possibility both of conducting a rigorous cost-benefit analysis even of small irrigation projects and of determining critical variables by rapid sensitivity analyses of various parameters. More needs to be done, however, before the cost-benefit analyses of the type here displayed can be used in making routine irrigation decisions.

22 PN-AAL-010

Bangladesh small - scale irrigation
Friedkin, Tom; Lester, Robert T.; et al.
U.S. Agency for International Development. Bureau for Program and Policy Coordination.
Office of Evaluation (Sponsor)
A.I.D. project impact evaluation report, no.42, Apr 1983, x, 27p. + 4 appendices, En
Project numbers: 3880019

The Small Scale Irrigation Project in Bangladesh is an example of a project which could not fail, but, due to a variety of institutional shortcomings, almost did. So concludes this evaluation of the project, which was initiated in 1976 to provide hand tubewells (HTW's) to small farmers in Bangladesh.

The project was designed to take advantage of a technology already widely accepted in Bangladesh and well-adapted to the country's climate and its high water table. The HTW, or handpump, is simple to operate and maintain, and makes use of cheap local labor. Most importantly, it is inexpensive, and with credit available, affordable by small farmers.

Despite these positive factors, the project was plagued by problems from its beginning, mainly because its initial design failed to adequately address a number of crucial issues: the need to import iron (lack of raw materials delayed implementation for years) for indigenous manufacture of HTW's; the exact design of the pump; production by local foundries; and, especially, the credit and distribution system.

To ensure that targeted farmers - those owning 3 acres or less - were reached, a system of certification and documentation was created. The system proved ineffective and its paperwork a hindrance. Worse, institutional inadequacies with the credit system (along with farmer dislike of the system, which required their land as collateral) made farmers owning 3 to 7 acres the primary beneficiaries. Such farmers are at the upper end of the landholding scale in Bangladesh.

Most of these problems have now been worked out - although spare parts are hard to obtain and the credit system still inadequate - and some 180,000 HTW's are in use, primarily for irrigating a third, dry season crop which would not have been planted but for the pumps, and which is, in some cases, a cash crop. A market has recently developed for used HTW's, making them available to the poorest farmers, those not well served by the credit system. The HTW's have also been used to increase the supply of potable water, reducing the incidence of dysentery and stomach ailments.

24 * PN-AAQ-503

Hydraulic design of a canal system for gravity irrigation
Gates, Timothy; Ree, William O.; et al.
Consortium for International Development
Colorado State University. Engineering Research Center
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
Egypt water use and management project : technical report, no.46, Apr 1984, ix, 210p., En
Project numbers: 2630017

* Microfiche not available

Irrigation by gravity from a water delivery system where the difference in elevation between the canal's source and the fields is small requires careful use of the limited head available. Drop structures normally used to control flow are not used in order to conserve head. Instead, a desired distribution of the flow is achieved by sizing canal and channel turnouts. Turnout size depends on the required discharge rate and on the differential head. This head, in turn, is determined by flow rates in the connected channels and their cross-sections, hydraulic roughnesses, and slopes. Because the flow rate and head are interdependent, an iterative procedure is required to solve the turnout size problem. Furthermore, a change in water level at a single point may be reflected throughout the entire system. A computer model solves the hydraulics of the integrated system. Application of the model is demonstrated in the design of the distribution system for the Abyuha region in Middle Egypt. Appended are a 16-item bibliography (1959-1984), computer programs, sample output, and extensive statistical data.

25 * PN-AAL-390

Irrigation pumping; water management synthesis project
Griffin, Richard E.; Hargreaves, George H.; et al.
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Consortium for International Development
Colorado State University. Engineering Research Center
Utah State University. Dept. of Agricultural and Irrigation Engineering
Jun 1982, 23p., En. Planning guide no. 3
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

* Also available in Spanish and French from the publisher.

In many areas of the developing world, pumping water may be the only solution to irrigating lands needed to increase agricultural production. This illustrated report is designed to serve as a guide in planning water pumping projects.

First, power sources (gasoline, diesel, electricity, and propane or natural gas) are reviewed and alternatives for powering mechanical pumps are compared. Three types of mechanical pumps - centrifugal, propeller, and turbine - and their particular applications are then considered. Explanations follow of the need to design pumping plants according to pumping needs (water volume and lift requirements) and energy availability and to select and maintain the proper pump for maximum efficiency. To insure the long-term effectiveness of a pumping project, knowledge of local legal and administrative structures and of soil characteristics, crop water requirements, and the quality and quantity of the available water supply is essential, as are training and extension programs.

26 PN-AAT-991

Pumps and water lifters for irrigation
Griffin, Richard E.; Hargreaves, George H.; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Colorado State University. Engineering Research Center
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Handbook / Water Management Synthesis Project, no.3, Jul 1983, v,75p. + 6 appendices : ill., charts, statistical tables, En
Project numbers: 9364127
Contract numbers: AID/DSAN-C-0058

A general overview of pumps and water lifters for irrigation, along with guidance for selecting, installing, and maintaining them without expert engineering services, is presented in this handbook. The handbook briefly surveys the sources of power that can be used to drive pumps and describes the various types of pumps, including pumps powered by humans and animals, propeller or axial flow pumps, and mixed flow and turbine pumps. Extensive criteria for selecting pumps and power units, such as the amount of water to be pumped, horsepower and efficiency, pump location, and specific speeds, are presented. Also considered are the use of pump components, semi-open and enclosed impellers, and

electrical connections. Sections describing and providing guidelines on pump installation, intake structures, typical pump design, costs, and on evaluating existing pumping plants are included. The handbook features 7 technical appendices and a total of 32 tables and figures.

27 PN-AAT-427

Report of the Egyptian irrigation management systems by the USAID design team : main report; Egyptian irrigation systems operation, maintenance, and structural replacement
Haapala, Richard V.; Conklin, Robert B.; Morgan, M.J.
CH2M Hill International
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
May 1981, 41p. + 7 annexes : charts, statistical tables, En
Project numbers: 2630042
Contract numbers: AID/OTR-C-1618

A USAID team worked with the Egyptian Ministry of Irrigation (MOI) to design a program to improve irrigation water use in medium size structures in the country's old lands irrigated area. Examining issues of irrigation system operation, maintenance, and structural replacement, the team concluded that the MOI would need $100 million in U.S. funding over the next 5 years to maintain quality levels, halt a trend towards system deterioration, and attract and retain additional MOI personnel. The team recommended implementing the project slowly and prioritizing structural replacement efforts. It also recommended that the MOI: use more modern, cost-effective alternative designs and upgrade the quality of materials and equipment used by its engineers and technicians; improve onsite quality monitoring and develop a capacity for internal maintenance; and improve internal communication and operational control of the existing irrigated service area. Current aerial photographs of the area and studies in the Gharbia Directorate and North Zifta District are recommended. An MOI commitment to continue future maintenance should accompany the project.

28 PN-AAR-142

Planning irrigation improvements in Egypt : the impact of policies and prices on farm income and resource use
Haider, Mohamed; Skold, Melvin
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP technical report, no.43, Aug 1983, viii, 80p., En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

The most profitable use of resources on a typical Egyptian farm is analyzed in view of resource, institutional, and government policies constraints. The linear programming model of a farm management decision problem, based on an average sized farm found in a

survey of 50 farms in Kafr El Sheikh, was used to allow observation of the interdependencies. Changes in the method of irrigation or in the government's system of water supply were evaluated.

Four sets of policy alternatives are examined. The base run reflects existing policies, a second option includes only administered prices. Additionally, a free market alternative is tested and, finally, a free market coupled with a system to charge farmers for the delivery of water is assessed.

Results show that existing policies do not greatly distort the optimal mix of enterprises, but it is likely that farmers would have incentive to achieve higher crop yields under different price policies. As yield associated with higher commodity prices are achieved, farmers' incentives and ability to adopt improved water management practices would be enhanced. (Author abstract, modified)

29 PN-AAR-508

Improving Egypt's irrigation system in the old lands : findings of the Egypt water use and management project; final report
Halim, Mary; Hilleman, Daniel
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Mar 1984, v, 68p. : ill., charts, tables, maps, En
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

The Egyptian Water Use and Management Project conducted an applied research and extension program with small farmers at three pilot sites (El-Mansuriya, Abu Raya, and Abyuha) to develop improved on-farm water management and delivery systems. Project findings are presented in this final report.

Following a review of existing Egyptian farming, water delivery, and groundwater systems, the report describes project-tested interventions for system improvement. On-farm water management interventions include precision land leveling, on-farm irrigation systems, irrigation scheduling, and crop management. Water delivery system interventions include watercourse improvements, hydraulic structures, management techniques (e.g., water users' associations), and design modification. Activities of the irrigation advisory service, established to assist farmers in adopting new irrigation techniques, are discussed. Recommendations are made concerning the research process, irrigation parameters, farmer involvement, water management, agronomic and structural changes, and training.

An 84-item (1976-83) reference list is provided.

30 PN-AAU-006

Irrigation water production functions : report on a training course
Hargreaves, George
Bangladesh Agricultural Research Council
International Agricultural Development Services
U.S. Agency for International Development. Bureau for Asia. Bangladesh (Sponsor)
(Training Course on Irrigation Water Production Functions, Dhaki, BD, 23 Mar - 11 Apr 1985)
Apr 1985, 27p. : statistical tables, En. WM-18-85
Project numbers: 3880051

In Spring 1985, a 3-person team from Utah State University's International Irrigation Center presented a course in agricultural water production functions at the Bangladesh Agricultural Research Institute. This report briefly describes the course's field practice component, which consisted of a 2-day trip to the Bangladesh Academy for Rural Development and to an adjoining agricultural cooperative and irrigation system; reproduces examination questions prepared by two of the team members; and summarizes students' evaluation of the course. Course-derived recommendations for research on nitrogen, water production functions, irrigation efficiencies, and water-fertility-variety interactions and for related training conclude the report. Appendices include lists of guest lecturers and of training materials distributed during the course.

31 PN-AAJ-608

Sederhana : Indonesia small - scale irrigation
Holloran, Susan; Corey, Gilbert L.; Mahoney, Timothy
U.S. Agency for International Development. Bureau for Program and Policy Coordination. Office of Evaluation
A.I.D. project impact evaluation report, no.29, Feb 1982, xi, 12p. + 4 annexes, En
Project numbers: 4970242

A.I.D.'s Sederhana project was designed to increase Indonesian rice production by rehabilitating or constructing small, technically simple irrigation systems. An A.I.D. team visited 29 subprojects (SP's) to prepare this review of Sederhana's impact.

The project proved difficult to administer. Only 52 of 600 SP's completed or underway by June, 1980 had been reimbursed by A.I.D. due to start-up problems, design and construction faults that required work to be redone, and to the Fixed Amount Reimbursement method which allowed payment only after technical certification of completed construction. Nonetheless, the project led to substantial increases in rice production on Java and Sulawesi, confirming the assumption that farmers could make immediate use of additional water. In Sumatra, however, the production impact was not encouraging, due to adverse environmental conditions and farmer resistance to growing labor-intensive, non-cash crops. In most SP's, increased production benefited both landowners and permanent tenants, but sometimes affected sharecroppers and landless laborers adversely, as landowning families filled many of the jobs created by the increasingly profitable Sederhana system.

Key problem areas were a trade-off between SP quantity and quality due to a highly centralized implementation process, which should be altered to increase participation from

the provinces and especially from farmers (whose participation, especially in geographically scattered projects such as Sederhana, is essential); lack of coordination between implementing agencies, a factor essential to the success of any project; and the lack of technical assistance which early on led to costly errors and the failure to build an experienced cadre in government agencies - technical assistance should be increased as the project moves to marginal areas, with a focus on improving local construction and management skills. The project also demonstrated the need for baseline data to assess a project's progress and the fact that programs such as Sederhana, while they can substantially benefit the rural poor, cannot result in the redistribution of wealth.

Appendices include an analysis of the project's irrigation and water management systems and a September, 1979 A.I.D. audit of the project.

32 PN-AAQ-505

Considerations of various soil properties for the irrigation management of vertisols
Honeycutt, C.W.; Heil, R.D.
Consortium for International Development
Colorado State University. Engineering Research Center
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
Egypt water use and management project : technical report, no.73, May 1984, vii, 25p., En, Summaries in Ar
Project numbers: 2630017

Most of the irrigated soils of the Nile River Delta are classified by the U.S. Soil Taxonomy as vertisols. For proper irrigation management, the extensive cracking exhibited by these soils upon drying requires an understanding of how crack formations affect, among other factors, infiltration, internal drainage, salt and sodium movement, root growth, and evaporation. Other considerations more specific to the Delta region with respect to the effect of textural stratification on various soil properties important in irrigation management are also addressed. Discussion of these considerations is based on pertinent findings reported in the literature. A 42-item bibliography (1923-1980) is appended. (Author abstract, modified)

33 PN-AAQ-507

Technical and economic analysis of low lift irrigation pumping in Egypt
Horsey, H.R.; Richardson, E.V.; et al.
Consortium for International Development
Colorado State University. Engineering Research Center
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
Egypt water use and management project : technical report, no.79, May 1984, xii, 221p., En
Project numbers: 2630017

The need for small, efficient, low-lift pumping devices is being recognized worldwide. Many developing countries need such pumps to lift irrigation surface water 0.5 to 3 meters. This paper analyzes the technical and economic characteristics of low-lift pumps.

