PN-ABC-772

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AN ANNOTATED BIBLIOGRAPHY OF FACTORS AFFECTING PUMPING AND IRRIGATION IN AFRICA

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Africa Bureau
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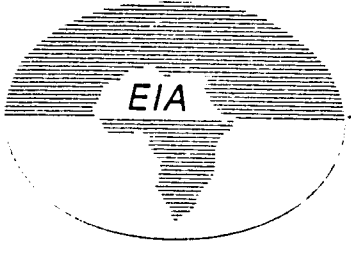
October 1985



ENERGY INITIATIVES FOR AFRICA
ENERGIE: INITIATIVES EN AFRIQUE
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT PROJECT 698-0424
ENERGY/DEVELOPMENT INTERNATIONAL

This bibliographic search was started in order to provide the background documents for the development of a methodology of economic analysis of water pumping projects, particularly the energy trade-offs in water pumping. The research has been conducted by John Gallup as part of the USAID funded Energy Initiatives for Africa project. In order to have accessible information about all the variables affecting irrigation, especially those that have traditionally not been included in economic analyses, the scope of this bibliography is wide.

The bibliography was prepared in June-September of 1985 to identify the most usable documents covering irrigation in Africa. These are documents which would make a good small reference library on the subject. The bibliography is arranged to progress from the general to the specific, ending with more extensive bibliographies and databases for the reader who wants further sources. While the choice of documents must be somewhat idiosyncratic, there are a comparatively small number of documents that are both general in scope and thorough in their treatment of the subject. The purpose of the bibliography is to bring together those documents most useful for actual evaluation of irrigation, not to list everything available. The irrigation documents listed in the bibliographies and databases cited below come to thousands, so this bibliography has culled the more rigorous general documents from those. Each of the documents annotated below has been read over to assess its usefulness.

The annotated documents, chosen out of many times their number, are those which serve one of three purposes. They are either:

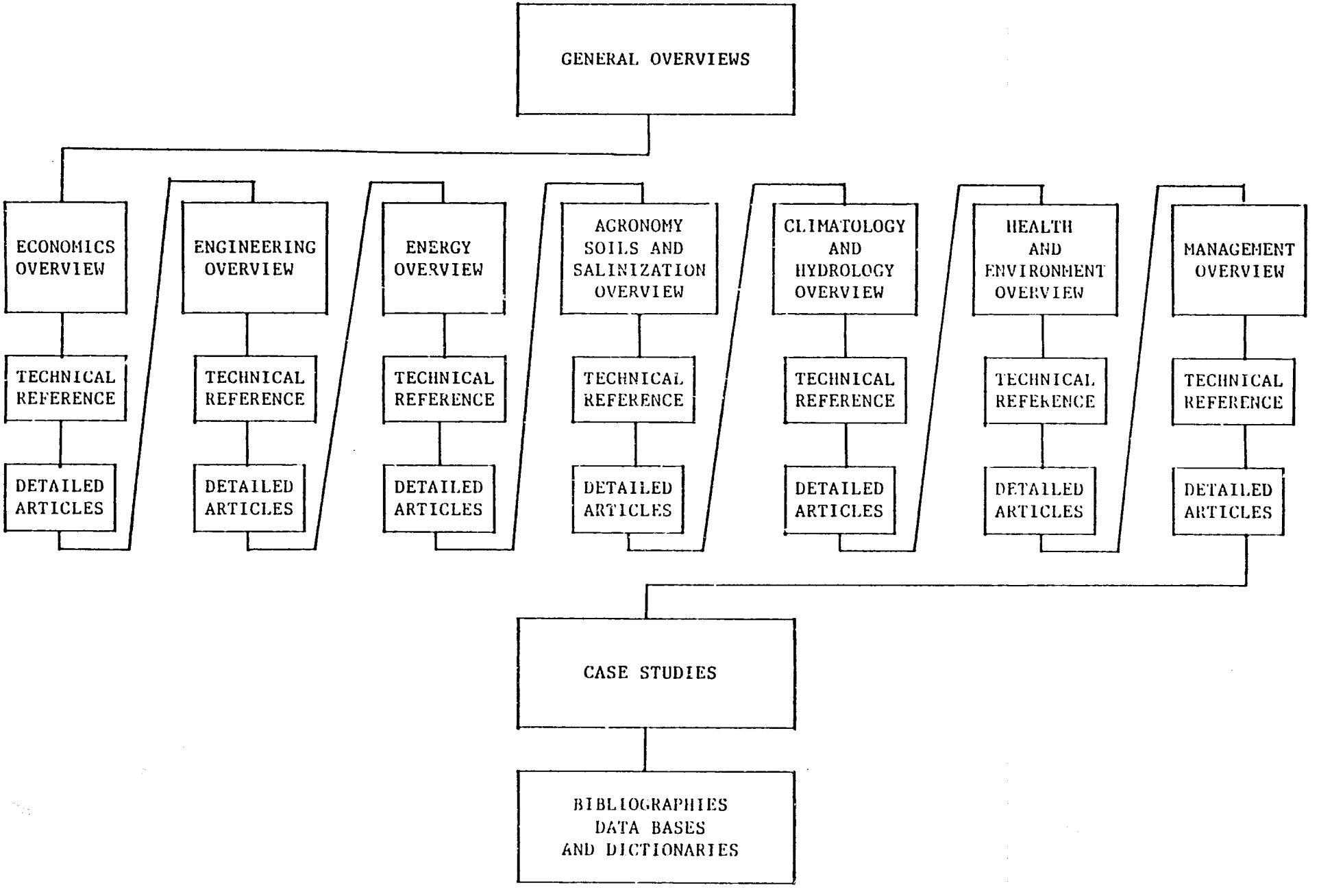
- Overviews of a subject or a practical handbook
- State of the art technical references
- Documents which more thoroughly describe particular features or which highlight interesting approaches

This structure is shown for each subject heading in the diagram below. Many documents cover material that falls in more than one subject category, but they are placed in the category of their primary emphasis. A few documents are put in more than one section. Additional sources are listed at the end of each section. The chronology of the sections in the bibliography is:

I. General Overviews

FIGURE 1

IRRIGATION BIBLIOGRAPHY:



II. Economics

III. Engineering

IV. Energy

V. Agronomy, Soils, and Salinization

VI. Climatology and Hydrology

VII. Health and Environment

VIII. Management

IX. Case Studies (by country)

X. Bibliographies, Databases, and Dictionaries

Within each category, the documents are arranged in order starting with those which best cover the subject and ending with those which are less thorough or clear.

French sources are few and far between in the U.S. The best place to look for them is in Sahelian Irrigated Agriculture: A Review of French Literature Sources (see under Bibliographies). This excellent bibliography includes a short assessment of the French state-of-the-art, but virtually none of the documents cited are available in the U.S.

This E/DI bibliography has a sprinkling of French-language citations, particularly case studies. The OECD economic assessment methodology (under Economics) was originally written in French, and its bibliography cites other documents in French. For further French sources, see the Transactions of the ICID conferences cited below. About a third of the conference papers presented are in French.

The case studies are not exhaustive and are presented more as examples of what is available than as a survey. Site specific case studies are the least likely irrigation documents to be published, and are usually found in dusty corners of government agencies and consulting firms. Many more case studies can be found in the bibliographies and databases cited below.

All the documents are listed alphabetically by author at the end of the bibliography.

Sources

The sources for these documents were the bibliographies and databases listed below, E/DI's own library, the A.I.D. Library in Rosslyn, Virginia, the National Agricultural Library, the Joint IMF/World Bank Library, the World Bank Sectoral Library, particular offices within A.I.D., the Water Management Synthesis II Project, the Egypt Water Use and Management Project, and the Library of Congress.

At the end of most citations there is an acronym indicating where the document can be ordered or seen. They acronyms are:

AID(__-___-___)
: Indicates AID microfiche that can be ordered in hard copy from:

  A.I.D. Document & Information
  Handling Facility
  7222 - 47th Street
  Chevy Chase, MD 20815
  Tel. 301 951-7191 or 301 951-9647

IMF/WB
: Joint IMF/World Bank Library
  Room IMF 530
  700 19th Street, N.W.
  Washington, D.C. 20433
  Tel. 202 477-7000

  The World Bank Libraries are not open to the public, but they do participate in inter-library loan. The only way to visit them is with the permission of a World Bank official.

E/DI
: This indicates that the only copy located in the bibliographic search is in E/DI's own library.

  Energy/Development International
  1015 18th Street, N.W. Suite 802
  Washington, D.C. 20036
  Tel. 202 822-8817

EWUP
: Order documents from:

  Egyptian Water Use and Planning Project
  Colorado State University
  Engineering Research Center
  Ft. Collins, CO 80521

Tel. 303 491-8655

LOC — Library of Congress
101 Independence Ave. SE
Washington, DC 20540
Tel. 202 287-5000

NAL — National Agricultural Library
Beltsville, Maryland 20705
Tel. 301 344-3355

NALDC — Branch of the NAL in the USDA building in Washington, DC. These documents should be moved to the NAL in Beltsville by January 1986. Tel. 202 447-3434.

NTIS — Order documents from:

National Technical Information Service
U.S. Dept. of Commerce
5285 Port Royal Rd.
Springfield, VA 22161
Tel. 703 487-4807

ODI — Order "Network Papers" from:

Overseas Development Institute
10-11 Percy Street
London W1P OJB U.K.
Tel. 01 580-7683

UNIPUB — Order documents from:

UNIPUB
P.O. Box 122
Ann Arbor, MI 48106
Tel. 800 521-8110
(Michigan residents: 313 761-4700)

VITA — Volunteers in Technical Assistance
1815 North Lynn Street
Arlington, VA 22209
Tel. 703 276-1800

WB Bookstore — Documents can be ordered from:

The World Bank
PUB H-2007
1818 "H" Street, N.W.
Washington, DC 20433
Tel. 202 473-2946

WB Sect — World Bank Sectoral Library
Room N145

801 19th Street, N.W.
Washington, D.C. 20433
Tel. 202 676-0153

The World Bank Libraries are not open to the public, but they do participate in inter-library loan. The only way to visit them is with the permission of a World Bank official.

WMSII Order documents from:

Water Management Synthesis II Project
University Services Center
Colorado State University
Fort Collins, CO 80523
Tel. 303 491-6991

I. GENERAL OVERVIEWS

Moris, Jon R.; Thom, Derrick. 1985. African Irrigation Overview. Water Management Synthesis II Project. Logan, Utah: Utah State University. Draft Copy. January. 70 p. WMSII.

Chapter 2 is a concise discussion of problems encountered in African irrigation showing the complexity of the factors involved. More complete and focussed than other overviews, but without technical detail. Divided into: Institutional Aspects, Potential for Irrigation, Conjunctive Groundwater Use, Soils, Environment, Engineering. Agronomy, Social Aspects, Economics, and Management.

Podmore, C.A.; Eynon, D.G.; Eds. 1983. Diagnostic Analysis of Irrigation Systems, Volume 2: Evaluation Techniques. Water Management Synthesis Project, University Services Center, Colorado State University. October. 349 p. WMSII.

Field handbook for the evaluation of the feasibility of a project. Outlines basic data gathering techniques and the different kinds of data needed for an evaluation. The low-tech common sense approach makes it good for small scale irrigation projects with small budgets for research and evaluation. Divided into four parts: Sociology, Economics, Agronomy, and Engineering. Volume 1 is more a discussion of report writing, management of project teams, and the importance of a interdisciplinary approach in planning than a discussion of irrigation. Volume I may be useful for small groups with little technical or managerial background.

Rydzewski, J.R., ed. 1977. Irrigation Development Planning (With Particular Reference to Conditions in Africa, South of the Sahara). Southampton: Southampton University. 236 p. WB Sect.

Overviews of existing African irrigation, water resources, social and health impacts of African irrigation, management and organization, and external assistance. List of African irrigation projects.

Stern, Peter H. 1979. Small Scale Irrigation: A Manual for Low-Cost Water Technology. International Irrigation Information Center. London: Intermediate Technology Publications. 152 p. WB Sect.

Provides basic information for small scale irrigation, soils, crop water requirements, simple engineering works and lifting devices. Written for those working with rural farmers on development and extension.

Sparling, Edward W. et al. 1980. Development Process for Improving Irrigation Water Management on Farms: Development of Solutions Manual. Colorado State University. Engineering Research Center, Fort Collins, CO. 3 vols. AID (PN-AAJ-361 - PN-AAJ-363).

A manual for water management, system design and economic analysis. Similar in design to Diagnostic Analysis of Irrigation Systems above, but on a much higher technical level. Presents a method for generating ideas and choosing between alternative solutions. The section on economic assessment is more useful. It includes discussion of risk aversion, credit, sensitivity analysis, externalities, shadow prices, water pricing methods, and income distribution effects. Good section on use of linear programming.

Steinberg, David. 1983. Irrigation and AID's Experiance: A Consideration Based on Evaluation. A.I.D. Program Evaluation Report No.8. Agency for International Development. August. AID(PN-AAL-019).