Water wheels and both portable and fixed axial flow pumps were considered, and animal, electric, and fossil fuel drivers investigated. The analysis was performed specifically for pumping conditions in Egypt, where discharges of 14 to 100 litres/sec are required at static lifts ranging from 0.5 to 3 meters. Both the economic costs of pumping based on international market prices and the on-farm pumping costs in Egypt were determined. A computer model was developed to aid in pump selection and to perform the economic calculations.

A 6-inch axial flow pump developed by the International Rice Research Institute (IRRI) was found to be the most efficient low-lift pump (efficiencies as high as 70% have been reported) at heads of 0.5 to 3 meters. Data from field tests indicate that discharges range from 46 litres/sec at a static lift of 1 meter to 27 litres/sec at a static lift of 2.8 meters.

The 6-inch IRRI pump driven by a 3-horsepower electric motor provided the lowest pumping costs. Where electricity is unavailable, the animal-powered water wheel resulted in the least expensive pumping costs. However, if the opportunity time of the farmer's labor is included and the opportunity cost is greater than three cents an hour, the cost of pumping with a diesel powered IRRI pump was less than with the water wheel.

A 4-page bibliography is appended, along with computer programs, sample output, cost data, and a computer model users' manual. (Author abstract, modified)

34 PN-AAT-152

Options in powering irrigation equipment for tubewells and low - lift pumps in Bangladesh
Howes, Richard R.
Bangladesh Agricultural Research Council (Sponsor)
7 Dec 1983, 20p., En

Due to the rising cost of imported fuel, the Government of Bangladesh (GOB) is evaluating different power sources for irrigation pumps. This report reviews studies and government policies affecting the choice between electric and diesel power.

A review of engineering and cost studies shows electricity to be more economical than diesel fuel for shallow and deep tubewells and for low-lift pumps. On the policy level, the GOB is promoting the use of electricity because it can be generated by natural gas, a locally available resource. There are problems, however, with the reliability of electricity in rural areas and with the security of local lines. Guidelines for choosing between diesel and electricity focus on using electricity whenever possible (e.g., for tubewells and stable low-lift pumps), fitting diesel pumps for future conversion to electricity, and coordinating activities of planning agencies in order to ensure the availability of electricity for particular projects. A final section discusses the potentially dramatic savings that could result from substituting liquid petroleum gas (LPG) for diesel in irrigation pumping, once Bangladesh becomes capable of separating LPG's from natural gases.

35 PN-AAS-243

Diagnostic analysis of farm irrigation systems in the Mahi-Kadana irrigation project, Gujarat, India

Jayaraman, T.K.; Lowdermilk, M.K. ; et al.
Colorado State University. University Services Center
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Water management synthesis project : WMS, no.18, Nov 1983, xx, 180p. : charts, maps, statistical tables, En
Project numbers: 9364127
Contract numbers: AID/DSAN-C-0058

Interdisciplinary on-farm diagnostic analysis of irrigated farming systems has proven effective in evaluating the operations and performance of irrigation projects. A professional development workshop, held 2/81-3/81 in Gujarat, India, and described herein, provided participants with skills needed to conduct such analyses by diagnosing two water supply systems (unimproved traditional, improved rotational) in the Mahi-Kadana Irrigation Project.

To teach participants teamwork principles, disciplinary skills, and interdisciplinary concepts and procedures used in diagnostic analysis, the workshop consisted of lectures followed by field work conducted by three participant teams. Teams first studied an irrigation outlet in detail (focusing on skills development). After analyzing the results, the teams planned and conducted a second detailed study (with emphasis on discipline training, team training, and principles of research planning and execution). Finally, the teams analyzed data gathered from the studies; major findings covering extension, economics, engineering, and agronomy, as well as recommendations and workshop evaluation results, are presented.

36 PN-AAT-420

Economic and technical criteria for location of deep and shallow tubewells : a consultancy report
Johnson, Sam H. III
International Agricultural Development Service
Bangladesh Agricultural Research Council
U.S. Agency for International Development. Bureau for Asia. Bangladesh (Sponsor)
Apr 1985, ii, 60p. + attachments : charts, maps, statistical tables, En. WM-15-85
Project numbers: 3880051

Social, economic, and technical factors involved in tubewell installation in Bangladesh are discussed, and eight criteria combining these factors are developed for installing four types of tubewells - shallow tubewells (STW's), deep tubewells (DTW's), hand-operated tubewells (HTW's), and deep sunk shallow tubewells (DSSTW's) - in specific locations. A final section compares the criteria against current groundwater development efforts.

It is concluded that present and planned tubewell efforts do not agree with the criteria, mainly because of inappropriate government subsidies for DTW's. Although DTW's are required in areas where STW's and DSSTW's are not technically feasible, subsidies have encouraged DTW installation in some of the best water-endowed areas in the country and so have increased rather than decreased regional income disparities. Generally, it is recommended that STW's be installed wherever conditions are suitable, and that excessive subsidies for DTW's be eliminated. In light of the country's growing trend toward privatization, regulation at the macro level, e.g., through zoning rules permitting only one type of tubewell in a given area, are advised. Appendices provide, inter alia, lists of upazilas (subdistrict administrative units) and data from a recent groundwater investigation study.

37 PN-AAJ-823

Non-agricultural uses of irrigation systems: Household water supplies
Jones, B.J.
Agricultural Development Council, Inc.
1981, 166P., En
Contract numbers: AID/OTR-0082-A-10-88

The magnitude of the world's need for water signaled by the U.N. Drinking Water and Sanitation Decade, the adverse health effects of irrigation projects, and the increasing awareness of the basic link between water and health provide the background for this study of the feasibility of designing irrigation schemes to provide a source of household water. While no firm conclusion is drawn, four key issues affecting the feasibility of dual-purpose irrigation systems are identified and discussed: engineering considerations; investment costs; administrative and organizational arrangements; and the convenience and health benefits of a steady water supply. Recommendations are, inter alia, to involve women as well as men in the operation and maintenance of dual-purpose systems; explore the possible role of water user associations in, and the access by landless to, such systems; and sensitize donors to the non-economic and non-quantifiable benefits of development.

Bangladesh / USAID : irrigation development options and investment strategies for the 1980's

Keller, Jack; Bishop, A.A.; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Development Support. Office of Agriculture (Sponsor)

WMS report, no.3, May 1981, ix, 37p. + 2 appendices, En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

A brief history of A.I.D. irrigation projects in Bangladesh prefaces this analysis of development options (e.g., irrigated vs. rainfed farming, expansion vs. intensification of irrigation) and investment strategies (e.g., direct and indirect funding) for A.I.D. involvement during the 1980's in that country's irrigation sector.

It was found that although existing irrigation projects have not met expectations (a major reason being inadequate water distribution in the field), the potential for improving them is great. Besides recommending the redesign of two proposed projects (Rural Irrigation Works and Nobagana Integrated Land and Water Use Study), the study team advocates A.I.D. support of: (1) rainfed agriculture (given Bangladesh's abundant water supply), while yet reserving a major emphasis on irrigation development; (2) supplemental irrigation with existing pump operations, designed to operate year-round; (3) cost-benefit studies of irrigation alternatives; (4) the private sector, but not of integrated land and water management projects that lack a strong monitoring and problem-solving capacity nor, given A.I.D.'s experience with large projects and the Government of Bangladesh's commitment to small projects, of further large projects; (5) software development, adaptive research, studies and planning for comprehensive agricultural resource development, and studies of the role of women in irrigation projects; (6) on-farm water delivery, provided a cost-benefit analysis per unit of command area is undertaken; and (7) given the widespread malnourishment of Bangladesh's rural population, of vegetable production in new irrigation projects.

Discussions of irrigation strategy in Asia and of the water balance in Bangladesh are appended.

39 PN-AAP-150

Ecuador irrigation sector review
Keller, Jack; LeBaron, Allen; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.12, Oct 1982, ix, 116p., En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

The current state of irrigated agriculture in Ecuador is reviewed, and recommendations are made for improving national hydraulic and irrigation planning to maximize social benefits. A background discussion of the Government of Ecuador's (GOE) administrative capacity for irrigation and lessons learned from rural development activities is included. The failure of public irrigation projects to live up to estimations is addressed. Future irrigation programs, including those in frontier and colonization regions, must be capable of helping meet a demand for food that is expected to double by the year 2000. The report's major conclusion is that the GOE should devote considerable effort to upgrading all existing irrigation works and irrigation methods (in both public and private systems) and to expanding the amount of agricultural land under irrigation. A final section of the report presents a lengthy description of the range of strategies and policy options for irrigation development. An 18-item list of references (1972-82) and 4 appendices are included.

40 PN-AAP-146

General Asian overview of irrigation development options and investment strategies for the 1980's
Keller, Jack; Lowdermilk, Max K.; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.7, May 1982, v, 69p. + 2 annexes, En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

Four papers on A.I.D.'s irrigation investment options and strategies for Asia are presented. The first two papers review, respectively, reports prepared by interdisciplinary study teams for Bangladesh, Northwest India, Pakistan, and Northeast Thailand and reports prepared by an Asia Bureau team during visits to India, Bangladesh, Pakistan, Nepal, and Thailand. The third paper presents a preliminary analysis of the development and strategy issues facing A.I.D. in the irrigation sector, while the fourth identifies areas for action, analysis, and research regarding canal irrigation management in India. Lists of key recommendations are appended.

41 PN-AAK-951

India / USAID : irrigation development options and investment strategies for the 1980's
Keller, Jack; Clyma, Wayne; et al.
Consortium for International Development (Sponsor)
Utah State University. Dept. of Agricultural and Irrigation Engineering
U.S. Agency for International Development. Bureau for Asia. India (Sponsor)
WMS report, no.6, Jul 1981, xviii, 55p. + 5 annexes, En
Project numbers: 9310007
Contract numbers: AID/DSAN-C-0058

To help A.I.D. focus and prioritize its irrigation efforts in India, this report reviews current A.I.D. irrigation projects (IP's) in the country and presents irrigation development options and investment strategies for the 1980's.

After background sections on irrigation in India and the USAID/I irrigation program, the authors review the technical and organizational aspects of 14. A.I.D. IP's and training programs in the states of Gujarat, Maharashtra, and Rajasthan. Most projects visited were inefficient or unreliable in distributing water to and within fields and lacked effective management between the plants and the water supply, leading to much underutilization (and waste of money) and inequity in benefit distribution. A review of the operations of the Command Area Development Authorities (CADA), the agency overseeing IP's, reveals poor overall control and coordination. To help redress these problems, a new management model for CADA, stressing policy management, is presented. Strategies suggested to improve IP's regard the distribution of irrigation water and the equity of this distribution and include a wide range of technical and management training options.

As guidelines for future A.I.D. irrigation investment policy, it is recommended that USAID/I: expand its technical staff and reduce farmer management unit size in medium IP's; set up a model management system in a medium IP; continue assessing the actual performance of IP's; and evaluate support to credit agencies in terms of specific objectives. A.I.D. should: develop a program to train Indian personnel in conducting diagnostic pre-investment surveys; encourage irrigation system technical innovations; develop power sources for quick and cost-effective tubewells; assist the Government of India in studying the nature and concentration of irrigation power needs; investigate remedies for waterlogged and saline areas; provide technical help in assessing and correcting siltation problems; support attractive minor IP's; and develop appropriate training programs in order to broaden water management expertise.

Appended are reports on water resource development, irrigation yield optimization, a canal supply rotational system, and on meetings between irrigation experts and Indian government officials.

42 PN-AAQ-702

Irrigation development options and investment strategies for the 1980's : USAID/Peru
Keller, Jack; Smith, Bryant; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.14, Mar 1984, viii, 53p., En
Project numbers: 9365942
Contract numbers: DAN-4127-C-00-2086-00

Results are presented of a rapid reconnaissance survey undertaken to determine a USAID/Peru strategy to support irrigated agriculture in the 1980's. Recommendations are that USAID/P support: (1) community-initiated micro-scale irrigation projects in the Sierra Region, along with incentive policies and services for Sierra agricultural development; (2) technical studies of, and private sector ventures in, commercially viable irrigation in the coastal region; (3) increased on-farm water management training; (4) further technical studies and research to support Upper Selva development; and (5) the gathering of data needed for near term, follow-on strategic planning. Included are suggestions for specifically recommended activities, as well as a statement of the main findings on which the recommendations were based. Part II of the report presents findings from certain related studies and the main arguments - based on discussions with farmers (in Quechua) and with Government of Peru operational personnel and on field inspections - supporting the above-noted recommendations. An annex provides further details. Eight tables are included.