Broader and less focussed than the overviews above. Concentrates on Asia with little analysis of Africa. General summary is good, and includes several project impact evaluation summaries of projects in Sudan, Egypt, and Somalia.

Baumli, George R., ed. 1982. Principles of Project Formulation for Irrigation and Drainage Projects. New York: American Association of Civil Engineers. 132 p. WB Sect.

How to go about planning an irrigation project. Describes important considerations and variables rather than specific methods for choosing among them.

Additional Sources

Blackie, J.M., ed. 1984. African Regional Symposium on Small Holder Irrigation. University of Zimbabwe 5-7 September 1984. Wallingford, England: Hydraulics Research Limited. 437p. WB Sect.

9 articles covering general issues, project evaluation and management, design, the role of the farmer, and country-specific papers.

II. ECONOMIC ANALYSIS

Bergmann, Hellmuth; Doussard, Jean-Marc. 1976. Guide to the Economic Evaluation of Irrigation Projects. Revised Version. Paris: Organization for Economic Cooperation and Development. 257p. LOC, WB Sect.

The methodology is broken into 6 sections: basic data requirements, profitability at the farm level, profitability to the economy, ex post evaluation of projects, indirect effects of projects, and pricing of irrigation water. Discussion of the elements of economic assessment is thorough including problems of financing, but there is little explanation of the disciplines necessary to develop the basic data. Assessment tables and examples are included for organization of the variables. Technical bibliography with German, French, Italian, and English language sources.

Carruthers, Ian; Clark, Colin. 1981. The Economics of Irrigation. Liverpool: Liverpool University Press. Third Edition. 300 p. LOC, IMF/WB, WB Sect.

The standard technical text for irrigation economics. Shrewd practical discussion of engineering, agronomy and soils, hydrology and climatology, health, and management factors as they affect the economic analysis of irrigation. Includes project planning considerations and the economics of water use fees. Large bibliography and index.

Bhatia, Ramesh. 1984. Energy Alternatives for Irrigation Pumping: An Economic Analysis of Northern India. World Employment Programme Research Working Paper. Intl. Labour Organization, Geneva. December. 50 p. E/DI.

The paper has 3 objectives: to briefly review field experience with renewable energy devices in India; to outline a methodology for economic evaluation of alternative energy sources for pumping; and to discuss impact of non-economic and organizational variables on project viability. Economic methodology is especially clear.

Rydzewski, J.R. 1984. "Appraisal Techniques for Small-Scale Irrigation Development," African Regional Symposium on Small Holder Irrigation, University of Zimbabwe, 5-7 September 1984. pp. 25-40. LOC, WB Sect.

Concise review of irrigation project objectives and the use of cost-benefit analysis to assess them. Discussion of analytical techniques, market versus

social prices, valuation of unskilled labor, discount rates, sensitivity analysis and risk analysis.

Sinha, Basawan; Bhatia, Ramesh C. 1982. Economic Appraisal of Irrigation Projects in India. New Delhi: Agricole Publishing Academy. 487 p. NAL, WB Sect.

Authors advocate updating Indian Government methodology by including a time stream with a NPV calculation, shadow pricing, and proportional weights for benefits to poor farmers to quantify income distribution effects. The methodology is applied in a case study of the Auranga Project (India). Large bibliography.

Tak, Herman G. van der; Schmedtje, Jochen K. 1965. Economic Aspects of Water Utilization in Irrigation Projects. Report no. EC-132. Washington, DC: World Bank. January. 75 p. WB Sect.

Describes methods for economic analysis of choices in irrigation: crop rotation, farm water use, intensity of irrigation, groundwater vs. canal irrigation, drainage problems, etc. Paper assumes that data on hydrology, soils, water requirements, cropping patterns have already been developed. Doesn't seem dated.

Wahby, H.; Quenemoen, M.; Helal, Mohamed. 1984. A Procedure for Evaluating the Cost of Lifting Water for Irrigation in Egypt. Project Technical Report No.7. Egypt Water Use and Management Project, Colorado State University. 39 p. EWUP.

Model emphasizes importance of using marginal, not average cost. Describes sensitivity analysis and identifies variables likely to be sensitive. Costing methodology is thorough, but the benefit side is not included.

French, David. 1979. The Economics of Renewable Energy Systems for Developing Countries. AID and al Dir'iyyah Institute. January. AID(PN-AAG-864).

Excellent explanation of financial and economic cost-benefit analysis for those unfamiliar with it including: NPV, IRR, quantifying non-monetary benefits, high discount rates of rural poor, availability of credit, subsidization of loans, and shadow prices. Followed by case studies on renewable energy systems and an annotated bibliography of more highly technical background sources.

Hurst, Christopher. 1984. "A Model of an Indian Village: A Study of Alternative Sources of Energy for Irrigation," World Development. 12(2): 141-156. NALDC.

A description of a complex linear programming model used to maximize farmer profits. The model simultaneously chooses optimal crop mix, crop scheduling and energy source for irrigation subject to the constraints of land, labor, and fertilizer. This kind of economic assessment is what one would want to

prepare for a project if the resources and data available were unlimited.

Lal, Deepak. 1972. Wells and Welfare: An Exploratory Cost-Benefit Study of the Economics of Small-Scale Irrigation in Maharashtra. Series on Cost-Benefit Analysis, Case Study No.1. Paris: Development Center of The Organization of Cooperation and Development. 162 p. WB Sect.

This book applies the Little-Mirrlees cost-benefit methodology to irrigation in a particular district in India. This is perhaps the most thorough cost-benefit anlysis of irrigation found. It is not a good field methodology because of the consistent use of econometrics, but it is a rare example of a theoretically rigorous cost-benefit analysis of irrigation. Explains the background of each of the parameters used.

Allam, Mohamed Nasr; Marks, David H. 1983. Irrigated Agricultural Expansion Planning in Developing Countries: Performance vs. Resilience vs. Reliability. Technology Adaptation Program, Massachusetts Institute of Technology. 226 p. AID (PN-AAP-919).

Investigation of trade-offs for very large scale irrigation. Linear programming models used to explore relationships of economic efficiency vs. cost recovery vs. income redistribution, and investment costs vs. physical resilience of projects. Uses hypothetical case study on the Nile. Large technical bibliography.

Bruce, Colin; Young, Kimaro. An Economic and Social Analysis of the Chao Phya Irrigation and Improvement Project II. World Bank Staff Working Paper No.299. Washington, DC: World Bank. 42 p. WB Bookstore.

A project cost-benefit analysis using methodology of Little-Mirrlees, Squire - van der Tak for project evaluation.

Livingstone, Ian; Hazlewood, Arthur. 1979. "The Analysis of Risk in Irrigation Projects in Developing Countries," Oxford Bulletin of Economics and Statistics. 41(1) February, pp.21-36. NAL.

How economic theory applies to problem of choosing the land area for irrigation development when the water available to irrigate the land fluctuates from year to year.

Downs, J.B. "Project Appraisal Techniques - Is Irrigation a Special Case?" Transactions of the Tenth Congress on Irrigation and Drainage. New Delhi: International Commission on Irrigation and Drainage. Vol II, pp.33.251-33.258. NAL, WB Sect.

Author argues that the conventional application of cost-benefit analysis tends to underestimate the worth of irrigation projects for two reasons. One is that

the benefit stream increases much more than the cost stream over time. Future benefits are either underestimated in project appraisal, or the payoff period for the internal rate of return is too short for the true social worth to be represented. The second distortion is the lack of consideration of variable rates of inflation.

Golan, A.; Harris, R.L.P.; Whiteford, P.W. 1978. "The Use of Social Cost-Benefit Analysis for Irrigation Projects," Transactions of the Tenth Congress on Irrigation and Drainage, Athens. New Delhi: International Commission for Irrigation and Drainage. vol.III, pp. 33.439-33.460. NAL, WB Sect.

Suggest that project planners using cost-benefit analysis should add a term to represent the benefit to society of private consumption resulting from the project and attach weights to the benefit stream to account for the social consequences of changes in the income distribution. The proposed method is used in a case study.

Horsey, H.R. et al. 1984. A Technical and Economic Analysis of Low Lift Irrigation Pumping in Egypt. Project Technical Paper No.79, Egypt Water Use and Management Project. May. 221 p. EWUP.

Conclusions about specific pumps tested are site specific because of the low lift conditions in Egypt. Economic methodology is sound, but this is a consideration of alternative pumps, not irrigation systems.

Omara, Gerald T. 1984. Issues in Efficient Use of Surface and Groundwater for Irrigation. World Bank Staff Working Paper No.707. Washington: World Bank. WB Bookstore, IMF/WB, WB Sect.

Potential and historical solutions for the allocation of irrigation water as a scarce public good among competing users. Discussion of water management institutions, taxing and pricing instruments, and centralized control.

Seagraves, James A.; Easter, K. William. 1983. "Pricing Irrigation Water in Developing Countries." Water Resources Bulletin. August 19(4):663-672. NAL.

Review article of different pricing regimes for water according to goals of cost recovery and economic efficiency. Discussion of other goals and the project variables which affect them.

Nasim, Ansari. 19 8. The Economics of Irrigation Rates. Agricultural Research Center, University of Delhi. Bombay: Asia Publishing House. 360 p. NALDC, WB Sect.

Discussion of different pricing instruments and the practical constraints on implimenting them.

Bowen, Richard; Young, Robert L. 1983. Allocative Efficiency and Equity of Alternative Methods of Charging for Irrigation Water: A Case Study of Egypt. EWUP Technical Report #37, Colorado State University. March. 74 p. EWUP.
Linear programming model used to assess alternative taxing and rationing policy instruments.

Easter, W.K. 1980. Capturing the Economic Surplus Created by Irrigation. Dept. of Agricultural and Applied Economics, University of Minnesota. AID contract no. AID/NE-C-1507. July. 23 p. AID (PN-AAJ-926).
How the government can make rather than lose money on large irrigation schemes by charging user fees. Describes different methods of taxing beneficiaries.

El Shinnawi, Shinnawi A.; Skold, Melvin D.; Lasr, Mohamed L. 1980. Economic Costs of Water Shortages Along Branch Canals. Project Technical Report #5, Egypt Water Use and Management Project, Colorado State University. 58 p. EWUP.
Quantification of economic losses due to erratic delivery and inefficient use of irrigation water.

Silliman, Jael; Lenton, Roberto. 1985. Irrigation and the Land-Poor. International Conference on Food and Water, Texas A&M University, May 27-30, 1985. 27 p. E/DI.
How irrigation affects the rural poor and the potential for improving income distribution and equity of irrigation projects.

Lovejoy, Derek. 1984. Comparative Costs of Solar, Wind, and Diesel Pumping at Village Sites in Nigeria, Somalia and Zimbabwe. Dept. of Technical Cooperation Working Paper, UNDP. October. 12 p. E/DI.
Indicates important variables in comparing the economics of three power sources, but data are much too simplified for this to be used as site evaluation procedure.

Kleinmann, E. 1978. "Evaluation Economique des Projets d'Irrigation: Hausse des Couts d'Investissements, Causes et Consequences." (Economic Evaluation of Irrigation Projects: Rise in Investment Costs, Causes and Consequences.) Transactions of the Tenth International Congress on Irrigation and Drainage, Athens. New Delhi: International Commission on Irrigation and Drainage. vol.II, pp.33.143-33.160. NAL, WB Sect.
Examines the consequences of the exceptionally rapid rise in investment and operating costs of irrigation projects during the '70s. Several projects in the Sahel are analyzed and recommendations are made for how

to reduce costs in project design.

McConnen, R.J. et al. 1982. Feasibility Studies and Evaluation of Irrigation Projects: Procedures for Analyzing Alternative Water Distribution Systems in Egypt. Egypt Water Use and Management Technical Report No.12. Fort Collins, Colorado: Colorado State University. July. EWUP.

Authors advocate use of "Partial Budget Analysis" (the comparison of average annual costs and benefits) as an economic evalution method for irrigation. Though they acknowledge that this simple method can sometimes produce deceptive results because it ignores the time stream of costs and benefits, they argue that data are not available for more thorough evaluation procedures. Includes basic discussion of economic prices, depreciation, and learning over time. Has worksheets for calculation of net costs and benefits of different options in project design.

Harlaut, A. 1979. "A Practical Method of Evaluating Alternative Water Supply Systems for the Development of Rural Areas," World Congress on Water Resources, International Water Resources Assoc., Mexico. vol. 2, pp.1039-1048. NAL.

A framework for a qualitative rather than quantitative evaluation method proposed because of narrowness and deceptive exactness of cost-benefit analysis. More of a concept paper than a "practical method".

Tabors, Richard D. 1978. The Economics of Water Lifting for Small Scale Irrigation in the Third World: Traditional and Photovoltaic Technologies. MIT Energy Lab Working Paper #MIT-EL-78-015. August. 17 p. E/DI.

Short paper that attempts to determine on the scale of the whole Third World what power source to use for low lift irrigation and what is the minimum farm size for irrigation. Considers diesel, gasoline, electricity, photovoltaic, animal, and human power sources. Disturbing use of world-wide figures for value and cost of cubic meter of water pumped. Determines that PV is the most attractive system for the Third World if the cost of PV arrays decline as expected.

Keller, Jack; Riley, J. Paul; Hawks, R. John. 1972. Irrigation Design and Management Related to Economics. Report under AID Contract No.AID/cds-2459, Utah State University. September. 17 p. AID (PN-RAA-069).

Yadav, R.C. 1983. "Cost Functions of Water Conveyances for Gravity Irrigation". Transactions of the ASAE. 26(4):1090-1096. NAL.

Equations for calculating cost of underground pipe or open channel irrigation conveyance. Includes cost of materials and construction, maintenance, seepage and evaporation loss, and land occupied by channel.

I. T. Power Ltd. 1983. The Relative Economics of Windpumps Compared with Diesel Engine and Solar Photovoltaic Powered Pumps on Boreholes in Kenya. I.T.Power Ltd., Mortimer, Reading, UK. Ref:ITP/82034. July. 7 p.
Very short paper on economic implications of results of field tests of a windmill in Kenya.

Walters, Forrest E. n.d. Water Lifting by Sakia: Incremental Cost of Cow Power. EWUP Staff Working Paper No. 21, Egypt Water Use and Management Project, Colorado State University. 21 p. EWUP.
Interesting economic consequences of joint products of cows as power sources, milk and manure producers.

Additional Sources

ICID. 1978. Transactions of the Tenth International Congress on Irrigation and Drainage, Athens. New Delhi: International Commission on Irrigation and Drainage. vol.II, pp.33.143-33.160. NAL, WB Sect.
One third of the Congress was devoted to papers on the economic evaluation of irrigation projects. Besides the papers already cited above, see:

R. 28 The Use of Input-Output Analysis to Estimate Secondary Benefits of Irrigation Schemes, by R.F. Camacho and Anthony Bottomley.
R. 29 Integration of Socio-Economic and Engineering Perspectives in Irrigation Design, by I.D. Carruthers and N. Mountstephens.
R. 32 Analyse de la Demande en Eau d'Irrigation Incidence du Prix de l'Eau, by Francois Remy.
R. 43 A Stochastic Approach for the Evaluation of Drainage Projects, by Osman Ahmed Alghamry.
R. 48 L'Evaluation Economique des Projets d'Irrigation et l'Evaluation des Projets Hydrauliques a Buts Multiples, by OECD.
R. 49 Cost Effective Strategies for Alleviating Water Quality Degradation from Irrigated Agriculture, by Gaylord V. Skogerboe, James P. Law, and Wynn R. Walker.
R. 51 Project Evaluation, by Karl Lee.
R. 52 Economic Impacts of Delays in the Construction of Irrigation and Drainage Projects, by Jerry W. Knapp.

III. ENGINEERING

Black, David L.; Mason, Herbert M. 1983. Technical Guide to Water Management on Small Farms. Southwest Research Institute for AID Project No.93110930. AID (PN-AAJ-437).

Practical explanation of technical aspects of irrigation except for actual pumping. Covers: crop water requirements using Pan Evaporation Equation; land grading; basin, furrow, sprinkler, and drip irrigation; water quality problems (salinity, soil permeability, boron and heavy metal contamination); drainage; distribution systems and measurement of water flow; erosion control; watercourse losses.

In-depth background on these subjects is listed in annotated bibliography of AID-sponsored technical reports.

Griffin, et al. 1983. Pumps and Water Lifters for Irrigation. Handbook No. 3. Water Management Synthesis Project, Utah State University. July. 75 p. WMSII.

A step by step guide to calculating pumping system efficiencies.

Jensen, M.E., ed. 1983. Design and Maintenance of Farm Irrigation Systems. American Society of Agricultural Engineers. Revised Edition. 829p. NAL.

An extensive technical source book for conventional technology irrigation systems. Covers: soil-water interactions, salinity problems, water requirements, drainage, land shaping, pumps, distribution systems (including drip irrigation), and water scheduling.

Kraenkel, Peter L. 1984. FAO Irrigation and Drainage Paper: Prime-Movers and Pumps for Small-Scale Lift Irrigation. I.T. Power Ltd., Mortimer, Reading, UK. October. Second Draft.

Encyclopedic reference to small and medium sized pumping systems. Discussion of matching power source to pump in system. Meant to replace FAO booklet Water Lifting Devices for Irrigation, 1956. A "basis for comparing all present and (near) future options for lifting irrigation water on small and medium sized landholdings (0.25 to 25 ha.)."

Krout, Thomas J.; Kemper, Doral W. 1980. Watercourse Improvement Manual. Water Management Technical Report no.58. Colorado

State University. February. 244p. NAL, WB Sect.
A technical handbook that fully covers assessment of conveyance losses in watercourses and methods of upgrading the structures.

IIIC. 1979. Irrigation Equipment Manufacturers' Directory. Second edition. Bet Dagan, Israel: International Irrigation Information Center. 312 p. IMF/WB.
Lists extensive manufacturer-supplied information on equipment and services. Indexed by manufacturer and by equipment.

Bos, M.G.; Nugteren, J. 1974. Irrigation Efficiency in Small Farm Areas. New Delhi: International Commission on Irrigation and Drainage. 34 p. NAL.
Short technical treatment of means to calculate water use efficiency on farms using different irrigation techniques.

Horsey, H.W., et al. 1984. A Technical and Economic Analysis of Low Lift Irrigation Pumping in Egypt. Project Technical Report No. 79, Egypt Water Use and Management Project, Colorado State University. May. 221 p. EWUP.
Technical specifications and comparison of twelve different pump/power supply combinations for low lift irrigation.

U.S. Bureau of Land Reclamation. 1978. Drainage Manual: A Guide to Integrating Plant, Soil, and Water Relationships for Drainage of Irrigated Lands. Denver: U.S. Dept. of the Interior. 286 p. WB Sect.
Technical description of drainage requirements and construction according to the water table, soil characteristics, and salinity.

Kraatz, D.B. 1977. Irrigation Canal Lining. Irrigation and Drainage Paper No.2. Rome: Food and Agricultural Organization. 170p. UNIPUB.
Covers determination of need of lining, determination of seepage losses, design and construction, and selection of type of lining. 170 reference bibliography. Includes very large scale canal lining.

Horst, L. 1983. Irrigation Systems - Alternate Design Concepts. Irrigation Management Network Paper 7c. London: Overseas Development Institute. April. 18 p. ODI, WB Sect.
Argues that new engineering design concepts should be adopted to reduce the malfunctioning and poor operation of existing irrigation designs due to their complexity and maintenance needs.

Yoder, Robert. 1983. Non-Agricultural Uses of Irrigation Systems: Past Experience and Implications for Planning and Design. Management Network Paper 7e. April. 24 p. ODI, WB Sect.
Most irrigation systems are used for non-cropping

purposes particularly for domestic water needs and animal watering. Paper discusses factors affecting compatibility of uses and design requirements. Bibliography.

National Academy of Sciences. 1974. More Water for Arid Lands: Promising Technologies and Research Opportunities. Washington, DC: National Academy of Sciences. 153 p. WB Sect.

Gives overviews of water supply and water conservation methods: rainwater harvesting, irrigation with saline water, wells, reducing evaporation and seepage losses, etc.

Withers, Bruce; Vipond, Stanley. 1980. Irrigation: Design and Practice. 2nd edition. Ithaca, New York: Cornell University Press. 306 p. WB Sect.

A college textbook on irrigaton. Covers similar ground as Design and Maintenance of Farm Irrigation Systems (above), but with much less technical detail.

Finkel, Herman, ed. 1983. CRC Handbook on Irrigation Technology. CRC Press, Boca Raton, Florida. 2 vol. NAL.

A highly technical handbook that covers much the same subjects as Design and Operation of Farm Irrigation Systems (above), but seems less useful. Most of the tests and technology described are too complex and costly to be used in LDCs.

Wood, A.D.; Ruff, J.F.; Richardson, E.V. 1977. Pumps and Water Lifters for Rural Development. Colorado State University, Fort Collins, CO. June. 189 p. EWUP.

A large reference to small and medium scale pumps divided by type of pump. Drawings and actions of many low technology pumps. Similar to Prime-Movers and Pumps for Small-Scale Lift Irrigation above, but more limited in scope. Large bibliography.

Slack, Roger; Wahby, Hassan; Clyma, Wayne. 1983. Discharge and Mechanical Efficiency of Egyptian Water-Lifting Wheels. Project Technical Report #36, Egypt Water Use and Management Project, Colorado State University. January. 29 p. EWUP.

A scientific assessment of the efficiency of this traditional device.

Anonymous. Irrigation Efficiency: A Bibliography. Water Resources Scientific Information Center, U.S. Dept. of the Interior. 3 vol. covering 1968-1978. NAL, NTIS.

Mostly technical articles analyzing systems in OECD countries as well as some in LDCs. Annotated, indexed, and indicates whether document can be ordered from National Technical Information Service.

FAO. 1973. Trickle Irrigation. FAO Irrigation and Drainage Paper No. 14. Rome: Food and Agricultural Organization. 153p. UNIPUB.

Four articles by members of the European Commission of Agriculture Working Party on Water Resources and Irrigation that review research in drip and trickle irrigation. Practcial descriptions of techniques used.

Jorgensen, Venita. 1975. Drip Irrigation Information Center and Archive: Bibliography. University of California, Riverside. 45 p. NAL.

Lists most of the drip irrigation documents available up to 1975. Documents listed are available from BIO-Agriculture Library at UCal, Riverside. Not annotated.

Maclean, Jayne T. Drip and Trickle Irrigation 1979-1981 and 1982-1984. Quick Bibliography Series, National Agricultural Library. 2 vol. of 25 p. NAL.

Searches made on AGRICOLA in English only. No annotations. 488 citations in 2 volumes.

IV. ENERGY

I. T. Power Ltd.; Sir William Halcrow and Partners. 1984. Handbook on Solar Water Pumping. UNDP Project GLO/80/003. Executed by the World Bank. February. 124 p. UNIPUB.

Good "how-to" book to calculate all necessary elements for the assessment of solar-power as a pumping energy source. Good technical information yet accessible. Covers: description of photovoltaic technology, assessment of crop water requirements, solar energy availability, system sizing, and basic procedure for cost-benefit analysis. Includes sample data sheets for necessary inputs.

Anonymous. 1980. Report of the Commonwealth Workshop on Low Cost Energy for Water Pumping. Kanye, Botswana, 24-29 Nov. Commonwealth Science Council, Commonwealth Secretariat, London. 145 p. E/DI.

Organized as a sourcebook for information about biogas and wind power technology. Includes several annotated bibliographies, lists of suppliers of equipment, and review articles on the technologies as used in Africa and Asia. Very useful as an overview and for further sources of information.

Halcrow, Sir William, and Partners; I.T. Power, Ltd. 1983. Small-Scale Solar-Powered Pumping Systems: The Technology, Its Economics and Advancement: Main Report. UNDP Project GLO/80/003, Executed by the World Bank. London: Sir William Halcrow and Partners. June. 200 p. E/DI.

Up-to-date technical reference for solar-powered pumping systems. Detailed laboratory test results on all available PV pumping systems, and comparison of PV pumping costs with costs pumping with other energy sources in several LDCs. Finds that costs and reliability have improved considerably since 1981. More field testing will be conducted.

Bhatia, Ramesh. 1984. Energy Alternatives for Irrigation Pumping: An Economic Analysis of Northern India. World Employment Programme Research Working Paper. Intl. Labour Organization, Geneva. December. 50 p. E/DI.

The paper has 3 objectives: to briefly review field experience with renewable energy devices in India; to outline a methodology for economic evaluation of alternative energy sources for pumping; and to discuss impact of non-economic and organizational variables on project viability.

Hurst, Christopher. 1984. "A Model of an Indian Village: A Study of Alternative Sources of Energy for Irrigation," World Development. 12(2): 141-156. NALDC.
A description of a complex linear programming model used to maximize farmer profits. The model simultaneously chooses optimal crop mix, crop scheduling and energy source for irrigation subject to the constraints of land, labor, and fertilizer. This is the kind of assessment one would want to prepare for a project if the resources and data available were unlimited.

McGowan, Richard; Burrill, George. n.d. Current Developments in Photovoltaic Irrigation in the Developing World. Associates in Rural Development, Inc., Burlington, Vermont. 21 p. E/DI.
Describes current state of technology (reliability, longevity, costs, etc.), solar requirements and pumping head capacities.

Griffin, et al. 1983. Pumps and Water Lifters for Irrigation. Handbook No. 3. Water Management Synthesis Project, Utah State University. July. 75 p. WMSII.
A step by step guide to calculating pumping system efficiencies.

I.T. Power, Ltd. 1985. Evaluating the Technical and Economic Performance of Photovoltaic Systems: A Methodology. AID Report under Contract No. AFR-0510-C-00-4042-00. May. 108 p. AID (PN-AAT-156).
Handbook for field testing of photovoltaic arrays and pumps. Includes method for calculating cost of running pumps.