43 PN-AAT-998

Irrigation sector strategy review
Keller, Jack; Coward, E. Walter; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Asia and Near East. India (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.35, Jul 1985, xxxxvi, 118p. : ill., statistical tables, En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

An analysis of India's irrigation sector is presented. The report reviews irrigation's role in the food and agriculture sector, describes India's irrigation agencies (mainly those of the central and state governments), assesses the key effects of A.I.D. irrigation assistance on institutional change and technology transfer, reviews major problems confronting the A.I.D. program, and suggests activities related to irrigation technology, institutional development, water user associations, and the productivity, equity, and economic returns of irrigation projects. A final section outlines four possible new program/project models: (1-2) direct assistance for canal irrigation system operation, management, and maintenance and for local projects which

generally fall outside the jurisdiction of State Irrigation Departments; (3) development of a model of improved system management through rehabilitation and disaggregation of a major canal reservoir system, plus ongoing management assistance; and (4) commercial groundwater development, to include technical assistance with pumpsets, improved applications systems, and marketing.

44 *PN-AAP-143*

Pakistan / USAID : irrigation development options and investment strategies for the 1980's

Keller, Jack; Bishop, A.A.; Weaver, Thomas F.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Development Support. Office of Agriculture (Sponsor)
WMS report, no.4, May 1981, vii, 18p. + 2 annexes, En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

Due to poorly maintained public watercourses and inadequate field ditches, water conveyance and application efficiencies are low in Pakistan's Indus Basin, the world's largest continuous irrigation system. This paper reports a study team's findings and recommendations for improving the system.

Given Pakistan's limited irrigation potential, the team recommends that A.I.D. adopt a twofold strategy, providing supplemental irrigation in rainfed hill areas by developing small irrigation reservoirs (tanks), and, where possible, developing tubewells outside of existing irrigation command areas. Such efforts, which should consider new technologies such as low pressure sprinklers and buried pipes, would help address equity issues and help farmers most in need. Specific programs recommended for A.I.D. support include: evaluation of existing shallow tubewell pumping; general analysis of the existing irrigation system to develop area models of water balance, quality, and drainage; a cost analysis of canal, watercourse, and on-farm irrigation improvements, followed by a shallow tubewell development program if appropriate; an applied research and development program to improve tubewell cost-effectiveness and to provide for in-country tubewell production; and extension of rural electrification to service tubewells, using increased generating capacity from direct river-run hydroelectric plants. The team also recommends increased A.I.D. support for politically acceptable water users' organizations, including distribution of training materials and training of field and professional personnel. Continued A.I.D. support of adaptive irrigation research is strongly urged.

45 PN-AAP-147

Project review for Bakel small irrigated perimeters
Keller, Jack; Meyer, Raymond E.; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.9, Jan 1982, xxii, 107p + 3 annexes, En
Project numbers: 9311007; 6850208
Contract numbers: AID/DSAN-C-0058

Evaluates irrigation/integrated farming project in Senegal's Bakel region. Special evaluation covers the period 3/80-11/81 and is based on document review, extensive site visits, and interviews with farmers, administrators, and project and other-donor personnel.

The project has not adhered to its design or the recommendations of the 1980 review team, and is not functioning as an integrated farming project, as no attempt has been made to introduce crops other than rice. Nonetheless, it can be viewed as a successful pilot effort which has exposed irrigation problems common to the Senegal River Valley and proven that high-yielding rice varieties can be grown there at close to their biological potential.

Farmers in the area are clearly educable - they rotate water efficiently, use short-season rice in dry fields, show interest in other crops, and in some cases adjust fertilizer use to soil conditions. However, they need more support: agents of the Senegalese Societe pour l'Amerragement et Exploitation du Delta (SAED) often lack experience in the techniques they are teaching; crop protection has been ignored; and due to lack of soil surveys, some farmers are growing flooded rice in unsuitable areas. Also, low nationally regulated rice prices may result in misallocation of farm resources; already farm federations are accumulating surpluses rather than sell at SAED prices. The project has been slow in collecting yield and production cost data.

Poor pumping plant maintenance, aggravated by problems with floats and fueling systems, is causing expensive, untimely breakdowns and drastically curtailed equipment life - problems which alone are sufficient to destroy the project's economic viability. Also, many pumping plants and penstocks which deliver water to the canals are poorly designed, the relationship between pump size and system size has been arbitrarily set, and farmers have not been helped to build water courses or level land. The project's solar thermal pump system is too materials-intensive (and maintenance-intensive) to be anywhere near cost-effective, and should be abandoned.

USAID/S lacks the capacity to manage complex projects such as this; an effective counterpart relationship has not been established; and no SAED offical participated in this evaluation (unusual in a joint project), nor were project personnel encouraged to cooperate with, or to learn from, the evaluation.

46 PN-AAT-988

Review of irrigation facilities operation and maintenance for Jordan Valley Authority
Keller, Jack; Hill, R.W.; et al.
Colorado State University. University Services Center
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Jordan (Sponsor)
WMS report, no.30, Nov 1984, xxvi, 78p. : ill., charts, map, statistical tables, En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

At the invitation of the Jordan Valley Authority (JVA), an A.I.D. consultant team visited the Jordan Valley to conduct a review of irrigation systems operation and maintenance (O&M). The review surveys, and recommends upgrading the main and subsystem O&M of, the irrigation projects in the Jordan Valley and Southern Ghors; emphasis is laid on water allocation and canal, pump station, drain, equipment, and special structure management and on the problems of silt and debris deposits, uncontrolled construction, and plugged pump screens. The team praises the JVA's general O&M performance, but urges that certain worn equipment and outdated procedures be replaced; recent organizational changes in the JVA's Irrigation Division are assessed favorably. A number of schemes to provide the JVA with better quality control and training are proposed, including an annual inspection tour, preparation of appropriate O&M manuals, and computerized management assistance.

47 PN-AAP-144

Thailand / USAID : irrigation development options and investment strategies for the 1980's
Keller, Jack; Clyma, Wayne; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Development Support. Office of Agriculture (Sponsor)
WMS report, no.5, Jun 1981, xiv, 40p. + 6 annexes, En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

A five-point USAID strategy to improve paddy farming in Northeast Thailand is detailed. The strategy calls for: (1) rehabilitating and/or completing existing small-scale irrigation systems with emphasis on on-farm water distribution; (2) developing new small-scale irrigation systems, i.e., reservoir systems and, where feasible, pumping from groundwater sources; (3) adopting a comprehensive approach to irrigation system development that includes on-farm water distribution and appropriate provision for operations and maintenance; (4) conducting operations research on ways to organize farmers in effective water use and maintenance of irrigation facilities; and (5) promoting increased and diversified agricultural production in the service areas of established irrigation systems, including attention to agricultural extension, market development, and food processing industry. Eleven AID-specific recommendations for planning and implementing on-farm water systems are listed.

48 PN-AAM-200

Social dimensions of Egyptian irrigation patterns
Knop, Edward C.; Sallam, Mohamed S.; et al.
Colorado State University
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
Egypt water use and management project : technical report, no.26, Sep 1982, ix, 26p., En
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Irrigation practices depend not only on physical conditions, but also on the socioeconomic patterns which influence farmers' lives. The Egypt Water Use and Management project team examined 28 sociological factors which could potentially influence farmers' irrigation behavior. Eleven of these factors showed significant statistical correlation with one or more of the 5 irrigation practices selected for study. The sociological factors were divided into: (1) background factors which could account for irrigation behavior in a general way and (2) situational factors which are related to types of behavior in particular sets of circumstances. Situational factors were found to have more significant correlations with irrigation behavior than background factors. Situational factors could also provide researchers with explanations for irrigation behavior. The study showed that a definite correlation exists between sociological factors and irrigation practices. (Author abstract, modified)

49 PN-AAT-688

Irrigation sector assessment : USAID / Haiti
LeBaron, Allen D.; Hill, Robert W.; Battikhi, Anwar M.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
U.S. Agency for International Development. Bureau for Latin America and the Caribbean. Haiti (Sponsor)
WMS report, no.36, Aug 1985, xxviii, 113p., En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

An assessment of Haiti's irrigation subsector is presented. The assessment covers infrastructure, sedimentation and its impact, system operation and water management efficiency, administrative issues, water charges and use efficiency, choice of irrigation water management technology, and institutional arrangements. The assessment's planning implications are analyzed in detail; stress is laid on solving key operational problems regarding the amount of water Haitian institutions are allowed to divert, the use of all the country's water resources, and equity in meeting the demands of agricultural and non-agricultural users. Recommendations include, inter alia, establishing an adequate

irrigation data base, developing and impartially enforcing adequate water use laws, assuring operation and maintenance entities with adequate operating budgets, extending on-farm water management and agronomic research information, and controlling soil erosion through revegetation and construction of dams and large terrace systems. A 4-page bibliography (1937-85) is included among the appendices.

50 PN-AAM-552

Mobilizing local resources for irrigation
Levine, Gilbert; Hart, Henry C.
Agricultural Development Council, Inc.
Research training network seminar report, no.22, Jun 1981, 16p., En

A seminar on mobilizing local resources for irrigation was held in Sri Lanka in August 1980 to provide an opportunity for sharing ideas and information, particularly from South and Southeast Asia; to identify knowledge useful to policymakers, planners and system designers; and to suggest directions for research relevant to irrigation development. This report summarizes the propositions agreed upon at the seminar under the headings of general objectives, types and amounts of resources, techniques for obtaining resources, irrigation administration, water user organizations, and experimentation. Following the summary outline are the keynote address on water management and the user, and abstracts of four theme papers: capturing the economic surplus created by irrigation; irrigation organization and social participation in the Philippines; mobilization of government resources for irrigation investment; and mobilization of local resources for irrigation through supportive changes in canal management.

51 PN-AAP-149

Sri Lanka / USAID : irrigation development options and investment strategies for the 1980's
Levine, Gilbert; Bagadion, Ben; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.11, Sep 1982, xvi, 45p. + 7 annexes, En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

Rather than explicitly considering irrigation development options, this paper identifies the problems facing Sri Lanka's irrigation sector and offers recommendations for their resolution.

First, the Government of Sri Lanka has not given sufficient attention to the role of irrigation in future agricultural development; relatedly, existing policies concerning crop diversification and intensification and fertilizer use need to be re-evaluated. Second, Sri Lanka's social, institutional, and legal infrastructure have not fostered farmer participation in irrigation systems development and management. Third, although Sri Lanka has developed expertise in irrigation system design and construction, it must

develop the same expertise in the operation, maintenance, and rehabilitation of those systems. Finally, greater emphasis must be placed on developing results-oriented irrigation management systems if optimum productivity is to be achieved.

52 PN-AAN-402

Farm irrigation system design, Kafr El Sheikh, Egypt
Ley, Thomas W.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.35, Mar 1983, xii, 80p. + 4 appendices, En
References p.77-79
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Level farm irrigation design methods, experience, and results from the Egypt Water Use and Management Project Kafr El Sheikh study area in Abu Raya District are reviewed in this three-part study. Part I reviews the Soil Conservation Service level furrow and level border design methods which have been used, as well as the effects of design parameter changes on irrigation performance, and presents HP-9825 and HP-67 computer and calculator programs for design. In Part II, design considerations for the Abu Raya area (and for areas with similar conditions) are reviewed by an analysis of the individual factors and parameters which affect level farm irrigation system design. The methods used in this case study should be applied in developing design recommendations in major areas having similar conditions. Part III of the report reviews the experience of the Kafr El Sheikh Team in implementing level irrigation designs in Abu Raya. Comparison of the improved methods with conventional methods shows that consistent water savings, labor savings, time savings, and improved efficiency result. The improvement package also gave improved crop yields. Design analysis is included to show how further design improvements should be made. Level irrigation design programs and user instructions for the HP-9825 and HP-67 are included in appendices. Advance-recession data plots from several farms where designs were constructed and evaluated are given in Appendix C. (Author abstract)

53 PN-AAP-342

Farm irrigation system improvement, Abu Raya, Egypt
Ley, Thomas W.; Litwiller, Kenneth E.; Metawie, Abdel F.
American Society of Agricultural Engineers
(American Society of Agricultural Engineers 1983 Winter Meeting, Chicago, IL, US, 13-16 Dec 1983)
ASAE paper, no.83-2580, Dec 1983, 18p., En
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

An on-farm water management improvement project in Egypt which identified problems with farm irrigation methods and practices is described in this paper from the 1983 winter meeting of the American Society of Agricultural Engineers. Suggested problem solutions were field tested, from which a demonstration program for improving surface irrigation evolved. Precision land leveling and level basin design were major components of the program. Improved efficiencies and water, labor, and time savings were consistently demonstrated. (Author abstract)

54 PN-AAR-141

Influence of farm irrigation system design and precision land leveling on irrigation efficiency and irrigation water management
Ley, Thomas W.; El-Kady, Mona; et al.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP project technical report, no.41, May 1984, xii, 97p., En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Presented herein are findings from studies of conventional farm irrigation systems at three locations in Egypt, along with the results of field trials which assessed land-leveling and system design improvements.