McGowan, Richard; Ashworth, John. 1984. Comparative Testing for Water-Pumping Systems Installed in Botswana: General Research Methodology and Specific Field Implementation Instructions. AID contract no. 633-0209-C-00-1-24-00. Burlington, Vermont: Associates in Rural Development. July. 55p. + append. E/DI.
Experimental procedure and analysis techniques for comparing wind, PV, and diesel powered pumping systems.

Horsey, H.R. et al. 1984. A Technical and Economic Analysis of Low Lift Irrigation Pumping in Egypt. Project Technical Paper No.79, Egypt Water Use and Management Project. May. 221 p. EWUP.
Conclusions about specific pumps tested are site specific because of the low lift conditions in Egypt. This is a consideration of alternative pumps, not irrigation systems.

El-Kady, Mona et al. 1984. "Power Requirements and Uses for Field Irrigation Lifting Devices in Egypt," Special Session: Twelfth World Congress on Irrigation and Drainage, Fort

Collins. New Delhi: International Commission on Irrigation and Drainage. Vol.I(c), pp. 523-560. WB Sect.
Analysis of energy requirements of different Egyptian irrigation lifting devices and potential for improving their energy efficiency.

Batty, J.C.; Hamad, Safa N.; Keller, Jack. 1974. Energy Inputs to Irrigation. Report under AID Contract No. AID/csd-2459, Utah State University. December. 25 p. AID (PN-AAA-948).
Energy requirements calculated for nine different types of irrigation systems. Includes energy inputs to manufacture components of the system, and install, operate and maintain the systems. Some of the systems are very complex and expensive.

Brandt, Hartmut; Hendricks, Klaus-Michael; Rathey, Rainer. 1982. "The Planning and Evaluation of the Use of Wind Pumps in Small-Scale Irrigation: A Case Study in Kenya," Quarterly Journal of International Agriculture. 21(2) April-June, pp. 122-138. NAL.
Authors optimization modeling reveals that combinations of wind pumps and diesel pumps are economically preferable to wind pumps alone under most cost and efficiency assumptions.

I.T. Power Ltd. 1983. Economic Comparison of Solar and Diesel Pumps. I.T. Power, Ltd., Mortimer, Reading, UK. June. 70 p. E/DI.
This volume actually contains a half dozen thumbnail sketches of various aspects of solar and wind power. The article named by the title is too short to be very enlightening, but there is a good method for choosing between solar irrigation pumps, and briefs cover the basic technical characteristics and suppliers of: PV panels, solar-powered water pumps, windmills, and wind-powered water pumps.

Lovejoy, Derek. 1984. Comparative Costs of Solar, Wind, and Diesel Pumping at Village Sites in Nigeria, Somalia and Zimbabwe. Dept. of Technical Cooperation Working Paper, UNDP. October. 12 p. E/DI.
Indicates important variables in comparing the economics of three power sources, but data are much too simplified for this to be used as site evaluation procedure.

Tabors, Richard D. 1978. The Economics of Water Lifting for Small Scale Irrigation in the Third World: Traditional and Photovoltaic Technologies. MIT Energy Lab Working Paper #MIT-EL-78-015. August. 17 p. E/DI.
Short paper that attempts to determine on the scale of the whole Third World what power source to use for low lift irrigation and what is the minimum farm size for irrigation. Considers diesel, gasoline, electricity, photovoltaic, animal, and human power sources.

Disturbing use of world-wide figures for value and cost of cubic meter of water pumped. Determines that PV is the most attractive system for the Third World if the cost of PV arrays decline as expected.

Hurst, Christopher. 1985. Energy and Irrigation in India. Employment and Development Department, International Labour Office. June. 134 p. E/DI.
Chapter 3 contains rough technical and economic data for pumpsets in India powered by diesel, electricity, biogas, photovoltaic array, wind, bullock, and hand. Assessment of relative costs of different energy sources.

Stacy, David B.; Stoner, Roy F.; Carruthers, Ian D. 1984. "The Energy Budget - Alternative Strategies for Energy Conservation," Special Session: Twelfth World Congress on Irrigation and Drainage, Fort Collins. New Delhi: International Commission on Irrigation and Drainage. Vol.I(c), pp. 377-404. WB Sect.
Because energy inputs now comprise such a dramatic part of irrigation costs, authors pinpoint ways to reduce energy input per unit of agricultural energy output eg. conjunctive use of ground and surface water and load shedding during irrigation.

Bunting, A.H. 1981. "The Future of High Yielding Variety Technology in Relation to Energy Cost," Promoting Increasing Food Production in the 1980s: Proceedings of the Second Annual Agriculture Sector Symposia, January 5-9, 1981. Washington, DC: World Bank. 499 p. WB Sect.
Overview of trade-off between increased yields of high yielding varieties and the energy inputs necessary to irrigate, fertilize and cultivate them.

Additional Sources

ICID. 1984. "Impact of the Energy Crisis on Irrigation and Drainage," Special Session: Twelth World Congress on Irrigation and Drainage, Fort Collins. New Delhi: International Commission on Irrigation and Drainage. Vol.I(c), pp. 177-560. WB Sect.
11 articles on energy problems in irrigation.

Anonymous. Irrigation Efficiency: A Bibliography. Water Resources Scientific Information Center, U.S. Dept. of the Interior. 3 vol. covering 1968-1978. NAL, NTIS.
Mostly technical articles analyzing systems in OECD countries as well as some in LDCs. Annotated, indexed, and indicates whether document can be ordered from National Technical Information Service.

V. AGRONOMY, SOILS AND SALINIZATION

Doorenbos, J.; Pruitt, W.O. 1977. Guidelines for Predicting Crop Water Requirements. FAO Irrigation and Drainage Paper No.24. Rome: Food and Agriculture Organization. 144p. UNIPUB.

Procedures for calculating crop water requirements by different methods, calculation of net irrigation requirements, and determination of field irrigation scheduling. Includes water requirement characteristics of many food crops.

Doneen, L.D.; Westcot, D.W. 1984. Irrigation Practice and Water Management, Revised edition. FAO Irrigation and Drainage Paper No. 1. Rome: Food and Agriculture Organization. 63 p. UNIPUB.

Practical guide for soil interactions with irrigation as they affect crop choice and irrigation method.

Yaron, Bruno; Vaadia, Yoash; eds. 1973. Arid Zone Irrigation. Ecological Studies 5. New York: Springer-Verlag. 434 p. WB Sect.

32 articles by specialists in agronomy, soil science, agrometeorology, water engineering, and plant physiology. A textbook in arid zone hydrology, soils, salinity, and crop water requirements as they affect irrigation design.

FAO. 1973. Irrigation, Drainage and Salinity: An International Sourcebook. Hutchison and Co., London. 510 p. NAL.

A large, thorough, highly technical volume. It explains in scientific detail the drainage and salinity problems described generally in Water Management on Small Farms (above, under Engineering).

Sanchez, Pedro A. 1976. Properties and Management of Soils in the Tropics. John Wiley and Sons, New York. 618 p. NAL.

"This book attempts to compile [all] the available information on the properties and management of tropical soils." Sections on physical properties, nutrients, fertility, and management practices. Many references.

Flack, T.E.; Podmore, T.H. 1985. African Irrigation Overview: The Soils Aspect. African Irrigation Overview Working Paper No.6. Water Management Synthesis II Project. Logan, Utah: Utah State University. March. 150 p. WMSII.

Soil descriptions for each of the sub-Saharan African

countries. Forty page annotated bibliography on the subject.

Ayers, R.S.; Westcot, D.W. 1976. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No.29. Rome: Food and Agriculture Organization. 97p. UNIPUB.
Water quality evaluation guidelines. Discussions of problems of salinity, permeability, toxicity, and others.

Shainberg, I.; Oster J.D. 1978. Quality of Irrigation Water. IIIC Publication No.2. Bet Dagan, Israel: International Irrigation Information Center. 65 p. WB Sect.
Describes chemical problems of salinity and heavy metal concentrations, and irrigation management necessary to control the problems. Bibliography.

Doorenbos, J.; Kassam, A.H. 1979. Yield Response to Water. FAO Irrigation and Drainage Paper No.33. Rome: Food and Agriculture Organization. 193p. UNIPUB.
Part A: Calculation of maximum and actual yield, and maximum and actual evapotranspiration.
Part B: Yield response data for 25 crops.

Humpal, Donald S. 1985. Agronomy and Irrigation in Sub-Saharan Africa. African Irrigation Overview Working Paper No.5. Water Management Synthesis II Project. Logan, Utah: Utah State University. January. 153 p. Draft Copy. WMSII.
Very thorough, detailed review focused on rice, sugar cane, and cotton. Discusses agronomic problems of soils, new varieties, pest management, etc. Second half of document is a bibliography on the subject.

Hanks, Ronald J.; Hill, Robert Wimmer. 1980. Modeling Crop Responses to Irrigation in Relation to Soils, Climate and Salinity. Bet Dagan, Israel: International Irrigation Information Center (Distributed by Pergamon Press). 70 p. WB Sect.
Describes crop yield equations as a function of evapotranspiration, of transpiration, and more complex formulations including salinity and upward flow effects. Some equation of this sort must be used if one is to calculate the marginal benefit of irrigation water.

FAO. 1973. Drainage of Salty Soils. FAO Irrigation and Drainage Paper No.16. Rome: Food and Agriculture Organization. 84 p. UNIPUB.
Five articles by the European Commission of Agriculture Working Party on Water Resources and Irrigation. Covers techniques for reclaiming saline-alkali soils and drainage experience in Spain and Turkey.

Skogerboe, Gaylord V.; Walker, Wynn R.; Evans, Robert G. 1979.

Environmental Planning Manual for Salinity Management in Irrigated Agriculture. Office of Research and Development, Environmental Protection Agency. NTIS.

Francois, L.E.; Maas, E.V., eds. 1978. Plant Responses to Salinity: An Indexed Bibliography. U.S. Dept. of Agriculture, Berkeley, California. NAL.
An unannotated bibliography with over 2000 entries from 1900 to 1977 on salt and boron effects on plants. Computer searches on this bibliography can be made through USDA.

Additional Sources

ICID 1980. Subject C: Cropping Patterns to Suit Soil and Climatic Conditions. Proceedings of the Third Afro-Asian Regional Conference of the International Commission on Irrigation and Drainage, New Delhi. 23-28 October. NAL.
18 articles address this subject.

VI. CLIMATOLOGY AND HYDROLOGY

Hargreaves, George. 1977. World Water for Agriculture. Report under AID Contract No. AID/ta-c-1103, Utah State University. January. 177 p. AID (PN-AAF-056).

30-year climatic records were used to develop country tables of precipitation probabilities, temperature, humidity, sunshine percentage, potential evapotranspiration, and potential evapotranspiration deficits. A classification of climate for agricultural purposes is proposed.

Vincent, Linden. n.d. (1985). Prospects for Irrigation Development in Hydrological Environments of Africa: A Literature Review and Annotated Bibliography. African Irrigation Working Paper No.4. Water Management Synthesis II Project. Logan, Utah: Utah State University. 162 p. WMSII.

Comparison of rainfed vs. irrigated farming, assessment of African climatic resources, surface water resources, and groundwater. Second half of document is an annotated bibliography on the subject.

Dastane, N.G. 1974. Effective Rainfall in Irrigated Agriculture. FAO Irrigation and Drainage Paper No.25. Rome: Food and Agriculture Organization. 62 p. UNIPUB.

Includes measurement of effective rainfall, use of rainfall data in irrigation project design, and means of increasing effective rainfall. 60 reference bibliography.

Jones, K.R. et al. 1980. Arid Zone Hydrology for Agricultural Development. FAO Irrigation and Drainage Paper No.37. Rome: Food and Agriculture Organization. 271p. + append. UNIPUB.

Covers rainfall, evaporation and evapotranspiration, surface water, sedimentation, and groundwater. Technical.

Manning, H.L. 1956. "The Statistical Assessment of Rainfall Probability and Its Application to Uganda Agriculture," Proceedings of the Royal Society. B144, pp.460-80. NAL.

The first major article to try to model risk in small farmer agriculture.

Rudloff, W. 1981. World Climates. Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart. 632 p. NAL.

For every country, there is data for at least one

location. Includes mean monthly data for: temperature, precipitation, days with precipitation > 1 mm., hours of sunshine duration, percentage ratio of total sun duration to sun duration on cloudless days. Data apparently comes from the German Weather Service.

Additional Sources

Pisa, Maria G. 1984. Groundwater Irrigation: 1970-1984. Quick Bibliography Series, National Agricultural Library. 15 p. NAL.

Unannotated bibliography compiled from database search on AGRICOLA using only English language sources. 224 citations.

VII. ENVIRONMENT AND HEALTH

Worthington, E. Barton, ed. 1977. Arid Land Irrigation in Developing Countries: Environmental Problems and Effects. Oxford: Pergamon Press. 460 p. NAL, WB Sect.

An overview of the main environmental effects and problems of irrigation in the first section, and then about forty articles covering different environmental problems.

White, Gilbert F., ed. 1978. Environmental Effects of Arid Land Irrigation in Developing Countries. MAB Technical Notes No.8. Paris: UNESCO. 67 p. UNIPUB.

Good overview of different environmental problems.

Pal, S.P. and Roy, C.R. 1982. "Environmental Implications and Economic Evaluations of Large Scale Irrigation Projects: Some Methodological Issues," Margin: Quarterly Journal of the National Council of Applied Economic Research (New Delhi). 14, July, pp.29-40. IMF/WB.

This paper discusses how far conventional tools of economic analyses are applicable in the evaluation of environmental impacts of river basin projects.

Jewsbury, J.M. 1985. "Small Scale Irrigation Projects and their Implications for Health," African Regional Symposium on Small Holder Irrigation. University of Zimbabwe 5-7 September 1985. pp. 41-56. WB Sect.

Review of major disease problems that are often aggravated by irrigation development. Describes biological hosts and vector control techniques.

Finkel, Herman J. 1983. "Health Hazards of Irrigation," in CRC Handbook of Irrigation Technology. CRC Press, Boca Raton, Florida. Vol. 2 pp. 47-59. NAL.

Summary of major diseases encouraged by irrigation, hazards of irrigation with sewage water, ground water pollution, and surface runoff pollution.

Mather, T.H.; That, Trinh Ton. 1984. Environmental Management for Vector in Rice Fields. Irrigation and Drainage Paper No.41. Rome: Food and Agriculture Organization. 152 p. UNIPUB.

Describes disease control measures concentrating in 3 areas: snail control, mosquito control, and domestic water use and sanitary facilities. Irrigation scheduling is the most important element for controlling snails and mosquitos and is generally

beneficial for rice production.

Rafatjah, H.A.; Kuo, Chen. 1981. "Health and Irrigation Development," in Transactions: Eleventh Congress on Irrigation and Drainage, Grenoble. Internal Commission on Irrigation and Drainage, New Delhi. R. 56, pp. 913-928. NAL.

Evans, A.C. 1983. "Control of Schistosomiasis in Large Irrigation Schemes by Use of Niclosamide: A ten-year study in Zimbabwe," American Journal of Tropical Medical Hygiene. 32(5):1029-1039. NAL.

Assessment of cost per hectare to control Schistosomiasis with pesticides in large projects in Zimbabwe.

Choudhry, A.W. 1979. "Schistosomiasis Control in the Bunyala Irrigation Scheme: A Pilot Project in the Yala Swamp of Western Kenya," East African Medical Journal. 56(2):71-75. NAL.

Emphasizes importance of project planning that prevents snail or schistosomiasis infestion.

VIII. MANAGEMENT

Sagardoy, J.A.; Bottrall, A.; Uittenbogaard, G.O. 1982. Organization, Operation and Maintenance of Irrigation Schemes. FAO Irrigation and Drainage Paper No.40, Rome: FAO. UNIPUB.

Management and planning guide for establishing water user associations, operating project and pumping system, maintaining the irrigation system, and administration.

Bottrall, Anthony. 1981. Comparative Study of the Mangement and Organization of Irrigation Projects. World Bank Staff Working Paper No. 458. Washington, DC: World Bank. 274 p. WB Bookstore, WB Sect.

Defines the function of irrigation project management, the usefulness and equity of different organizational structures, the farmers' role in management, and makes recommendations for project management improvements.

Tiffen, Mary. n.d. (1985). Land Tenure Issues in Irrigation Planning Design and Management in Sub-Saharan Africa. African Irrigation Overview Working Paper No.2. Water Management Synthesis II Project. Logan, Utah: Utah State University. 80 p. WMSII.

A review of water law and land tenure in Africa. Second half of the document is an annotated bibliography.

General Accounting Office. 1983. Irrigation Assistance to Developing Countries Should Require Stronger Commitments to Operation and Maintenance. U.S. General Accounting Office, Washington. 48 p.

The GAO presented three main recommendations: require identification and funding plan for operation and maintainance costs, reduce recurrent costs in project design, and require that water user associations be formed before construction is carried out.

Easter, K. William. 1985. Recurring costs in Irrigation in Asia: Operation and Maintenance. USAID (ASIA/TR/ARD), Washington. 46 p.

A critique of project management, especially operation and maintenance, in India, Nepal, Philippines, Sri Lanka, and Pakistan.

Hotes, Frederick L. 1983. "World Bank Irrigation Experience," International Journal of Water Resources Development. 1(1).

Reprinted in: ODI Irrigation Management Network Paper 9d, April 1984. London: Overseas Development Institute. 14 p. WB Sect.

Irrigation Advisor for the World Bank reviews the management and project design factors he found crucial in the success of irrigation projects.

Bromley, Daniel. n.d. Irrigation Institutions: The Myth of Management. Department of Agricultural Economics, University of Wisconsin, Madison. 15 p. E/DI.

"As long as new irrigation projects are available to countries, that management effort is undermined. A moratorium on new irrigation projects would properly concentrate the collective mind on improved management of existing systems." Paper is very general - the above is the main point.

Additional Sources

Commonwealth Secretariat. 1978. Proceedings of the Commonwealth Workshop on Irrigation Management, Hyderabad, India, 17-27 October, 1978. London: Food Production and Rural Development Division, Commonwealth Secretariat. 264 p. WB Sect.

10 papers on the subject.

IX. CASE STUDIES

Botswana

Turral, H. 1981. An Investigation into the Cost Effectiveness of Wind Pumps for Irrigation in Botswana. RIIC, Kanye, Botswana. 49 p. VITA.

An assessment of wind as an energy source for vegetable irrigation. Explains the basic principles of windmills, and the agroclimate, soils and water supply in Botswana. Economic analysis made of when wind-powered irrigation is viable.

Mitchell, A.J.B. 1976. The Irrigated Potential of Soils Along the Main Rivers of Eastern Botswana: A Reconnaissance Assessment. Land Resources Division, Ministry of Overseas Development, Surbiton, Surrey, England. 220 p. NAL.

Egypt

Abdel Al, Farouk; Lybecker, Donald W.; Martella, David. 1984. Farming System Analysis of EWUP Case Studies. Project Technical Paper No.50. Fort Collins, Colorado: Colorado State University. May. 49 p. EWUP.

Summary of extensive farm-level data from Egyptian farms over a three year period and calculation of rates of return on various factors. Data on land used, crops grown, crop income and expenses, livestock income and expenses, etc. Missing the quantity yields of specific crops or crop prices. No analysis of reasons for trends.

Abdel Al, Farouk; Skold, Melvin. 1982. Farm Record Summary and Analysis for Case Studies at Abyuha, Mansuriya and Abu Rava Sites. Project Technical Report No.23, Egypt Water Use and Management Project. Fort Collins, Colorado: Colorado State University. April. 104 p. EWUP.

Raw data from each farm on the study sites that were used for Farm System Economic Analysis of EWUP Case Studies (above). Also missing certain prices and quantities implicitly used to calculate the values reported. No analysis.

More Case Studies of Egyptian irrigation can be found in other Egypt Water Use and Management Project publications.

Ethiopia

Makin, M.J. et al. 1976. Prospects for Irrigation Development around Lake Zwai, Ethiopia. Land Resource Study 26. Surbiton, England: Land Resources Division, Ministry of Overseas Development. 316 p. + volume of maps. WB Sect.

Large, thorough study of irrigation by region and by site. A good economic analysis has detailed price, yield and cost data.

The Gambia

Dey, Jennie. 1982. "Development Planning in The Gambia: The Gap Between Planners' and Farmers' Perceptions, Expectations, and Objectives," World Development. 10, May, 377-396. IMF/WB.

Challenges the view that irrigation development largely depends on engineering, agricultural and managerial inputs and argues with reference Gambian irrigation projects that new technologies may be adapted by farmers in ways that are incompatible with planners' objectives.

Kenya

Chambers, Robert; Moris, Jon; eds. 1973. Mwea: An Irrigated Rice Settlement in Kenya. Munchen: Weltforum Verlag. 539 p. NALDC.

15 articles about the long-running and well documented Mwea irrigation scheme including a social cost-benefit analysis.

Hogg, Richard. 1983. "Irrigation Agriculture and Pastoral Development: A Lesson from Kenya," Development and Change. 14, pp.577-591.

Comparison of capital intensive, centrally administered Malka Dakaa irrigation scheme with labor intensive, farmer-run Gafarsa project. High cost of Malka Dakaa has not had commensurate returns and the author recommends that lower cost locally-initiated irrigation efforts are more productive and successful.

Baarspul, J.A. 1971. "The Tana Irrigation Scheme: an integrated development project." Netherlands Journal of Agricultural Science. 19:76-84. NAL.

Outlines six steps toward improving yields for farmers on project: mechanized soil preparation, advanced sowing date, better weed control, increased feritlizer application, pest control, and irrigation and drainage.

Cursory cost-benefit analysis.

Singleton, Carey Bryan. 1974. A Case Study of the Effect of Organized Irrigation: The Mwea Irrigation Settlement, Kenya. Ann Arbor, Michigan: University Microfilms International. 374 p. NALDC.

Doctoral dissertation on a comparatively successful large scale state-run irrigation scheme. Includes extensive questionaire results on tenant practices.

Baum, Gerhard A.; Migot-Adholla, Shem. 1982. "South Kano Irrigation Scheme - Socio-Economic Adjustments in Rural Development Planning," Quarterly Journal of International Agriculture. 21, January/March, pp. 37-51. IMF/WB.

Assessment based on the experience of a recent working assignment in Kenya.

Nigeria

Ansell, Alison; Upton, Martin. 1979. Small Scale Water Storage and Irrigation: An Economic Assessment for South West Nigeria. Development Study No.17, Department of Agricultural Economics and Management. Reading: University of Reading. 97 p. NALDC.

A particularly clear presentation of an economic analysis. Has data covering a wide range of crops.

Wallace, T. 1981. "The Kano River Project, Nigeria: The Impact of an Irrigation Scheme on Productivity and Welfare," in Heyer, Judith; Roberto, Pepe; Williams, Gavin; eds. Rural Development in Tropical Africa. pp.281-305. NALDC.

Failure of project management to be interested in farmers' welfare caused the irrigation scheme to fail. The project made the farmers participating in it worse off.

Senegal

Franzel, Steven. 1979. An Interim Evaluation of Two Agricultural Production Projects in Senegal: The Economics of Rainfed and Irrigated Agriculture. Dept. of Agricultural Economics, Michigan State University. Working Paper No. 28. June. 65 p. AID.

One of the few evaluations to explicitly recognize that the trade-off in irrigation development is not between the returns to irrigation and leaving the land fallow, but between irrigation and the returns to rainfed or recession farming. Franzel finds that the rate of return on investing in improvements in rainfed farming techniques is considerably greater than the returns to

irrigation development.

Keller, Jack, et al. 1982. Project Review for Bakel Small Irrigated Perimeters. Water Management Synthesis Project. Utah State University, Logan, Utah. Report No. 9. 107 p. WMSII.

An example of the value of good interdisciplinary evaluations. The report focusses on those factors which are hindering the project from being as productive as planned. Most of the detailed technical information is not included.

USAID/RBDO. 1983. Integrated Development Project Papers. USAID/OMVS Project No.625-0621. many volumes. E/DI.

This project analysis fills a bookshelf with all its volumes. Although the project was not approved, the documents provide a wealth of detailed data on the Senegal River Valley. Unusually extensive economic analysis (vol.III, Section 1.0) for an African irrigation project.

Nesgos, George; Teagan, Peter W.; Carroll, Frank P. 1984. Assessment of Relative Economy of Alternative Options for Irrigation Pumping in Identified IDP Project Areas. Energy/Development International for AID Project No. 698-0424. 150 p. E/DI.

An extensive engineering and economic technical assessment of diesel and electric pumps in the Senegal River basin. Limited to the pumping aspects of irrigation and consequently considers only costs, not benefits.

LeBloas, Jean. 1983. Perimetres Irrigues de la Region de Bakel. USAID/RBDO Dakar. 29 July. 100 p. E/DI.

Concise analysis of present state of the Bakel perimeters and SAED, the Senegalese irrigation authority. Substantial technical data on the pumping systems used and the irrigation civil works.

De Rafols, W. 1982. Projet Action Ble - Dire: Economic Analysis. AID PD-BAG-096. 37 p. E/DI.

Cost-benefit analysis of this Malian project. Includes sensitivity analysis on some of the important variables.

LeBloas, Jean. 1984. Amenagement Hydro-Agricole de la Plaine de Dirol: Avant-Projet Sommaire. USAID/RBDO Dakar. March. 80 p. E/DI.

A well-researched project proposal full of data. The economic evaluation (from IDP project proposal, by Benjamin Stoner) is unusually extensive.

GERSAR. 1984. Rehabilitation, Feasibility and Detailed Design Studies of the Irrigation Project Areas on the Left Bank of the Senegal River: Podor Project Area, Synthesis Report.

GERSAR, Paris. January. 20 p. E/DI.
A short technical report mostly filled with data tables on costs and irrigation techniques. Nevertheless, data is sketchy for the evaluation attempted.