The typical irrigation method in Egypt involves surface gravity flooding of small flat or furrowed basins. Basin size depends on field levelness, farm size, crop patterns/rotation, and water supply, as well as farmer needs. The small basins require careful water management and high labor inputs for the construction of ditches and dikes and for the irrigation operation itself. Field trials at the three locations assessed: (1) precision land leveling to dead level; and (2) irrigation system improvements (level border strip or level long furrow design). Most of the trials were successful in improving irrigation efficiency and/or water control. Reasons for their success, or lack thereof, are reviewed herein, and further improvements or adaptations are suggested.

Generally, results showed that water delivery is a major factor in the success of on-farm irrigation improvements. Given a consistent and regular stream size of 25-30 liters per second, level long basins and level long furrows enable efficient and uniform

application of water. Results also showed the need to continue advising farmers on improved management practices for new irrigation systems, even after system construction is finished. If this factor is lacking, results can be worse than under conventional methods. (Author abstract, modified)

55 PN-AAM-708

Irrigation and production of rice in Abu Raya, Kafr El-Sheikh Governorate
Ley, Thomas W.; Tinsley, Richard L.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.9, Jan 1983, x, 63p., En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Over 4 years of studies by the Egypt Water Use and Management Project (EWUP) in on-farm rice irrigation and production in Abu Raya, Governorate of Kafr El-Sheikh, are reviewed. Included are descriptions of the irrigation and cropping systems, studies to define irrigation and production constraints, assessments of solutions, and descriptions of related pilot programs.

Irrigation water delivery studies show that modifying the rotation schedule in order to provide extra water during long off periods during the rice nursery period would enhance seedling development. Also, curtailing the 4-on, 4-off rotation by up to 1 month at the end of the season when rice is drying in the fields would reduce the water flowing directly into the drains.

Rice irrigation and production studies show that high on-farm conveyence losses, unlevel fields, and losses through perimeter bunds increase irrigation frequency and total application of more water than necessary; that current water supply in puddling fields is inadequate; that micronutrient deficiency of zinc reduces yield; and that soil salinity (which rice cultivation has proven effective in combating) may affect seedling development. Rice water requirements were measured to be near 8,000 square m/feddan (50% for evapotranspiration, 50% for percolation) - slightly above the Ministry of Irrigation's (MOI) water duty for rice. In one set of field trials, precision land leveling resulted in a 14% water savings. Field trials to test the effect of zinc application to nurseries produced significant yield increases. While mechanical transplanting of seedlings has been demonstrated, the need for special matted nurseries may limit wide-scale use.

A pilot demonstration program currently being implemented to improve on-farm water management in Kafr El-Shiekh is briefly described. Available results of the program for the 1981 rice crop are included.

Relevant recommendations made to the MOI are provided. (Author abstract, modified)

56 PN-AAR-144

Relation between irrigation water management and high water tables in Egypt
Litwiller, Kenneth E.; El-Kady, Mona; et al.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP technical report, no.61, Jul 1984, x, 83p., En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

High water table levels presenting hazards to crop growth were measured at field sites in upper, middle, and lower Egypt. Water table contribution to evapotranspiration was significant at each site. A water balance model of the water table aquifier was used to predict the effect of various interventions on water table levels. Desirable lower water table levels could not be maintained through on-farm irrigation efficiency improvement, which included lining of on-farm channels while using surface irrigation methods. Branch, distributary, and private canal lining would have negligible effect on water table levels. However, increasing drainage outflows could maintain desirable water table levels. Corresponding increases in required water deliveries would be expected. (Author abstract)

57 PN-AAL-807

Planning concepts for a flexible irrigation water management strategy in Asia
Lowdermilk, Max K.; Svendsen, Mark T.
U.S. Agency for International Development. Bureau for Asia. Office of Technical Resources
Sep 1982, 188p. + attachments, En

Nine key concepts for an A.I.D. irrigation strategy in Asia are discussed: (1) realism in assessing the availability of and the demand for water; (2-3) the importance of water management and of long-term institutional commitment to it; (3-4) use of diagnostic project analysis and of an experimental research mode; (5-8) the importance in projects of internal monitoring/evaluation, institutional development, and early and appropriate training elements; and (9) collaboration with other donors.

58 PN-AAS-773

Community participation and local organization for small - scale irrigation
Lynch, Barbara D.
Cornell University
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.34, Mar 1985, iv, 102p., En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

The success of small-scale irrigation projects often depends upon participation by small farmer beneficiaries. This study, based on experience in Asia, Latin America, and to a lesser extent in sub-Saharan Africa, examines forms of local organization (formal or informal) and types of participation (empowered/unempowered, direct/indirect); the impact of contextual variables (physical environment, water availability, local social structure, national economic and institutional context) on the local organization potential; and characteristics desirable in local organizations (accountability to constituents, ability to perform tasks and interact with development and regulatory agencies). A final section on agency roles in encouraging participation and local organization notes that effective local participation will depend on the agency's understanding of local irrigation factors - an understanding for which a baseline sociocultural study is critical - and on agency style and behavior (adopting a service rather than a construction orientation, employing a learning process approach that involves users early on, and having the community organizer act as a resource person who builds local technical and communication capacities). A 117-item bibliography (1952-84) is appended.

59 PN-AAL-614

Feasibility studies and evaluation of irrigation projects : procedures for analyzing alternative water distribution systems in Egypt
McConnen, R.J.; Aal, Farouk A.; et al.
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
Consortium for International Development
Colorado State University. Engineering Research Center
Jul 1982, vi, 41p. + 6 appendices, En. Technical report no.12
References: p.79
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

A host of opportunities is currently available for rebuilding Egypt's existing irrigation system and developing new systems. This report outlines a methodology for comparing various irrigation water distribution systems prior to implementing an irrigation program.

Following a brief discussion of benefit/cost analyses, the authors recommend use of partial-budget analyses (a related but simplified approach), largely because the data needed for detailed analysis are not always available. The partial-budget methodology presented here centers on the use of a set of worksheets (provided in an appendix). As an example of partial-budget analysis in action, the worksheets are used to analyze an irrigation system located in Upper Egypt near El Minya.

The report also discusses the relationship between partial-budget analysis and net present value analysis and compares the results obtained by each method. Finally, various methods for extending the usefulness of the analytical methods (e.g., post-analysis for design innovation and identification of missing data) are discussed.

60 * PN-AAQ-565

Watercourse improvement evaluation
McConnen, Richard; Martella, David; et al.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.63, May 1984, x, 62p., En
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

* EWUP, Colorado State University, Engineering Research Center, Fort Collins, CO 80523

Water course improvements made on two <<mesqas>> by the Egypt Water Use and Management Project (EWUP) - #10 at Mansuriya and #26 at Abyuha - were used to study the various methods of evaluating water course improvements. Partial budgets of benefits and costs for the two sites have been prepared in conjunction with determination of average crop yields per feddan for 1973-82. Results of the study indicated that significant cost reductions in design and construction are needed if water course improvement projects are to be economically viable. Explicit attention must be paid to the farmers regarding acceptance of the project, extensive dialogue about project objectives, minimum interference, and timely completion of the work. Although the two field sites were financially advantageous to the farmers, there was no consistent evidence of yield increases due to water course improvement. However, projects with longer data periods have indicated such increases. In economic terms, the Ministry of Irrigation must search for more efficient designs, construction techniques, and maintenance programs if the projects are to be beneficial to Egypt. Future water course improvement projects should recognize and adopt lessons learned from these evaluations. (Author abstract, modified)

61 PN-AAT-151

Comparative testing for water - pumping systems installed in Botswana : general research methodology and specific field implementation instructions
McGowan, Richard; Ashworth, John
Associates in Rural Development, Inc.
U.S. Agency for International Development. Bureau for Africa. Botswana (Sponsor)
9 Jul 1984, i, 55p. + appendices, En
Project numbers: 6330209
Contract numbers: 633-0209-C-00-1-24-00

A methodology to compare the productivity, cost, and reliability of alternative energy-driven water pumping systems such as windmills and solar photovoltaic pumps used in Botswana with similarly sized diesel pump sets is described.

The methodology, which aims at meeting the information needs of decisionmakers rather than technicians, judges pump performance with respect to output curves (water pumped as a function of total pumping head), the strength of the resource base (wind, sun), expected maintenance needs, time lost to breakdowns, the ease of installation, maintenance, and repairs, and the costs and training requirements associated with these operations. The experimental apparatus and the procedures needed to perform the testing are described, along with methodologies for data collection and analysis. Sample data collection sheets are among the appendices.

62 PN-AAL-683

Rotation water distribution system vs. continual flow water distribution system
Mona, El K.; Wolfe, John W.; Wahby, Hassan
Consortium for International Development
Colorado State University. Engineering Research Center
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
Egypt water use and management project : technical report, no.20, Apr 1982, vii, 25p., En
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Two types of irrigation systems introduced in Egypt under A.I.D.'s Water Use and Management Project - the traditional rotational system and the continuous flow system - were compared for effectiveness in water distribution as herein reported.

The two systems were compared on nine counts: (1) water savings; (2) acceptability to farmers; (3) equitable distribution of water; (4) length of interval between irrigations; (5) effect on water table; (6) land savings; (7) effect on seepage from canals; (8) effect on growth of weeds in canals; and (9) crop yield. Even allowing for generous margins of error to compensate for data inadequacies, results show that continuous flow irrigation was a marked improvement over the rotational system. The former freed land, eliminated detrimental fluctations in the water table, and reduced water waste by 1,000,000 cubic meters per year.

To achieve full benefits, farmers will need to adapt to this new system; the system should be directed by an irrigation engineer who regulates daily water flows. Recommendations for future continuous flow constructions and rotational flow modifications are made. (Author abstract, modified).

63 PN-AAN-326

Status and performance of irrigation in Thailand
Mongkolsmai, Dow
International Food Policy Research Institute
International Fertilizer Development Center
International Rice Research Institute
Rice policies in Southeast Asia project : working paper, no.8, Jun 1983, iv, 44p., En
Project numbers: 936411102; 936411114

The long-term development of irrigation in Thailand and its effect on rice yields are analyzed, using data from the period 1961-69.

After providing an overview of the historical development of irrigation in Thailand, the report examines the status and performance of irrigation projects in terms of area irrigated and rice produced. Different categories of state irrigation systems are set forth and irrigation projects carried out by local populations described. The regional distribution of irrigated lands is assessed and types of irrigation work by region are identified. Next, wet-season yields in irrigated and rainfed areas are compared. It is noted that while irrigated yields have surpassed rainfed yields, the gap between them has declined since 1968-69.

The costs of constructing, operating, and maintaining large, medium, and small irrigation projects and land consolidation and ditches and dikes projects are then discussed. Finally, prospects for addressing the irrigation objectives of the Government of Thailand's 1982-86 national development plan are assessed. It is concluded that rice yields are likely to increase as a result of expansions of both irrigated and rainfed areas. Twenty-two tables illustrate the text.

64 PN-AAT-428

Report of the Egyptian irrigation management systems by the USAID design team : manpower development and training
Morgan, M.J.; Haapala, Richard V.; Conklin, Robert B.
CH2M Hill International
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
May 1981, 44p. + 7 annexes : statistical tables, En
Project numbers: 2630042
Contract numbers: AID/OTR-C-1618

A design is presented for a Manpower Development and Training Program (MDTP), part of a proposed A.I.D. project (Irrigation Systems Management) to upgrade the institutional capabilities of Egypt's Ministry of Irrigation (MOI). The design team recommends that the MOI meet short-term needs for engineering staff through a training program, a recruiting

drive to attract newly graduated engineers, and an incentive program to reward outstanding MOI staff performance. The Water Research Center should have responsibility for the training program. Training should largely consist of short courses in the following order of subject matter priority: (1) irrigation design, construction, and construction methods, materials, and quality control; (2) operation and maintenance and on-farm water management; and (3) administration and management. Latter training should take place in the United States and be complemented by in-country seminars for senior managers. Also proposed are long- and short-term technical assistance, and on-the-job training for all MOI departments.

65 PN-AAQ-700

Prospects for small - scale irrigation development in the Sahel
Moris, Jon; Thom, Derrick J.; Norman, Ray
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.26, Jun 1984, xx, 160p., En
Project numbers: 9365942
Contract numbers: DAN-4127-C-00-2086-00

Water is the limiting constraint affecting all forms of land use in the Sahel. This report presents an overview of Sahelian irrigation, with special attention to small-scale development prospects, and advocates combining the respective desirable features of small- and large-scale irrigation programs.

After a general characterization of Sahelian irrigation (regional characteristics, hydrological resources, health aspects, small- and large-scale systems, emergent issues), basic irrigation concepts are defined and a detailed review of the irrigation spectrum (including small to large, traditional to modern, and bureaucratic to participatory systems) is presented. Mali's and Niger's irrigation systems (which include large schemes) are then described in detail, followed by case studies of small systems in these same countries. The social aspects of irrigation development - associated crops, occupational structure and ethnicity, migration, land and water rights, impact on women, labor constraints, social benefits and costs, entrepreneurship, cooperatives - are discussed. A final section reviews general issues (the economic environment, irrigation strategy, downstream impacts, maintenance, and needed large-scheme improvements) and specific small-scale sector needs (for communal management, technology development, on-farm water management, soil and water conservation, and research into traditional irrigation systems).

A 251-item bibliography (1957-84) and reports on Operation Riz-Mopti in Mali and on the Dallou irrigation system are appended.

66 PN-AAT-687

African irrigation : An overview, Annotated bibliography
Moris, Jon R.; Thom, Derrick J.; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
U.S. Agency for International Development. Bureau for Latin America and the Caribbean. Haiti (Sponsor)
WMS report, no.37, Aug 1985, xiv, 283p., En
African irrigation : an overview, v.3
Summary : PN-AAT-686
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

Working papers and bibliographies prepared by several experts in irrigation and related fields have been compiled to form this 1,554-item annotative bibliography on irrigation systems in Africa. Information has also been obtained from existing bibliographies and through computer searches of <<Dialog>> and <<Commonwealth Agricultural Bureaux Abstracts>>. Citations in French have been gathered from archival research done in Paris at the <<Ministere de la Cooperation>>, <<Club du Sahel>>, <<Bureau pour le Developpement de Production Agricole>>, and the <<Office de Recherche Scientifique et Technique d'Outre Mer>>. While this bibliography is extensive, it is not complete; some sources of information were not accessible because of time, financial, or other constraints. The citations are arranged alphabetically by author; subject and geographic indexes are provided.

67 PN-AAT-686

African irrigation overview, Vol. 1 : Summary
Moris, Jon R.; Thom, Derrick J.; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
U.S. Agency for International Development. Bureau for Latin America and the Caribbean. Haiti (Sponsor)
WMS report, no.37, Oct 1985, xxiv, 97p. + 2 appendices : statistical tables, En
African irrigation overview, v.1
Annotated bibliography: PN-AAT-687
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

The basic issue addressed in this continent-wide overview of Africa's irrigation experience is how A.I.D. can best promote irrigation that will help African nations achieve food security. First, 75 lessons learned from Africa's irrigation experience are presented (covering: irrigation potential versus demand; soils; existing systems; engineering; agronomy; environmental impact; social and economic factors; and institutional aspects), followed by 25 more specific rules of thumb for project designers

and field staff. The remainder of the review assesses the implications of these lessons for donors, examining 15 points on which donor policy decisions are required prior to investment and identifying the 9 most significant gaps in research or institutional effort which currently constrain irrigation. The authors suggest that A.I.D. give first priority to strengthening irrigation capabilities both within the USAID system and in host nations; other areas of importance are, inter alia, cooperation with other donors more active in African irrigation, inclusion of irrigation in farming systems research projects, support for remote-sensing drought warning systems, and further attention to small-scale irrigation. Appendices include summaries of four technical working papers used in compiling this volume, and 12 pages of references (1963-85).

68 PN-AAR-821

Influence of soil properties on irrigation management in Egypt
Moustafa, A.T.A.; Tinsley, R.L.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Technical report / Egypt Water Use and Management Project, no.64, Sep 1984, viii, 66p. : charts, map, statistical tables, En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351; NEB-0017-C-00-0022-00

The Egypt Water Use and Management Project conducted soil surveys in pilot areas on four irrigation canals, of which three were mostly vertisols (heavy clay soils) and the other entisols (sandy soils). This report reviews water management of these soils and discusses the influence of the soil type on the design and operation of Egypt's irrigation systems.

Although considered difficult soils to manage, vertisols can be irrigated fairly efficiently with minimum management due to infiltration characteristics which allow the soil water deficit to be replaced. Uniform water applications are generally possible even with highly variable flow rates. Since available water was considerably less than expected from clay soils, irrigation had to be planned around a deficit of 5-7 cm. Problems of canal maintenance in vertisols (areas of cracking and heaving, surface drainage due to sealing) suggest that canals lower than the farmers' fields and lift irrigation are preferable to raised canals and gravity irrigation in these areas.

Entisols are not suitable for surface irrigation; infiltration rates are too high, resulting in extensive conveyance losses. Distribution of water through the system is uneven and irrigation efficiency is very low, resulting in a high water table which partly compensates for this inefficiency by allowing subirrigation. Included are 16 tables and a three-page bibliography (1962-84).

69 PN-AAM-532

Status and performance of irrigation in Indonesia and the prospects to 1990 and 2000
Nyberg, Albert J.; Prabowo, Dibyo
International Food Policy Research Institute
International Fertilizer Development Center
International Rice Research Institute
Rice policies in Southeast Asia project : working paper, no.4, Feb 1982, iv, 56p., En
Project numbers: 936411102; 936411114

The extent of irrigation development in Indonesia and its future prospects are addressed in this study, one of a series on Southeast Asian rice policies.

Irrigated areas are inventoried by province, and rice production (and cropping intensity) are analyzed with the help of statistical tables. The efficiency of existing water management programs is then evaluated and efforts to rehabilitate irrigation systems and establish pilot tertiary plots aimed at demonstrating terminal water control are noted. Next, the operation and maintenance of irrigation systems is viewed organizationally, with reference to provincial and village-level lines of authority. Tertiary canal development and its effects on crop yields are examined, as are Sederhana irrigation schemes (small, run-of-the-mill, diversion weir projects). The economic feasibility of alternative irrigation projects, such as water impoundment, run-of-the-river diversion, and tidal reclamation, are evaluated. Finally, rice production and the extent of areas irrigated are projected to the years 1990 and 2000. It is concluded that continued expansion of irrigated areas is necessary, primarily in Java, and that more emphasis should be placed on small-scale expansion programs. A four-page bibliography (1963-81) of Indonesian and English sources is appended.

70 PN-AAS-245

Rice irrigation water management
Oad, R.N.; Fowler, Darlene A.
Colorado State University. University Services Center
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Dec 1983, iii, 20p. : ill., En
Project numbers: 9364127
Contract numbers: AID/DSAN-C-0058

The increasing scarcity of land and water resources requires rice farmers in Southeast Asia to adopt more effective water management techniques, according to this report. After listing the benefits of improved water management on rice production (e.g., enabling farmers to grow rice and other upland crops during the dry season, reducing conflicts over water supplies), the report describes both the climatic and resources conditions needed for optimum rice production and the traditional practices of rice cultivation such as land preparation and leveling and rice planting; particular attention is given to water application (paddy-to-paddy flow during the wet and dry seasons) and the relation of paddy flow to land use. After noting the importance of community- and government-based irrigation organizations in allocating water supplies (especially in

Asian countries, where reservoirs are lacking), the report concludes by discussing key problems affecting the management of water for rice agriculture in Asia - water control, the maintenance of channel banks, construction and maintenance financing, farmer participation, and farmer adherence to the rules established by irrigation organizations.

71 PN-AAM-196

Impact evaluation of Bone - Bone irrigation system in Luwu, South Sulawesi, Indonesia
Ohorella, M.G.; Kristanto, Kustiah; et al.
University of Hasanuddin
U.S. Agency for International Development. Bureau for Asia. Indonesia (Sponsor)
Mar 1981, ix, 57p., En
Indonesian ed.: PN-AAM-197
Project numbers: 4970244

Evaluates the socioeconomic impact of the Bone-Bone Irrigation subproject in Indonesia, part of the Luwu Area Development and Transmigration project. Special evaluation covers the period 1980-81 and is based on comparisons of pre- and postproject conditions of irrigated and unirrigated areas. of irrigated and unirrigated areas.

The Bone-Bone irrigation system has significantly increased rice production, land productivity, farm and household income, employment, level of consumption, and marketable rice surpluses. Rice yield has increased by 121%-212% due to double cropping, and net farm income in irrigated areas is almost twice that of unirrigated areas. In some irrigated areas, household income has increased even faster than net farm income. Total costs have tended to rise faster than gross farm income due to higher applications of chemicals, more use of animal labor, more hired labor, and higher land taxes. There is a substantial difference in income distribution before and after irrigation, with 54% of farmers having achieved higher income status. Labor utilization has also increased significantly (37-42%), although the increase is not proportional to the crop yield, due to increased animal labor. Marketable surpluses have increased by 32%-100%.

On the other hand, irrigation did not significantly increase labor or capital productivity or farm size distribution (although, apropos to the latter, future farm consolidation is likely).

It is recommended to: (1) extend the irrigation system to Sidomukti; (2) establish a uniform planting time for rice varieties with different maturation dates; (3) adopt mechanization or increase use of draft animals to overcome labor shortages during land preparation; (4) form a water user organization for effective water management during fluctuations in supply; and (5) provide facilities for reducing postharvest losses and providing postharvest training.

72 * PN-AAM-531

Irrigation and rice production in the Philippines : status and projections
Ongkingco, Pat S.; Galvez, Jose A.; Rosegrant, Mark W.
International Food Policy Research Institute
International Fertilizer Development Center
International Rice Research Institute
Rice policies in Southeast Asia project : working paper, no.3, Feb 1982, iv, 37p., En
Project numbers: 936411102; 936411114

* IRRI, P.O. Box 933, Manila, Philippines

The past and projected future impacts of irrigation on rice area, yield, and production in the Philippines are the subject of this report, a revision of a presentation made at a May 1977 workshop of the Rice Policies in Southeast Asia Project.

An analysis of area, production, and yield data between 1957-58 and 1978-79 at increasing levels of disaggregation shows that rice production grew steadily during the 1970's due primarily to adoption of modern varieties, increased use of fertilizer, and expansion of irrigated land. Annual yield increases due to irrigation ranged from 1.8 to 2.8 MT's per ha, depending on the quality of the irrigation. Increasing water supply to farms through improved water control and rehabilitation of deteriorated systems is recommended to increase yields.

Projections based on recent trends, current irrigation investment plans, and constant real prices show that production will almost match domestic consumption, with a small exportable surplus through most of the 1980's and a small net surplus later on. Projections based on a 6% increase in food demand indicate that an additional 340,000 ha of irrigated area would be needed by 1989 or 1990 at a cost of $400 million. A 10% fertilizer subsidy to reduce the disincentive of declining real farm prices would cost an estimated $250 million over the next decade. Conclusions are supported by 22 tables of data.

73 PN-AAN-638

Tanks of South India (a potential for future expansion in irrigation)
Palanisami, K.; Easter, K.W.
University of Minnesota. Institute of Agriculture, Forestry and Home Economics
U.S. Agency for International Development. Bureau for Science and Technology.
Office of Agriculture (Sponsor)
Jun 1983, ix, 137p., En. Economic report no.83-4
Project numbers: 931023609
Contract numbers: AID/TA-BMA-5

The potential for modernizing and improving tank (small reservoir) irrigation in the Indian state of Tamil Nadu is assessed.

After reviewing tank irrigation in Tamil Nadu and the problems affecting its performance, the report examines irrigation in the drought-prone Ramanathapuram District (where there is a large concentration of tanks), focusing on climate and rainfall,

irrigation sources, soil conditions, land use and cropping patterns, and farm labor. Data collected via interviews with farmers and officials on the characteristics and performance of 10 tanks of varying dimensions in the District are presented, covering, inter alia, tank scale and type; tank water supply, distribution, and management; encroachment; sluice location; and the role of water user organizations. It was found that 7 of the 10 tanks have inadequate water supplies 50-70% of the time and that a third of the farmers use supplemental water from wells. Two models - production function and simultaneous equation - are employed to measure the impact of varying water conditions on rice production; both reveal the critical importance of adequate irrigation water. Finally, channel lining and community wells are proposed as means of improving tank irrigation. A summary of findings and suggestions for further rehabilitation and research efforts concludes the report. Included are 37 tables, 5 figures, the production function model, and a 4-page bibliography (1935-82).