Ministry of Economy and Finance, Islamic Republic of Mauritania. 1981. Irrigated Agriculture. RAMS Project. Financed by USAID with cooperation of Checchi and Company, Louis Berger International, and Action Programs International. 102 p. E/DI.
Assessment of irrigation along the Senegal River with detailed data on cultivation techniques and costs, and market prices.

Diemer, Geert; van der Laan, Ellen C.W. 1983. Using Indigenous Skills and Institutions in Small-Scale Irrigation: An Example from Senegal. ODI Irrigation Management Network Paper 8b. London: Overseas Development Institute. October. 11 p.
Discussion of reasons for success of small-holder irrigation when large-scale SAED projects have performed so poorly.

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ENERGY IN AFRICA SERIES

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EIA

An Annotated Bibliography of Factors Affecting Pumping & Irrigation in Africa

This bibliographic search was started in order to provide the background documents for the development of a methodology of economic analysis of water pumping projects, particularly the energy trade-offs in water pumping. The research has been conducted by John Gallup as part of the USAID funded Energy Initiatives for Africa project. In order to have accessible information about all the variables affecting irrigation, especially those that have traditionally not been included in economic analyses, the scope of this bibliography is wide.

The bibliography was prepared in June-September of 1985 to identify the most usable documents covering irrigation in Africa. These are documents which would make a good small reference library on the subject. The bibliography is arranged to progress from the general to the specific, ending with more extensive bibliographies and databases for the reader who wants further sources. While the choice of documents must be somewhat idiosyncratic, there are a comparatively small number of documents that are both general in scope and thorough in their treatment of the subject. The purpose of the bibliography is to bring together those documents most useful for actual evaluation of irrigation, not to list everything available. The irrigation documents listed in the bibliographies and databases cited below come to thousands, so this bibliography has culled the more rigorous general documents from those. Each of the documents annotated below has been read over to assess its usefulness.

The annotated documents, chosen out of many times their number, are those which serve one of three purposes. They are either:

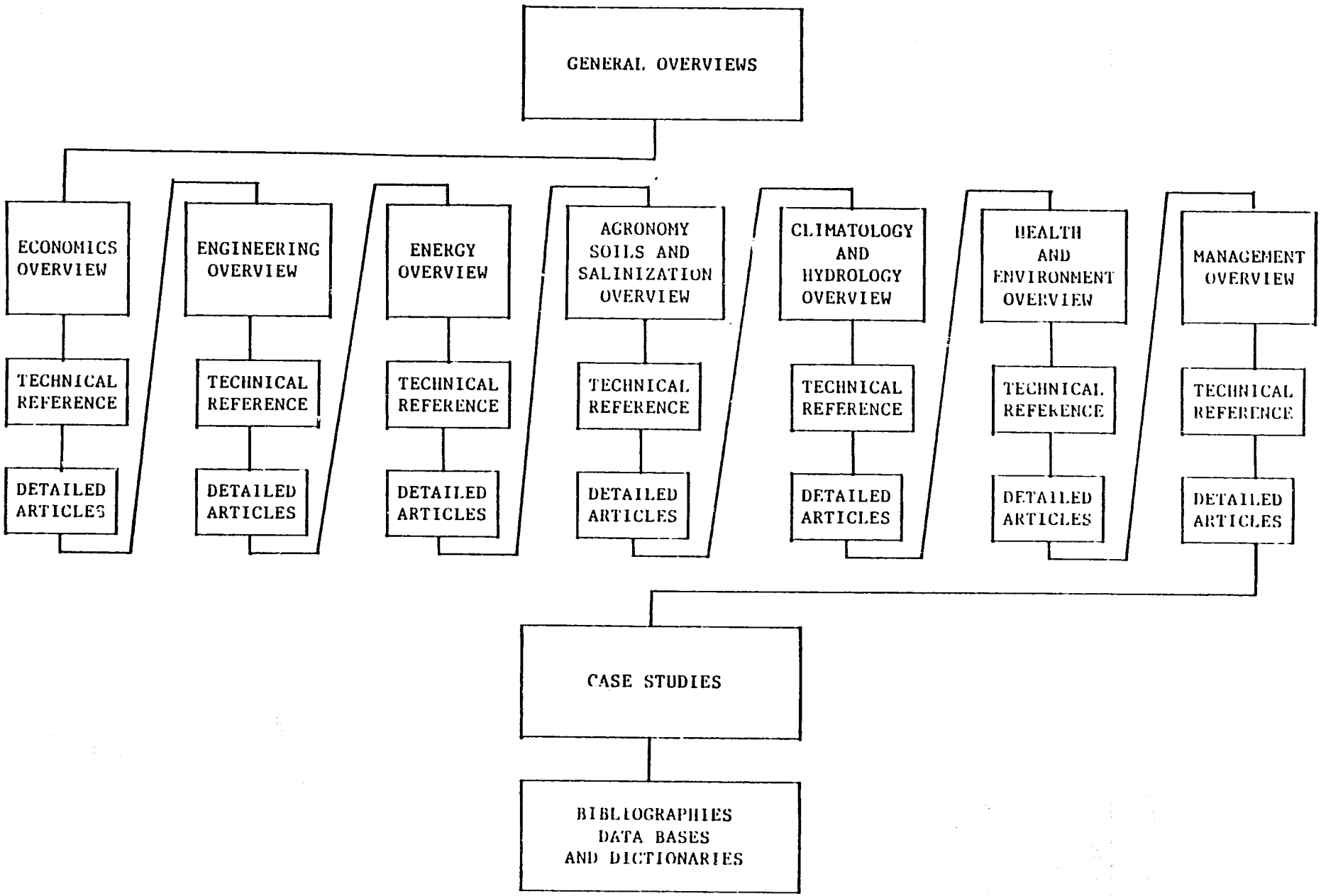
- o Overviews of a subject or a practical handbook
- o State of the art technical references
- o Documents which more thoroughly describe particular features or which highlight interesting approaches

This structure is shown for each subject heading in the diagram below. Many documents cover material that falls in more than one subject category, but they are placed in the category of their primary emphasis. A few documents are put in more than one section. Additional sources are listed at the end of each section. The chronology of the sections in the bibliography is:

I. General Overviews

IRRIGATION BIBLIOGRAPHY:

FIGURE 1



II. Economics

III. Engineering

IV. Energy

V. Agronomy, Soils, and Salinization

VI. Climatology and Hydrology

VII. Health and Environment

VIII. Management

IX. Case Studies (by country)

X. Bibliographies, Databases, and Dictionaries

Within each category, the documents are arranged in order starting with those which best cover the subject and ending with those which are less thorough or clear.

French sources are few and far between in the U.S. The best place to look for them is in Sahelian Irrigated Agriculture: A Review of French Literature Sources (see under Bibliographies). This excellent bibliography includes a short assessment of the French state-of-the-art, but virtually none of the documents cited are available in the U.S.

This E/DI bibliography has a sprinkling of French-language citations, particularly case studies. The OECD economic assessment methodology (under Economics) was originally written in French, and its bibliography cites other documents in French. For further French sources, see the Transactions of the ICID conferences cited below. About a third of the conference papers presented are in French.

The case studies are not exhaustive and are presented more as examples of what is available than as a survey. Site specific case studies are the least likely irrigation documents to be published, and are usually found in dusty corners of government agencies and consulting firms. Many more case studies can be found in the bibliographies and databases cited below.

All the documents are listed alphabetically by author at the end of the bibliography.

Sources

The sources for these documents were the bibliographies and databases listed below, E/DI's own library, the A.I.D. Library in Rosslyn, Virginia, the National Agricultural Library, the Joint IMF/World Bank Library, the World Bank Sectoral Library, particular offices within A.I.D., the Water Management Synthesis II Project, the Egypt Water Use and Management Project, and the Library of Congress.

At the end of most citations there is an acronym indicating where the document can be ordered or seen. They acronyms are:

AID(__-___-___)
: Indicates AID microfiche that can be ordered in hard copy from:

  A.I.D. Document & Information
  Handling Facility
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  Chevy Chase, MD 20815
  Tel. 301 951-7191 or 301 951-9647

IMF/WB
: Joint IMF/World Bank Library
  Room IMF 530
  700 19th Street, N.W.
  Washington, D.C. 20433
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E/DI
: This indicates that the only copy located in the bibliographic search is in E/DI's own library.

  Energy/Development International
  1015 18th Street, N.W. Suite 802
  Washington, D.C. 20036
  Tel. 202 822-8817

EWUP
: Order documents from:

  Egyptian Water Use and Planning Project
  Colorado State University
  Engineering Research Center
  Ft. Collins, CO 80521

Tel. 303 491-8655

LOC — Library of Congress
101 Independence Ave. SE
Washington, DC 20540
Tel. 202 287-5000

NAL — National Agricultural Library
Beltsville, Maryland 20705
Tel. 301 344-3355

NALDC — Branch of the NAL in the USDA building in Washington, DC. These documents should be moved to the NAL in Beltsville by January 1986. Tel. 202 447-3434.

NTIS — Order documents from:

National Technical Information Service
U.S. Dept. of Commerce
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Springfield, VA 22161
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ODI — Order "Network Papers" from:

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UNIPUB — Order documents from:

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Documents can be ordered from:

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Washington, D.C. 20433
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WMSII

Order documents from:

Water Management Synthesis II Project
University Services Center
Colorado State University
Fort Collins, CO 80523
Tel. 303 491-6991

I. GENERAL OVERVIEWS

Moris, Jon R.; Thom, Derrick. 1985. African Irrigation Overview. Water Management Synthesis II Project. Logan, Utah: Utah State University. Draft Copy. January. 70 p. WMSII.

Chapter 2 is a concise discussion of problems encountered in African irrigation showing the complexity of the factors involved. More complete and focussed than other overviews, but without technical detail. Divided into: Institutional Aspects, Potential for Irrigation, Conjunctive Groundwater Use, Soils, Environment, Engineering, Agronomy, Social Aspects, Economics, and Management.

Podmore, C.A.; Eynon, D.G.; Eds. 1983. Diagnostic Analysis of Irrigation Systems, Volume 2: Evaluation Techniques. Water Management Synthesis Project, University Services Center, Colorado State University. October. 349 p. WMSII.

Field handbook for the evaluation of the feasibility of a project. Outlines basic data gathering techniques and the different kinds of data needed for an evaluation. The low-tech common sense approach makes it good for small scale irrigation projects with small budgets for research and evaluation. Divided into four parts: Sociology, Economics, Agronomy, and Engineering. Volume 1 is more a discussion of report writing, management of project teams, and the importance of a interdisciplinary approach in planning than a discussion of irrigation. Volume I may be useful for small groups with little technical or managerial background.

Rydzewski, J.R., ed. 1977. Irrigation Development Planning (With Particular Reference to Conditions in Africa, South of the Sahara). Southampton: Southampton University. 236 p. WB Sect.

Overviews of existing African irrigation, water resources, social and health impacts of African irrigation, management and organization, and external assistance. List of African irrigation projects.

Stern, Peter H. 1979. Small Scale Irrigation: A Manual for Low-Cost Water Technology. International Irrigation Information Center. London: Intermediate Technology Publications. 152 p. WB Sect.

Provides basic information for small scale irrigation, soils, crop water requirements, simple engineering works and lifting devices. Written for those working with rural farmers on development and extension.

Sparling, Edward W. et al. 1980. Development Process for Improving Irrigation Water Management on Farms: Development of Solutions Manual. Colorado State University. Engineering Research Center, Fort Collins, CO. 3 vols. AID (PN-AAJ-361 - PN-AAJ-363).

A manual for water management, system design and economic analysis. Similar in design to Diagnostic Analysis of Irrigation Systems above, but on a much higher technical level. Presents a method for generating ideas and choosing between alternative solutions. The section on economic assessment is more useful. It includes discussion of risk aversion, credit, sensitivity analysis, externalities, shadow prices, water pricing methods, and income distribution effects. Good section on use of linear programming.

Steinberg, David. 1983. Irrigation and AID's Experiance: A Consideration Based on Evaluation. A.I.D. Program Evaluation Report No.8. Agency for International Development. August. AID(PN-AAL-019).

Broader and less focussed than the overviews above. Concentrates on Asia with little analysis of Africa. General summary is good, and includes several project impact evaluation summaries of projects in Sudan, Egypt, and Somalia.

Baumli, George R., ed. 1982. Principles of Project Formulation for Irrigation and Drainage Projects. New York: American Association of Civil Engineers. 132 p. WB Sect.

How to go about planning an irrigation project. Describes important considerations and variables rather than specific methods for choosing among them.

Additional Sources

Blackie, J.M., ed. 1984. African Regional Symposium on Small Holder Irrigation. University of Zimbabwe 5-7 September 1984. Wallingford, England: Hydraulics Research Limited. 437p. WB Sect.

9 articles covering general issues, project evaluation and management, design, the role of the farmer, and country-specific papers.

II. ECONOMIC ANALYSIS

Bergmann, Hellmuth; Doussard, Jean-Marc. 1976. Guide to the Economic Evaluation of Irrigation Projects. Revised Version. Paris: Organization for Economic Cooperation and Development. 257p. LOC, WB Sect.