74 PN-AAR-658

Participant training plan : irrigation systems management project 391-0467
U.S. Agency for International Development. Bureau for Asia. Pakistan
Dec 1983; v.p. : Tables, En
Project numbers: 3910467

Given Pakistan's reliance on managed water for agricultural production, training for professional staff is critical to the improvement of its irrigation system. Identified herein are options for providing - under the A.I.D. Irrigation Systems Management Project - external participant training (degree, medium, and short term) for Government personnel in planning, designing, and managing irrigation systems and in governing the use of water delivered through those systems. A first section reviews Pakistan's agricultural sector, the status of the Indus River Irrigation system, and Pakistan's basic water policy stance; identifies the public agencies involved in irrigation management, training, and research; and details training needs and issues to be considered in developing the training system. Section Two provides information on: (1) programs and courses at selected U.S. universities (Colorado State University; Washington State University; University of Idaho; University of California, Davis; Utah State University); (2) undergraduate and continuing education programs at the Asian Institute of Technology; (3) on-the-job training opportunities at the U.S. Bureau of Reclamation; and (4) international short and medium course opportunities.

75 PN-AAT-764

Participatory experiences in irrigation water management : proceedings of the expert consultation on irrigation water management held in Yogyakarta and Bali, Indonesia, 16-22 July 1984
U.N. Food and Agriculture Organization
(Expert Consultation on Irrigation Water Management, Yogyakarta, ID, 16-20 Jul 1984)
(Expert Consultation on Irrigation Water Management, Bali, ID, 20-22 Jul 1984)
1985, 200p. : charts, maps, statistical tables, En

Proceedings are presented of an international conference, held in Indonesia in 1984, on farmer participation in irrigation water management. The report summarizes case studies from Indonesia, the Philippines, Sri Lanka, China, and India and reports on conference discussions on the meaning of participation, the roles of government agencies and farmers in irrigation management, the impacts of participation and the situations conducive to it, and the factors enhancing and inhibiting farmer participation. Recognizing the primary role of governments in this matter, conferees urged their commitment to farmer participation, e.g., by training agency personnel in participatory skills, removing legal and procedural constraints, and establishing pilot projects. Recommendations to donors included providing long-term support for national training programs and encouraging countries to establish policies that promote farmer participation in irrigation development. The full texts of the case studies are included, as are country papers from Bangladesh, the Republic of Korea, Malaysia, Nepal, Pakistan, Sierra Leone, and Thailand.

76 PN-AAT-880

Evaluation techniques
Podmore, C.A.; Eynon, D.G.
Colorado State University. University Services Center
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Oct 1983, i, 349p. + attachment : ill., charts, statistical tables, En
Diagnostic analysis of irrigation systems, v.2
V.1: PN-AAS-247
Project numbers: 9364127
Contract numbers: AID/DSAN-C-0058

A companion to a previously published study which provided a conceptual framework for the diagnostic analysis of irrigation systems, this manual presents a collection of 32 articles on evaluation techniques in this area. The articles are grouped according to four disciplines: sociology (5 articles); economics (5 articles); agronomy (9); and engineering (13). Although grouped according to discipline to make field use easier, the articles are also meant to complement one another within an overall interdisciplinary approach; hence, many articles located under one subject title are applicable to others. The article on sampling techniques located in the sociology section, for example, can be useful to economists and agronomists as well.

77 PN-AAR-138

Irrigation system improvement by simulation and optimization, Pt.2 : Application
Reddy, J. Mohan; Clyma, Wayne
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP project technical report, no.16B, Jan 1984, v, 35p., En, Ar
Pt.1: PN-AAR-137
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

Results are presented of a test, made on a 3.17-ha wheat farm in Pakistan, of a mathematical model for evaluating irrigation system improvement alternatives. In developing the model, water conveyance, application, and water use subsystem models were calibrated with data from the test site. Efficiencies of the existing irrigation system were 39% for application and 53% for conveyance. Optimal design of the application system with precision land leveling provided net benefits of PKR 3625, compared to PKR 2612 under traditional field conditions. Canal lining was not economical. Earthen improvement of the conveyance system yielded a net profit of PKR 3304. Improvement of both the application and conveyance systems almost doubled the total net benefits (although with an increased level of investment), largely due to an increase in irrigated area. The benefit-cost ratio of each improvement alternative was different. The difference in benefits between improving the conveyance system and improving the application system was small, but there was a significant difference in net benefits between any single improvement and the combined improvement of the application and conveyance systems. Ten tables are included. (Author abstract, modified)

78 PN-AAR-400

Optimal design of border irrigation systems
Reddy, J. Mohan; Clyma, Wayne
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP project technical report, no.17, Jun 1984, vi, 34p., En, Summaries in Ar
Project numbers: 2630017

A procedure combining simulation and mathematical programming to derive an optimal irrigation system design given scarce resources is described. A hydraulics simulation model for surface irrigation was used to develop relationships between water requirement efficiency and the system design variables. A crop production function was used to relate crop yield to the water requirement efficiency, while gross returns from the crop and the costs of water, labor, ditch construction, and crop production were considered in determining the combination of water requirement efficiency and design variables yielding optimum net benefit. Several system constraints (e.g., length and slope of field,

infiltration) were incorporated into the design process. Generalized geometric programming was applied to the optimal design of border and basin irrigation systems, using the length of run, inflow rate into the border, time of inflow, number of lengths of run, width of the border, and the number of border widths in the field as the design variables. Thirteen references (1960-80) and a 7-page bibliography of related technical reports and manuals are provided. (Author abstract, modified)

79 PN-AAR-137

Theory
Reddy, J. Mohan; Clyma, Wayne
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP project technical report, no.16A, Jun 1984, v, 23p., En, Ar
Irrigation system improvement by simulation and optimization, Pt.1
Pt.2: PN-AAR-138
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

A theory to evaluate improvement alternatives for an irrigation system by way of simulation and optimization is presented. A mathematical simulation model combining existing models of conveyance, application, and water use subsystems was developed and verified using available field data from Pakistan. A methodology for the optimal design of a level basin irrigation system is described. Irrigation system improvements alternatives such as canal lining, earthen improvement of the canals, and traditional and precision land leveling of the application system are evaluated. (Author abstract)

80 PN-AAR-623

Farm irrigation structures
Robinson, A.R.
Colorado State University. Engineering Research Center
Utah State University. Dept. of Agricultural and Irrigation Engineering
U.S. Agency for International Development. Bureau for Science and Technology.
Office of Agriculture (Sponsor)
Mar 1983, vii, 97p. + 4 appendices : ill., tables, charts, En. Handbook no.2
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

A handbook of information on small irrigation structures is presented. Individual sections treat: delivery channels and ditches and control, water measuring, and other structures; low pressure pipe systems; construction and installation of ditches and pipes; and operation and maintenance. Included are extensive bibliographies, a section defining terms used in the handbook, several technical appendices, and 75 figures and 6 tables.

81 * PN-AAL-391

Farm irrigation structures; water management synthesis project
Robinson, A.R.
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Consortium for International Development
Colorado State University. Engineering Research Center
Utah State University. Dept. of Agricultural and Irrigation Engineering
Sep 1982, 29p., En. Planning guide no. 4
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

* Also available in Spanish and French from the publisher

Although well-designed irrigation control structures are essential to successful on-farm water management, farm irrigation structures are often the most neglected part of an irrigation system. This illustrated report examines why farm irrigation structures are needed and what types of structures (turnouts, measuring flumes, drops, divisors, checks, gated pipes, spiles, siphons, and drops) are required.

Design considerations are examined and construction and installation needs are outlined. The importance of proper system maintenance is stressed. Finally, to improve on-farm irrigation structures, the authors recommend establishing educational programs for farmers, farmer organizations, and government agencies; having government agencies furnish designs for irrigation structures; and evaluating these structures after construction.

82 PN-AAR-145

Experience with water users' associations
Sallam, Mohamed; Naguib, Mohamed; et al.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
EWUP technical report, no.65, Jul 1984, viii, 66p., En, Summaries in Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

To fill the management gap between the government and the farmer, water users' associations (WUA's) mobilize local resources to manage an irrigation system, provide a communication link between government and farmers, and enable farmers to make decisions regarding irrigation. The potential of WUA's in Egypt's irrigation management system is explored in this report, which demonstrates that there is a sociopolitical network that manages the physical component of an irrigation system, and outlines specific procedures needed to organize such a network to provide the type of irrigation management desired by the Egyptian government.

In order to demonstrate where a WUA can be effective, namely, at the local level, the context in which the WUA functions is explored, with emphasis on the type of control and the levels of operation associated with the irrigation system. The report then presents the principles which guide WUA development (specific goals, local participation, local acceptability, and integration into the irrigation bureaucracy) and describes the stages in WUA development (introductory, planning, organization, operation, and continuation). Organizational and operational aspects - task assignments, and procedures for organizational maintenance, coordination, control, decisionmaking, communications network, adaptation, and conflict - are also explained. Work with farmers at Egypt Water Use and Management Project (EWUP) field sites, which was based on the above-mentioned procedures, shows that farmers can work with government to develop effective WUA's. (Author abstract, modified)

83 PN-AAR-817

Irrigation advisory service : a proposed organization for improving on - farm water management in Egypt
Sallam, Mohamed; Naguib, Mohamed; et al.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.66, Dec 1984, v, 30p., En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351; NEB-0017-C-00-0022-00

The feasibility of establishing an Irrigation Advisory Service (IAS) in Egypt and the form such an IAS should take in the Ministry of Irrigation is discussed.

An opening section on current in-country conditions reveals that, despite the conservative nature of Egyptian farmers and the lack of resources available to support an IAS, an IAS could serve as a viable mechanism for helping farmers meet their irrigation needs. The second section covers several specific points. Philosophically, the IAS should adopt an action-oriented systematic research procedure and should be composed of an interdisciplinary team embracing at least the fields of agronomy, economics, engineering, and sociology. Programmatically, the IAS should: (1) base planning on factual analysis; (2) focus on recognized needs; (3) maintain the flexibility needed to respond to long- and short-term situations and to emergencies; (4) use an educational approach directed toward improving farmers' ability to solve their own problems; (5) employ democratic methods in dealing with farmers; (6) orient programs to farmers' technical, economic, and social level; (7) have objectives that are clearly defined and understandable by farmers and by program evaluators; (8) employ well-trained and effectively supervised personnel; and (9) be realistic in allocating personnel, finances, time, and facilities. Concluding sections of the report discuss components of the IAS's internal structure (personnel, facilities and infrastructure, and procedures) and its need to establish external linkages. It is noted that final authority to establish an IAS rests with the Government of Egypt.

84 PN-AAR-717

Irrigation systems management project design report, Sri Lanka
Skogerboe, Gaylord V.; Brewer, Jeffrey D.; et al.
Colorado State University. University Services Center
Consortium for International Development
Sri Lanka. Ministry of Lands and Land Development (Sponsor)
U.S. Agency for International Development. Bureau for Asia. Sri Lanka (Sponsor)
WMS report, no.33, Dec 1984, xxi, 160p. + 12 annexes : ill., charts, maps, statistical tables, En
Project numbers: 3830080; 9311007

A.I.D.'s Irrigation Systems Management (ISM) Project in Sri Lanka will serve as the second phase of a water management improvement program begun in 1979. Designed to promote reliable and equitable water distribution and national, district, and scheme-level institution building, ISM will be implemented at eight sites in the Amparai, Polonnaruwa, and Kurunegala Districts. Contained herein is a detailed description of the project, including component plans (financial, implementation, procurement); technical, economic, social soundness, and administrative analyses; and a technical assistance reference. The project will support irrigation construction activities, develop computer-assisted operations plans for water delivery, enhance operations and maintenance, improve financial practices, strengthen monitoring and evaluation, and continue training and research; a major thrust will be technical training to upgrade and maintain irrigation systems. The project is expected to enable some 55,000 farm families to increase agricultural production.

85 PN-AAS-240

Maintenance plan for the Lam Nam Oon irrigation system in Northeast Thailand
Skogerboe, Gaylord V.; Olansatien, Suphakiet; et al.
Colorado State University. University Services Center
Utah State University. Dept. of Agricultural and Irrigation Engineering
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Water management synthesis project : WMS report, no.13, Dec 1982, x, 278p. : ill., maps, statistical tables, En
Project numbers: 9364127
Contract numbers: AID/DSAN-C-0058

Catch-up and preventive maintenance plans are outlined for the Lam Nam Oon irrigation system in Northeast Thailand, which is deteriorating due to lack of manpower, equipment, and budget for proper upkeep.

Catch-up maintenance will involve emergency methods (constructing deep drains and replacing damaged lining panels), contract methods (providing surface and subsurface drainage), and force account methods, which will use resources supplied by the Royal Thai Operation and Maintenance Division. Equipment needs for these procedures are outlined and expected costs summarized.

The long-term maintenance plan calls for completing all drainage facilities, eliminating 90% of all sediment sources along irrigation channels, sealing all concrete lining panel joints, periodically replacing worn-out equipment, budgeting for maintenance materials, and adhering to a strict preventive maintenance program. A key recommendation is to provide technical assistance to water user groups and to strengthen their authority to prosecute system abusers. Included are 24 tables, 27 figures, and detailed appendices on the maintenance needs of specific Lam Nam Oon irrigation structures.

86 PN-AAT-996

Selected alternatives for irrigated agricultural development in Azua Valley, Dominican Republic
Skogerboe, Gaylord V.; Anderson, D. Craig; et al.
Consortium for International Development
Colorado State University. University Services Center
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
U.S. Agency for International Development. Bureau for Latin America. Dominican Republic (Sponsor)
WMS report, no.28, Aug 1984, iii, 23p. : maps, statistical tables, En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

Findings of a 2-week study to define options - primarily through public sector channels - for increasing the productivity of irrigated farming in the Dominican Republic's Azua Valley are summarized. The Valley's agricultural system and existing and planned irrigation infrastructure are briefly discussed in the context of recent water management problems. A narrative summary of the Secretariat of Agriculture's proposed complementary investment project for the Valley's land reform resettlement areas highlights the proposed project's six components (irrigation and drainage system construction, agricultural credit, acquisition of machinery and equipment, technical assistance, research support, and electric power system installation). Additional options for improving irrigated agriculture in the Valley are discussed, including A.I.D.'s On-Farm Water Management Project, rehabilitation of Puerto Viejo, and investment in Phase II of ongoing irrigation system construction. Proposals concerning the composition of project development teams conclude the paper.

87 PN-AAM-711

Discharge and mechanical efficiency of Egyptian water - lifting wheels
Slack, Roger; Wahby, Hassan; Clyma, Wayne
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.36, Jan 1983, vi, 29p., En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351

In Egypt and neighboring areas, where waterwheels are used to lift water from irrigation supply canals to field level, two important parameters in evaluating an irrigation system are the discharge per revolution and the mechanical efficiency of the waterwheel.

Data on 35 spiral-shaped waterwheels from the Mansuriya and Kafr El-Sheikh regions of Egypt were used to develop a field procedure for calibrating the discharge per revolution relative to the percent of submergence of the wheel. Thus, the rate and quantity of water applied to a field could be determined using data on the number of revolutions and the change in submergence of the wheel over time. A typical discharge per revolution of a 3-m diameter wheel, lifting water 75 cm, was 600 liters per revolution. In addition, a procedure was developed to determine a wheel's mechanical efficiency from field data. Data on 11 waterwheels from the Kafr El-Sheikh area were analyzed; the data indicated that a well-designed and maintained installation might be expected to have a mechanical efficiency of 45%. (Author abstract, modified)

88 PN-AAK-513

Consulting report : a survey and analysis of ex-post cost - benefit studies of Sahelian irrigation projects 0s0B
Sparling, Edward W.
Colorado State University. Dept. of Economics
1981, 25p., En

Existing ex-post cost-benefit analyses of irrigation projects in the Sahel are reviewed. The main lesson taught by the analyses is that decentralized and participatory small-scale irrigation of rice is a sound investment in the Sahel, whereas highly centralized, large-scale irrigation of rice is not. Policy recommendations reflecting these conclusions are provided. The need for additional cost-benefit data on large-scale, indivisible water diversion or impoundment facilities is noted.

89 PN-AAL-019

Irrigation and A.I.D.'s experience : A consideration based on evaluations
Steinberg, David I.; Clapp-Wincek, Cynthia; Turner, Allen G.
U.S. Agency for International Development. Bureau for Program and Policy Coordination
A.I.D. program evaluation report, no.08, Aug 1983, xii, 237p., En

Lack of good management is the principal reason that most irrigation projects have failed to reach their potential. Thus concludes this review of A.I.D. irrigation projects, based on impact evaluations, other studies, and a 5/83 AID-sponsored conference on irrigation management. Included are discussions of types of irrigation systems; social and economic impacts; policies and investment strategies; management; maintenance and rehabilitation; and project planning, monitoring, and sustainability.

Although irrigation normally improves yields, it is not a simple solution to food deficits. Socioeconomic impacts (on, e.g., civic participation, women, the environment) are difficult to assess. Irrigation systems range along a continuum from local management to external control. The former is most effective, yet traditional community-based systems are often ignored in policy considerations.

Problems of water management, either by water user associations or implementing agency, are exacerbated by donors' bureaucratic priorities; involving farmers in planning undoubtedly leads to improved management. System maintenance is also best done at the local level. Existing water user associations should be encouraged and equitable cost recovery from users fostered.

Irrigation project planning is subject to a series of pressures prompting hurried approval. Design problems include poor donor coordination and failure to adequately consider such factors as farmer needs, host country commitment, agronomic realities, and social context. Planning should be done within the context of natural resource strategy, and relationships between irrigated and nonirrigated areas understood. Issues such as system size, public vs. private, or rehabilitation vs. new construction are closely interrelated. Technology choice should allow maximum flexibilty in design, installation, and operation.

Agricultural triage (choosing between competing needs and goals) is usually dictated by fiscal constraints, but may reinforce income and social differences; a donor influencing policy should realize the implications thereof.

Appended are a 9-page bibliography (1950-83), a list of A.I.D. irrigation studies, summaries and a discussion of the impact evaluations, and the conference proceedings.

90 PN-AAK-258

Investments in large scale infrastructure : Irrigation and river management in the Sahel
Stryker, J.D.; Gotsch, Carl H.; et al.
Tufts University. Fletcher School of Law and Diplomacy
Stanford University. Food Research Institute
Jan 1981, iii, 117p., En
Project numbers: 6250929
Contract numbers: AID/AFR-C-1130

To determine whether large-scale irrigation infrastructure projects (IIP) in the Sahel are consistent with the Congressional mandate that A.I.D. projects benefit the poor majority, this report reviews existing IIP's and the Sahel's current irrigation needs in light of the mandate's legislative history.

The U.S. Congress, it is argued, is willing in principle to finance large-scale IIP's in the Sahel if it can be shown that no better alternatives exist and that the majority of benefits would accrue to small producers with secure land tenure. IIP's in the Sahel and worldwide, as well as the two largest IIP's in sub-Saharan Africa, in Sudan and Mali, are reviewed to develop a typology of IIP's aiding the poor. Results show that large-scale IIP's are likely to be costly and of scant benefit to the poor if carried out using capital-intensive construction and cultivation techniques (CCT), but that technically and economically viable alternatives exist which would substantially benefit the poor without being socially disruptive. The system envisioned would involve total water control and at least two crops per year, both labor-intensive and mechanized CCT's, traditionally based farmer organizations, and both commercial and food crop production.

A review of current irrigation systems and needs for river flow regulation in each Sahelian country and major river basin indicates that the potential for expanding rainfed agriculture and small-scale irrigation - development of which must begin now - is best in Chad, Mali, and Burkina Faso and poorest in Mauritania and Niger, with the Gambia and Senegal holding intermediate positions.

It is recommended that A.I.D. help develop the prototype IIP sketched above; promote agricultural development and irrigation in higher rainfall areas of the Sahel and facilitate immigration from those areas to areas with lower rainfall; promote research on marketing for irrigated cash and food crops and on the potential of cash crops for sustaining river basin development programs; train specialists for major river basin development; incorporate primary and secondary cost and benefit analyses into IIP's; and promote the use of a quantified, multi-objective, systems approach to river basin planning. Appendices detail the two surveys mentioned above.

91 PN-AAT-893

Nepal's small and medium scale irrigation sector : Report of the special US review team
Svendsen, Mark; Macura, Dan; Rawlings, Jim
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture
Nov 1984, vi, 39p. + 5 appendices : charts, statistical tables, En

In June 1984, three U.S. experts conducted an in-country study of Nepal's small and medium scale irrigation sector and assessed its needs for assistance. The team's key conclusions, presented herein, are: (1) Irrigation water management is the most neglected aspect of Nepal's water development; priority should be given to improving O&M in government-operated systems and a special O&M unit should be established. (2) Efforts to increase irrigation water supply should focus on capturing lesser tributary streams and on developing shallow groundwater for use in conjunction with existing surface supplies. (3) Community involvement (some 80% of irrigation in Nepal is farmer developed and operated) should be preserved; government assistance to farmer-managed systems should be limited to improvements that are beyond farmers' technical or financial capacity. (4) Technical assistance should promote institution building as much as irrigation development. (5) Rapid appraisal studies of existing systems and an institutional analysis of the irrigation sector should be undertaken.

Included are an overview of irrigation development in Nepal, discussions of recent irrigation sector reviews and of current governmental policy priorities, and (in appendices) tabulated socioeconomic data and 13 references (1981-84).

92 PN-AAJ-560

Swaziland water and related land resources framework plan
U.S. Army. Corps of Engineers
1981, 436P., En
Project numbers: 6980135

Large-scale irrigation and related industrial development can significantly contribute to the Government of Swaziland's (GOS) goals in the problem areas of employment, government revenue, foreign exchange, imports, and environmental degradation. This report is designed to provide a conceptual framework for future water resources development in Swaziland and to enable the GOS to effectively negotiate with its neighbors, particularly the Republic of South Africa (RSA), regarding development of international rivers. The report consists of: (1) an analysis of the impact of planned RSA water resources development on the supply and demand for water from the Komati, Lomati, Mbuluzi, Great Usutu, Ngwavuma, Ngwempisi, and Mkondo Rivers; (2) detailed preliminary plans and analyses of proposed water resources development projects on the Lomati and Komati rivers and in the Mbuluzi, Ngwavuma, and Usutu basins; and (3) a series of 21 baseline studies on population, soil conservation, water quality, recreation, tourism, fisheries, energy, ground water, land use, hydrology, hydropower, irrigation, water consumption, damsite screening, and the economy in Swaziland. The report points out that irrigation is the largest consumer of water and the key to the economic feasibility of water resources development; current and proposed RSA irrigation developments could significantly affect Swazi water development; and neither hydropower nor other

multipurpose uses of water development will add to the viability of Swazi water resources development. The report also highlights the need for: (1) detailed analyses of flow records, crop yields, and water resource development's impact on agricultural supplies and prices; (2) reservoir surveys, site investigations, and sediment, soil, and spillway design studies; (3) mathematical models capable of evaluating complex water systems; and (4) careful research and planning regarding attainment of long-term socioeconomic and environmental goals with only minimal short-term disruption. Also included are 13 maps on transport and land tenure in Swaziland and the physiography and hydrology of the nation, and a 71-item bibliography (1965-80).

93 PN-AAR-822

Evaluation of farmers' irrigation practices in El-Hammami sands
Tawfic, T.A.; Tinsley, R.L.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.74, Aug 1984, ix, 81p. : charts, statistical tables, En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351; NEB-0017-C-00-0022-00

A study of the farms of the El-Hammami area in the El-Mansuriya region of Egypt's Giza Governorate was carried out to evaluate three issues in the irrigation of sandy soils: (1) irrigation application efficiency at the farm level; (2) farmers' design criteria; and (3) water table contribution to water uptake by plants. The on-farm irrigation practices in the area indicated that the farmers at the beginning of the El-Hammami canal apply more water than do farmers at the tail end of the canal; the latter showed a higher rate of efficiency in irrigation application. The data also indicated that subsurface irrigation due to seepage from neighboring fields contributed substantially to crop water use. The study showed that surface irrigation might not be the best way to irrigate these sandy soils. Included in the report are 28 technical tables, 12 figures, and an 18-item bibliography (1955-82). (Author abstract, modified)

94 PN-AAL-388

Circular concrete irrigation turnout : design and construction
Trout, Thomas; Kemper, W.D.; Hasan, Hafiz S.
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
Colorado State University. Engineering Research Center
Utah State University. Dept. of Agricultural and Irrigation Engineering
Apr 1982, ii, 45p. + attachment, En. Handbook no. 1
Project numbers: 9310489; 9311007
Contract numbers: AID/DSAN-C-0058

Improved conveyance channel water control structures are very important for bettering on-farm water management and increasing irrigation efficiency. This handbook describes the design, construction, and use of an irrigation channel turnout for rotational distribution systems in Pakistan.