The methodology is broken into 6 sections: basic data requirements, profitability at the farm level, profitability to the economy, ex post evaluation of projects, indirect effects of projects, and pricing of irrigation water. Discussion of the elements of economic assessment is thorough including problems of financing, but there is little explanation of the disciplines necessary to develop the basic data. Assessment tables and examples are included for organization of the variables. Technical bibliography with German, French, Italian, and English language sources.

Carruthers, Ian; Clark, Colin. 1981. The Economics of Irrigation. Liverpool: Liverpool University Press. Third Edition. 300 p. LOC, IMF/WB, WB Sect.

The standard technical text for irrigation economics. Shrewd practical discussion of engineering, agronomy and soils, hydrology and climatology, health, and management factors as they affect the economic analysis of irrigation. Includes project planning considerations and the economics of water use fees. Large bibliography and index.

Bhatia, Ramesh. 1984. Energy Alternatives for Irrigation Pumping: An Economic Analysis of Northern India. World Employment Programme Research Working Paper. Intl. Labour Organization, Geneva. December. 50 p. E/DI.

The paper has 3 objectives: to briefly review field experience with renewable energy devices in India; to outline a methodology for economic evaluation of alternative energy sources for pumping; and to discuss impact of non-economic and organizational variables on project viability. Economic methodology is especially clear.

Rydzewski, J.R. 1984. "Appraisal Techniques for Small-Scale Irrigation Development," African Regional Symposium on Small Holder Irrigation, University of Zimbabwe, 5-7 September 1984. pp. 25-40. LOC, WB Sect.

Concise review of irrigation project objectives and the use of cost-benefit analysis to assess them. Discussion of analytical techniques, market versus

social prices, valuation of unskilled labor, discount rates, sensitivity analysis and risk analysis.

Sinha, Basawan; Bhatia, Ramesh C. 1982. Economic Appraisal of Irrigation Projects in India. New Delhi: Agricole Publishing Academy. 487 p. NAL, WB Sect.

Authors advocate updating Indian Government methodology by including a time stream with a NPV calculation, shadow pricing, and proportional weights for benefits to poor farmers to quantify income distribution effects. The methodology is applied in a case study of the Auranga Project (India). Large bibliography.

Tak, Herman G. van der; Schmedtje, Jochen K. 1965. Economic Aspects of Water Utilization in Irrigation Projects. Report no. EC-132. Washington, DC: World Bank. January. 75 p. WB Sect.

Describes methods for economic analysis of choices in irrigation: crop rotation, farm water use, intensity of irrigation, groundwater vs. canal irrigation, drainage problems, etc. Paper assumes that data on hydrology, soils, water requirements, cropping patterns have already been developed. Doesn't seem dated.

Wahby, H.; Quenemoen, M.; Helal, Mohamed. 1984. A Procedure for Evaluating the Cost of Lifting Water for Irrigation in Egypt. Project Technical Report No.7. Egypt Water Use and Management Project, Colorado State University. 39 p. EWUP.

Model emphasizes importance of using marginal, not average cost. Describes sensitivity analysis and identifies variables likely to be sensitive. Costing methodology is thorough, but the benefit side is not included.

French, David. 1979. The Economics of Renewable Energy Systems for Developing Countries. AID and al Dir'iyyah Institute. January. AID(PN-AAG-864).

Excellent explanation of financial and economic cost-benefit analysis for those unfamiliar with it including: NPV, IRR, quantifying non-monetary benefits, high discount rates of rural poor, availability of credit, subsidization of loans, and shadow prices. Followed by case studies on renewable energy systems and an annotated bibliography of more highly technical background sources.

Hurst, Christopher. 1984. "A Model of an Indian Village: A Study of Alternative Sources of Energy for Irrigation," World Development. 12(2): 141-156. NALDC.

A description of a complex linear programming model used to maximize farmer profits. The model simultaneously chooses optimal crop mix, crop scheduling and energy source for irrigation subject to the constraints of land, labor, and fertilizer. This kind of economic assessment is what one would want to

prepare for a project if the resources and data available were unlimited.

Lal, Deepak. 1972. Wells and Welfare: An Exploratory Cost-Benefit Study of the Economics of Small-Scale Irrigation in Maharashtra. Series on Cost-Benefit Analysis, Case Study No.1. Paris: Development Center of The Organization of Cooperation and Development. 162 p. WB Sect.

This book applies the Little-Mirrlees cost-benefit methodology to irrigation in a particular district in India. This is perhaps the most thorough cost-benefit anlysis of irrigation found. It is not a good field methodology because of the consistent use of econometrics, but it is a rare example of a theoretically rigorous cost-benefit analysis of irrigation. Explains the background of each of the parameters used.

Allam, Mohamed Nasr; Marks, David H. 1983. Irrigated Agricultural Expansion Planning in Developing Countries: Performance vs. Resilience vs. Reliability. Technology Adaptation Program, Massachusetts Institute of Technology. 226 p. AID (PN-AAP-919).

Investigation of trade-offs for very large scale irrigation. Linear programming models used to explore relationships of economic efficiency vs. cost recovery vs. income redistribution, and investment costs vs. physical resilience of projects. Uses hypothetical case study on the Nile. Large technical bibliography.

Bruce, Colin; Young, Kimaro. An Economic and Social Analysis of the Chao Phya Irrigation and Improvement Project II. World Bank Staff Working Paper No.299. Washington, DC: World Bank. 42 p. WB Bookstore.

A project cost-benefit analysis using methodology of Little-Mirrlees, Squire - van der Tak for project evaluation.

Livingstone, Ian; Hazlewood, Arthur. 1979. "The Analysis of Risk in Irrigation Projects in Developing Countries," Oxford Bulletin of Economics and Statistics. 41(1) February, pp.21-36. NAL.

How economic theory applies to problem of choosing the land area for irrigation development when the water available to irrigate the land fluctuates from year to year.

Downs, J.B. "Project Appraisal Techniques - Is Irrigation a Special Case?" Transactions of the Tenth Congress on Irrigation and Drainage. New Delhi: International Commission on Irrigation and Drainage. Vol II, pp.33.251-33.258. NAL, WB Sect.

Author argues that the conventional application of cost-benefit analysis tends to underestimate the worth of irrigation projects for two reasons. One is that

the benefit stream increases much more than the cost stream over time. Future benefits are either underestimated in project appraisal, or the payoff period for the internal rate of return is too short for the true social worth to be represented. The second distortion is the lack of consideration of variable rates of inflation.

Golan, A.; Harris, R.L.P.; Whiteford, P.W. 1978. "The Use of Social Cost-Benefit Analysis for Irrigation Projects." Transactions of the Tenth Congress on Irrigation and Drainage, Athens. New Delhi: International Commission for Irrigation and Drainage. vol.III, pp. 33.439-33.460. NAL, WB Sect.

Suggest that project planners using cost-benefit analysis should add a term to represent the benefit to society of private consumption resulting from the project and attach weights to the benefit stream to account for the social consequences of changes in the income distribution. The proposed method is used in a case study.

Horsey, H.R. et al. 1984. A Technical and Economic Analysis of Low Lift Irrigation Pumping in Egypt. Project Technical Paper No.79, Egypt Water Use and Management Project. May. 221 p. EWUP.

Conclusions about specific pumps tested are site specific because of the low lift conditions in Egypt. Economic methodology is sound, but this is a consideration of alternative pumps, not irrigation systems.

Omara, Gerald T. 1984. Issues in Efficient Use of Surface and Groundwater for Irrigation. World Bank Staff Working Paper No.707. Washington: World Bank. WB Bookstore, IMF/WB, WB Sect.

Potential and historical solutions for the allocation of irrigation water as a scarce public good among competing users. Discussion of water management institutions, taxing and pricing instruments, and centralized control.

Seagraves, James A.; Easter, K. William. 1983. "Pricing Irrigation Water in Developing Countries." Water Resources Bulletin. August 19(4):663-672. NAL.

Review article of different pricing regimes for water according to goals of cost recovery and economic efficiency. Discussion of other goals and the project variables which affect them.

Nasim, Ansari. 1968. The Economics of Irrigation Rates. Agricultural Research Center, University of Delhi. Bombay: Asia Publishing House. 360 p. NALDC, WB Sect.

Discussion of different pricing instruments and the practical constraints on implimenting them.

Bowen, Richard; Young, Robert L. 1983. Allocative Efficiency and Equity of Alternative Methods of Charging for Irrigation Water: A Case Study of Egypt. EWUP Technical Report #37, Colorado State University. March. 74 p. EWUP.
Linear programming model used to assess alternative taxing and rationing policy instruments.

Easter, W.K. 1980. Capturing the Economic Surplus Created by Irrigation. Dept. of Agricultural and Applied Economics, University of Minnesota. AID contract no. AID/NE-C-1507. July. 23 p. AID (PN-AAJ-926).
How the government can make rather than lose money on large irrigation schemes by charging user fees. Describes different methods of taxing beneficiaries.

El Shinnawi, Shinnawi A.; Skold, Melvin D.; Lasr, Mohamed L. 1980. Economic Costs of Water Shortages Along Branch Canals. Project Technical Report #5, Egypt Water Use and Management Project, Colorado State University. 58 p. EWUP.
Quantification of economic losses due to erratic delivery and inefficient use of irrigation water.

Silliman, Jael; Lenton, Roberto. 1985. Irrigation and the Land-Poor. International Conference on Food and Water, Texas A&M University, May 27-30, 1985. 27 p. E/DI.
How irrigation affects the rural poor and the potential for improving income distribution and equity of irrigation projects.

Lovejoy, Derek. 1984. Comparative Costs of Solar, Wind, and Diesel Pumping at Village Sites in Nigeria, Somalia and Zimbabwe. Dept. of Technical Cooperation Working Paper, UNDP. October. 12 p. E/DI.
Indicates important variables in comparing the economics of three power sources, but data are much too simplified for this to be used as site evaluation procedure.

Kleinmann, E. 1978. "Evaluation Economique des Projets d'Irrigation: Hausse des Couts d'Investissements, Causes et Consequences." (Economic Evaluation of Irrigation Projects: Rise in Investment Costs, Causes and Consequences.) Transactions of the Tenth International Congress on Irrigation and Drainage, Athens. New Delhi: International Commission on Irrigation and Drainage. vol.II, pp.33.143-33.160. NAL, WB Sect.
Examines the consequences of the exceptionally rapid rise in investment and operating costs of irrigation projects during the '70s. Several projects in the Sahel are analyzed and recommendations are made for how

to reduce costs in project design.

McConnen, R.J. et al. 1982. Feasibility Studies and Evaluation of Irrigation Projects: Procedures for Analyzing Alternative Water Distribution Systems in Egypt. Egypt Water Use and Management Technical Report No.12. Fort Collins, Colorado: Colorado State University. July. EWUP.

Authors advocate use of "Partial Budget Analysis" (the comparison of average annual costs and benefits) as an economic evalution method for irrigation. Though they acknowledge that this simple method can sometimes produce deceptive results because it ignores the time stream of costs and benefits, they argue that data are not available for more thorough evaluation procedures. Includes basic discussion of economic prices, depreciation, and learning over time. Has worksheets for calculation of net costs and benefits of different options in project design.

Harlaut, A. 1979. "A Practical Method of Evaluating Alternative Water Supply Systems for the Development of Rural Areas," World Congress on Water Resources, International Water Resources Assoc., Mexico. vol. 2, pp.1039-1048. NAL.

A framework for a qualitative rather than quantitative evaluation method proposed because of narrowness and deceptive exactness of cost-benefit analysis. More of a concept paper than a "practical method".

Tabors, Richard D. 1978. The Economics of Water Lifting for Small Scale Irrigation in the Third World: Traditional and Photovoltaic Technologies. MIT Energy Lab Working Paper #MIT-EL-78-015. August. 17 p. E/DI.

Short paper that attempts to determine on the scale of the whole Third World what power source to use for low lift irrigation and what is the minimum farm size for irrigation. Considers diesel, gasoline, electricity, photovoltaic, animal, and human power sources. Disturbing use of world-wide figures for value and cost of cubic meter of water pumped. Determines that PV is the most attractive system for the Third World if the cost of PV arrays decline as expected.

Keller, Jack; Riley, J. Paul; Hawks, R. John. 1972. Irrigation Design and Management Related to Economics. Report under AID Contract No.AID/cds-2459, Utah State University. September. 17 p. AID (PN-RAA-069).

Yadav, R.C. 1983. "Cost Functions of Water Conveyances for Gravity Irrigation". Transactions of the ASAE. 26(4):1090-1096. NAL.

Equations for calculating cost of underground pipe or open channel irrigation conveyance. Includes cost of materials and construction, maintenance, seepage and evaporation loss, and land occupied by channel.

I. T. Power Ltd. 1983. The Relative Economics of Windpumps Compared with Diesel Engine and Solar Photovoltaic Powered Pumps on Boreholes in Kenya. I.T.Power Ltd., Mortimer, Reading, UK. Ref:ITP/82034. July. 7 p.