Initial sections provide a background explanation of the need for technological improvements in water diversion structures in traditional irrigation systems which suffer high losses of scarce water resources. The authors then describe the evolution of circular concrete check and turnout structures which was designed to be structurally sound, technologically efficient (i.e., made of local materials), and socially acceptable. Initial structural flaws and subsequent improvements to achieve optimum performance are indicated, allowing inferences on how irrigation structures to meet other needs might be developed. Explicit, illustrated instructions for fabricating and installing the concrete turnouts and panels are given in succeeding sections. Finally, alternatives to the basic circular design are examined. Information on the manufacture of concrete for small jobs is appended.

95 PN-AAT-150

Procedure for evaluating the cost of lifting water for irrigation in Egypt
Wahby, H.; Quenemoen, M.; Helal, Mohamed
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute. Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project report, no.7, Aug 1984, 39p. + 5 appendices, En
Project numbers: 2630017

An analytical model for assessing alternative water lifting systems in Egypt, designed for use by policymakers, is presented. The procedure computes the cost of lifting water from tertiary delivery canals to farmers' fields on the basis of a combination of 23 variables: economic factors, such as prices for energy, machines and repairs, and food; technical factors, such as state of the art and innovations in machines, energy sources, pumps, and methods of production; and political factors, such as government policies on energy prices, agriculture, and taxes. Following a detailed description of these variables and their computation, the model is illustrated with cost curves for sakias (animal-powered pumps), diesel pumps, and electric pumps using data sets

from two sources, Menoufia University and the Egypt Water Use and Management Project (EWUP); the cost curves are then tested for sensitivity by changing the value of individual variables. These examples arrive at contradictory conclusions for policymaking: the Menoufia data favor the electrification of pumping systems, while the EWUP data suggest use of the traditional sakia pumping system. Because the model allows the user to assign values to the variables, its use in assessing irrigation alternatives is recommended.

96 PN-AAT-997

Small - scale irrigation development
Walker, Wynn R.; Coward, E. Walter, Jr.; et al.
Consortium for International Development
Utah State University. Dept. of Agricultural and Irrigation Engineering
U.S. Agency for International Development. Bureau for Asia. Indonesia (Sponsor)
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
WMS report, no.32, Nov 1984, xxiv, 130p. : maps, statistical tables, En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

Design elements of a proposed A.I.D. small-scale irrigation development project in West Java and Eastern and Western Nusa Tenggara, Indonesia, are presented. The report analyzes the proposed project's overall institutional and social setting, provides a technical analysis of irrigation technology in Indonesia, describes the agrometeorological and social characteristics of the three project areas, and outlines proposed project activities in these areas and a project implementation plan. A 3-part project strategy is proposed: (1) Augment the rainy and dry season water supply in order to mitigate hydrological variations in rainfall-runoff processes that make irrigation water supply uncertain. (2-3) Alleviate the burden on the Public Works Department by making it responsible for basic water supply functions, while relying on village-level farmer organizations to operate and maintain the systems. Appendices include a list of related technical manuals and guidelines and an economic comparison of alternative run-of-the-river diversions.

97 PN-AAT-994

Rapid mini appraisal of irrigation development options and investment strategies for Tanzania / USAID
Weaver, Thomas; Keller, Jack; et al.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology. Office of Agriculture (Sponsor)
U.S. Agency for International Development. Bureau for Africa. Tanzania (Sponsor)
WMS report, no.23, Jan 1984, xv, 57p. : map, statistical tables, En
Project numbers: 9364127
Contract numbers: DAN-4127-C-00-2086-00

The Government of Tanzania's (GOT) recent emphasis on offsetting the effects of drought through small-scale irrigation projects that use local currency and self help is encouraged in this rapid survey of the country's irrigation sector. Incremental rather than long-term planning and the development of new irrigation technologies are urged. Overall, it is recommended that the GOT: upgrade the information networking capabilities of its Irrigated Agriculture Coordination Center; hire six new irrigation engineers for the Ministry of Agriculture's Irrigation Division and have them provide short-term training to civil engineers; and undertake a rehabilitation program for irrigation equipment (a six-point program is provided). Specific recommendations in other areas are included. One of the appendices expands on a caution made in the body of the report that the GOT not depend solely on irrigation to achieve food security; reasons cited are economic and institutional constraints, the existence of other ways to increase production, and the sensitivity of irrigation water itself to drought.

98 PN-AAP-141

Nepal / USAID : irrigation development options and investment strategies for the 1980's
Weaver, Thomas F.; Peterson, Howard B.
Utah State University. Dept. of Agricultural and Irrigation Engineering
Consortium for International Development (Sponsor)
U.S. Agency for International Development. Bureau for Development Support. Office of Agriculture (Sponsor)
WMS report, no.2, Mar 1981, iii, 10p. + annex, En
Project numbers: 9311007
Contract numbers: AID/DSAN-C-0058

The irrigation development options and investment strategies available to A.I.D. in Nepal's hill country are assessed.

First, review of development options concludes in favor of irrigation system improvement over expansion and of small- over large-scale projects. Considerable effort should be devoted to project design and to organizational implications, and consideration given to experimental delivery systems using pipesand conduits. On the whole, however, rainfed systems offer more promise than do irrigation systems.

Review of investment strategies advocates an integrated or indirect approach and stresses the need for broad guidelines for project selection, initial emphasis on physically and socially simpler situations, and, given reported difficulties with irrigation associations, downplaying farmer cooperation. The inclusion of both hardware and software systems and both main and on-farm systems is suggested, as is development of rural electric cooperatives as promoters of technological change. Assessment of the development potential of the Terai region is urged.

The study also notes that A.I.D. should not support irrigation development unless other needed outputs (e.g., better crop varieties) are included; that considerable technology is practiced by farmers and advisors in the hill country; and that assistance to the rural poor is hindered by rough physical conditions and lack of infrastructure.

A report on the Small Irrigation and Soil Conservation Project in Guatemala is appended.

99 PN-AAU-002

Small - scale irrigation : design issues in government assisted systems
Wensley, Christopher J.; Walter, Michael F.
Cornell University. New York State College of Agriculture and Life Sciences.
Dept. of Agricultural Engineering
Consortium for International Development
U.S. Agency for International Development. Bureau for Science and Technology.
Office of Agriculture (Sponsor)
WMS report, no.39, Jul 1985, v, 50p. : charts, En
Project numbers: 9364127
Contract numbers: DAN-1427-C-00-0086-00; DAN-4127-C-00-2086-00

Two governmental approaches to small-scale irrigation projects - the traditional "top-down" approach and an evolutionary approach - are analyzed. Advocating a blend of the two, the report highlights key issues relevant to each of the approaches. Conventional projects need to increase local participation in project identification, data collection, and technical design; fit the designs to the data; make designs site-specific and have them balance water use efficiency and equity; and assess the use of local contractors on a case-by-case basis. Advocates of the evolutionary approach should realize that: government experience in technically assisting local irrigation projects is generally sparse (the U.S. Department of Agriculture may provide a model); the investment needed to spur development is low if limited to the technology farmers are prepared to use; more needs to be known about how long farmers take to gain the confidence and skills they need to operate the systems at full potential; too much help can smother local initiative; and the most appropriate technologies may be traditional rather than modern.

100 PN-AAL-040

Peru : improved water and land use in the Sierra
Wilkinson, John L.; McKean, Cressida; et al.
U.S. Agency for International Development. Bureau for Program and Policy Coordination. Office of Evaluation
U.S. Agency for International Development. Bureau for Latin America and the Caribbean. Peru
A.I.D. project impact evaluation report, no.54, Dec 1984, ix, 21p. + 8 appendices, En
Loan no.527-T-059
Project numbers: 5270156

The key problem facing Peruvian agriculture is that of realizing more effective use of land and water resources. To this end, A.I.D.'s Improved Land and Water Use in the Sierra project (1976-83), called Plan MERIS after its Spanish acronym, included construction of irrigation and drainage works, investment credit for on-farm land development, complementary tree plantings, technical assistance, and training.

Although Plan MERIS did not reach its numerical goals for construction, beneficiaries reached, or total irrigated hectares (despite a 2-year project extension), all farmers, large and small, now have greater access to a reliable water supply. The infrastructure built under the project appears to be well designed and was constructed at a relatively low cost. However, for the most part neither credit nor technical assistance have reached the small farmers who were to be Plan MERIS's primary beneficiaries; in fact, the credit component has reached less than 1% of beneficiaries overall. Implementation shortfalls were largely due to the Government of Peru's budgetary difficulties; in this connection, revenues for future maintenance of the irrigation systems are not assured. The project's forestry component appears to be progressing adequately, although community awareness of the benefits of such activities is lacking.

On the whole, the Plan MERIS model is well-suited to small farm conditions in much of the developing world. However, it must be recognized that the primary purpose of such a project is to provide technical assistance and services based on an assured source of water for irrigation, not to provide irrigation works supplemented by technical assistance. Other implications of the Plan MERIS experience are: (1) beneficiaries should be involved in project activities from the early stages; (2) production credit and especially technical assistance must accompany investment credit; (3) financing should be ensured from the start, even if A.I.D. must shoulder the burden; and (4) in irrigation projects, land ownership patterns must be clearly understood and a realistic time period allotted for implementation.

101 PN-AAT-995

Identification and utilization of farmer resources in irrigation development : a guide for rapid appraisal
Yoder, Robert; Martin, Edward
U.S. Agency for International Development. Bureau for Asia. Nepal (Sponsor)
Apr 1983, 27p., En
Project numbers: 3670129

Wherever irrigation exists, there is also some form of organization for managing the system. This paper, based on experience in Nepal's Gulmi, Palpa, and Nawal Parasi Districts, alerts the reader as to what to look for in community irrigation organizations.

In Nepal, a broad range of local organizations and methods exist for developing and maintaining basic irrigation systems. The sophistication of each organization is directly related to how much labor must be mobilized to maintain the water delivery system. Specific examples are presented of existing practices in: (1) irrigation system construction; (2) water allocation and distribution; (3) operation and maintenance; (4) local resource mobilization; and (5) conflict management. The authors conclude that limited governmental resources can best be utilized by working with existing community organizations and mobilizing the local resources represented by them.

Included is an 18-page question guide for assessing local resources for irrigation development.

102 PN-AAJ-824

Non-agricultural uses of irrigation systems : Past experience and implications for planning and design
Yoder, Robert
Agricultural Development Council, Inc.
1981, 44P., En
Contract numbers: AID/OTR-0082-A-10-88

A review of developing country experience in using irrigation water for domestic and other nonagricultural purposes prefaces this study of the feasibility of designing multipurpose irrigation systems. Technical and cultural factors affecting feasibility are addressed, and multipurpose systems in various countries are cited to exemplify some of the principles governing system design. Outstanding issues include the paucity of research on design alternatives, system cost-effectiveness, the maintenance of water quality standards, the continuing emphasis on crop production at the irrigation system design stage, rivalry among host government departments and among donors over "turf," and disputes over water rights. Implementing a policy to incorporate non-agricultural uses into irrigation systems will require adding experts in these uses to the design team and shifting from a no-risk to an incremental improvement approach to planning. Recommendations are to conduct action research in several countries on the key issues, develop a methodology to assess community needs that could be met by an irrigation system, conduct a pilot project in designing a multipurpose system, and sensitize donors to the importance of the issue.

103 PN-AAR-818

Sociological evaluation of the on - farm irrigation practices introduced in Kafr El-Sheikh
Yousef, Sohair Kamal; El Attar, Ahmed; et al.
Colorado State University. Engineering Research Center
Consortium for International Development
Egypt. Ministry of Irrigation. Water Distribution Research Institute.
Water Research Center (Sponsor)
U.S. Agency for International Development. Bureau for Near East. Egypt (Sponsor)
Egypt water use and management project : technical report, no.67, Nov 1984, iv, 24p.,
En, Ar
Project numbers: 2630017
Contract numbers: AID/NE-C-1351; NEB-0017-C-00-0022-00

One of the major objectives of the Egypt Water Use and Management Project (EWUP) has been to experiment with various on-farm practices in order to improve irrigation management by farmers. The practices tested were precision land leveling, irrigation system design (long furrows and border irrigation), irrigation scheduling, field drain elimination, <<marwa>> improvement techniques, and specific plant and crop practices. This report presents the farmers' evaluation of each of these practices. Fifty-four farmer programs were conducted in a six-season time span (summer season 1980 to winter season 1983). The package of practices introduced by EWUP generally provided an increase in crop yield for the farmers, but the farmers have not accepted all of the practices; some are too expensive and cannot be supported by the existing institutional setting, some are not applicable in the field, and others are not seen by the farmers as appropriate to their present situations. While the practices themselves have demonstrated a positive effect on yields, the questions regarding farmers' ability to adopt the practices as presented by EWUP still remain to be pursued. (Author abstract)

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