Very short paper on economic implications of results of field tests of a windmill in Kenya.

Walters, Forrest E. n.d. Water Lifting by Sakia: Incremental Cost of Cow Power. EWUP Staff Working Paper No. 21, Egypt Water Use and Management Project, Colorado State University. 21 p. EWUP.

Interesting economic consequences of joint products of cows as power sources, milk and manure producers.

Additional Sources

ICID. 1978. Transactions of the Tenth International Congress on Irrigation and Drainage, Athens. New Delhi: International Commission on Irrigation and Drainage. vol.II, pp.33.143-33.160. NAL, WB Sect.

One third of the Congress was devoted to papers on the economic evaluation of irrigation projects. Besides the papers already cited above, see:

R. 28 The Use of Input-Output Analysis to Estimate Secondary Benefits of Irrigation Schemes, by R.F. Camacho and Anthony Bottomley.

R. 29 Integration of Socio-Economic and Engineering Perspectives in Irrigation Design, by I.D. Carruthers and N. Mountstephens.

R. 32 Analyse de la Demande en Eau d'Irrigation Incidence du Prix de l'Eau, by Francois Remy.

R. 43 A Stochastic Approach for the Evaluation of Drainage Projects, by Osman Ahmed Alghamry.

R. 48 L'Evaluation Economique des Projets d'Irrigation et l'Evaluation des Projets Hydrauliques a Buts Multiples, by OECD.

R. 49 Cost Effective Strategies for Alleviating Water Quality Degradation from Irrigated Agriculture, by Gaylord V. Skogerboe, James P. Law, and Wynn R. Walker.

R. 51 Project Evaluation, by Karl Lee.

R. 52 Economic Impacts of Delays in the Construction of Irrigation and Drainage Projects, by Jerry W. Knapp.

III. ENGINEERING

Black, David L.; Mason, Herbert M. 1983. Technical Guide to Water Management on Small Farms. Southwest Research Institute for AID Project No.93110930. AID (PN-AAJ-437).
Practical explanation of technical aspects of irrigation except for actual pumping. Covers: crop water requirements using Pan Evaporation Equation; land grading; basin, furrow, sprinkler, and drip irrigation; water quality problems (salinity, soil permeability, boron and heavy metal contamination); drainage; distribution systems and measurement of water flow; erosion control; watercourse losses.
In-depth background on these subjects is listed in annotated bibliography of AID-sponsored technical reports.

Griffin, et al. 1983. Pumps and Water Lifters for Irrigation. Handbook No. 3. Water Management Synthesis Project, Utah State University. July. 75 p. WMSII.
A step by step guide to calculating pumping system efficiencies.

Jensen, M.E., ed. 1983. Design and Maintenance of Farm Irrigation Systems. American Society of Agricultural Engineers. Revised Edition. 829p. NAL.
An extensive technical source book for conventional technology irrigation systems. Covers: soil-water interactions, salinity problems, water requirements, drainage, land shaping, pumps, distribution systems (including drip irrigation), and water scheduling.

Fraenkel, Peter L. 1984. FAO Irrigation and Drainage Paper: Prime-Movers and Pumps for Small-Scale Lift Irrigation. I.T. Power Ltd., Mortimer, Reading, UK. October. Second Draft.
Encyclopedic reference to small and medium sized pumping systems. Discussion of matching power source to pump in system. Meant to replace FAO booklet Water Lifting Devices for Irrigation, 1956. A "basis for comparing all present and (near) future options for lifting irrigation water on small and medium sized landholdings (0.25 to 25 ha.)."

Trout, Thomas J.; Kemper, Doral W. 1980. Watercourse Improvement Manual. Water Management Technical Report no.58. Colorado

State University. February. 244p. NAL, WB Sect.
A technical handbook that fully covers assessment of conveyance losses in watercourses and methods of upgrading the structures.

IIIC. 1979. Irrigation Equipment Manufacturers' Directory. Second edition. Bet Dagan, Israel: International Irrigation Information Center. 312 p. IMF/WB.
Lists extensive manufacturer-supplied information on equipment and services. Indexed by manufacturer and by equipment.

Bos, M.G.; Nugteren, J. 1974. Irrigation Efficiency in Small Farm Areas. New Delhi: International Commission on Irrigation and Drainage. 34 p. NAL.
Short technical treatment of means to calculate water use efficiency on farms using different irrigation techniques.

Horsey, H.W., et al. 1984. A Technical and Economic Analysis of Low Lift Irrigation Pumping in Egypt. Project Technical Report No. 79, Egypt Water Use and Management Project, Colorado State University. May. 221 p. EWUP.
Technical specifications and comparison of twelve different pump/power supply combinations for low lift irrigation.

U.S. Bureau of Land Reclamation. 1978. Drainage Manual: A Guide to Integrating Plant, Soil, and Water Relationships for Drainage of Irrigated Lands. Denver: U.S. Dept. of the Interior. 286 p. WB Sect.
Technical description of drainage requirements and construction according to the water table, soil characteristics, and salinity.

Kraatz, D.B. 1977. Irrigation Canal Lining. Irrigation and Drainage Paper No.2. Rome: Food and Agricultural Organization. 170p. UNIPUB.
Covers determination of need of lining, determination of seepage losses, design and construction, and selection of type of lining. 170 reference bibliography. Includes very large scale canal lining.

Horst, L. 1983. Irrigation Systems - Alternate Design Concepts. Irrigation Management Network Paper 7c. London: Overseas Development Institute. April. 18 p. ODI, WB Sect.
Argues that new engineering design concepts should be adopted to reduce the malfunctioning and poor operation of existing irrigation designs due to their complexity and maintenance needs.

Yoder, Robert. 1983. Non-Agricultural Uses of Irrigation Systems: Past Experience and Implications for Planning and Design. Management Network Paper 7e. April. 24 p. ODI, WB Sect.
Most irrigation systems are used for non-cropping

purposes particularly for domestic water needs and animal watering. Paper discusses factors affecting compatibility of uses and design requirements. Bibliography.

National Academy of Sciences. 1974. More Water for Arid Lands: Promising Technologies and Research Opportunities. Washington, DC: National Academy of Sciences. 153 p. WB Sect.

Gives overviews of water supply and water conservation methods: rainwater harvesting, irrigation with saline water, wells, reducing evaporation and seepage losses, etc.

Withers, Bruce; Vipond, Stanley. 1980. Irrigation: Design and Practice. 2nd edition. Ithaca, New York: Cornell University Press. 306 p. WB Sect.

A college textbook on irrigaton. Covers similar ground as Design and Maintenance of Farm Irrigation Systems (above), but with much less technical detail.

Finkel, Herman, ed. 1983. CRC Handbook on Irrigation Technology. CRC Press, Boca Raton, Florida. 2 vol. NAL.

A highly technical handbook that covers much the same subjects as Design and Operation of Farm Irrigation Systems (above), but seems less useful. Most of the tests and technology described are too complex and costly to be used in LDCs.

Wood, A.D.; Ruff, J.F.; Richardson, E.V. 1977. Pumps and Water Lifters for Rural Development. Colorado State University, Fort Collins, CO. June. 189 p. EWUP.

A large reference to small and medium scale pumps divided by type of pump. Drawings and actions of many low technology pumps. Similar to Prime-Movers and Pumps for Small-Scale Lift Irrigation above, but more limited in scope. Large bibliography.

Slack, Roger; Wahby, Hassan; Clyma, Wayne. 1983. Discharge and Mechanical Efficiency of Egyptian Water-Lifting Wheels. Project Technical Report #36, Egypt Water Use and Management Project, Colorado State University. January. 29 p. EWUP.

A scientific assessment of the efficiency of this traditional device.

Anonymous. Irrigation Efficiency: A Bibliography. Water Resources Scientific Information Center, U.S. Dept. of the Interior. 3 vol. covering 1968-1978. NAL, NTIS.

Mostly technical articles analyzing systems in OECD countries as well as some in LDCs. Annotated, indexed, and indicates whether document can be ordered from National Technical Information Service.

FAO. 1973. Trickle Irrigation. FAO Irrigation and Drainage Paper No. 14. Rome: Food and Agricultural Organization. 153p. UNIPUB.

Four articles by members of the European Commission of Agriculture Working Party on Water Resources and Irrigation that review research in drip and trickle irrigation. Practcial descriptions of techniques used.

Jorgensen, Venita. 1975. Drip Irrigation Information Center and Archive: Bibliography. University of California, Riverside. 45 p. NAL.

Lists most of the drip irrigation documents available up to 1975. Documents listed are available from BIO-Agriculture Library at UCal, Riverside. Not annotated.

Maclean, Jayne T. Drip and Trickle Irrigation 1979-1981 and 1982-1984. Quick Bibliography Series, National Agricultural Library. 2 vol. of 25 p. NAL.

Searches made on AGRICOLA in English only. No annotations. 488 citations in 2 volumes.

IV. ENERGY

I. T. Power Ltd.; Sir William Halcrow and Partners. 1984. Handbook on Solar Water Pumping. UNDP Project GLO/80/003. Executed by the World Bank. February. 124 p. UNIPUB.

Good "how-to" book to calculate all necessary elements for the assessment of solar-power as a pumping energy source. Good technical information yet accessible. Covers: description of photovoltaic technology, assessment of crop water requirements, solar energy availability, system sizing, and basic procedure for cost-benefit analysis. Includes sample data sheets for necessary inputs.

Anonymous. 1980. Report of the Commonwealth Workshop on Low Cost Energy for Water Pumping. Kanye, Botswana, 24-29 Nov. Commonwealth Science Council, Commonwealth Secretariat, London. 145 p. E/DI.

Organized as a sourcebook for information about biogas and wind power technology. Includes several annotated bibliographies, lists of suppliers of equipment, and review articles on the technologies as used in Africa and Asia. Very useful as an overview and for further sources of information.

Halcrow, Sir William, and Partners; I.T. Power, Ltd. 1983. Small-Scale Solar-Powered Pumping Systems: The Technology, Its Economics and Advancement: Main Report. UNDP Project GLO/80/003, Executed by the World Bank. London: Sir William Halcrow and Partners. June. 200 p. E/DI.

Up-to-date technical reference for solar-powered pumping systems. Detailed laboratory test results on all available PV pumping systems, and comparison of PV pumping costs with costs pumping with other energy sources in several LDCs. Finds that costs and reliability have improved considerably since 1981. More field testing will be conducted.

Bhatia, Ramesh. 1984. Energy Alternatives for Irrigation Pumping: An Economic Analysis of Northern India. World Employment Programme Research Working Paper. Intl. Labour Organization, Geneva. December. 50 p. E/DI.

The paper has 3 objectives: to briefly review field experience with renewable energy devices in India; to outline a methodology for economic evaluation of alternative energy sources for pumping; and to discuss impact of non-economic and organizational variables on project viability.

Hurst, Christopher. 1984. "A Model of an Indian Village: A Study of Alternative Sources of Energy for Irrigation," World Development. 12(2): 141-156. NALDC.
A description of a complex linear programming model used to maximize farmer profits. The model simultaneously chooses optimal crop mix, crop scheduling and energy source for irrigation subject to the constraints of land, labor, and fertilizer. This is the kind of assessment one would want to prepare for a project if the resources and data available were unlimited.

McGowan, Richard; Burrill, George. n.d. Current Developments in Photovoltaic Irrigation in the Developing World. Associates in Rural Development, Inc., Burlington, Vermont. 21 p. E/DI.
Describes current state of technology (reliability, longevity, costs, etc.), solar requirements and pumping head capacities.

Griffin, et al. 1983. Pumps and Water Lifters for Irrigation. Handbook No. 3. Water Management Synthesis Project, Utah State University. July. 75 p. WMSII.
A step by step guide to calculating pumping system efficiencies.

I.T. Power, Ltd. 1985. Evaluating the Technical and Economic Performance of Photovoltaic Systems: A Methodology. AID Report under Contract No. AFR-0510-C-00-4042-00. May. 108 p. AID (PN-AAT-156).
Handbook for field testing of photovoltaic arrays and pumps. Includes method for calculating cost of running pumps.

McGowan, Richard; Ashworth, John. 1984. Comparative Testing for Water-Pumping Systems Installed in Botswana: General Research Methodology and Specific Field Implementation Instructions. AID contract no. 633-0209-C-00-1-24-00. Burlington, Vermont: Associates in Rural Development. July. 55p. + append. E/DI.
Experimental procedure and analysis techniques for comparing wind, PV, and diesel powered pumping systems.

Horsey, H.R. et al. 1984. A Technical and Economic Analysis of Low Lift Irrigation Pumping in Egypt. Project Technical Paper No.79, Egypt Water Use and Management Project. May. 221 p. EWUP.
Conclusions about specific pumps tested are site specific because of the low lift conditions in Egypt. This is a consideration of alternative pumps, not irrigation systems.

El-Kady, Mona et al. 1984. "Power Requirements and Uses for Field Irrigation Lifting Devices in Egypt," Special Session: Twelfth World Congress on Irrigation and Drainage, Fort

Collins. New Delhi: International Commission on Irrigation and Drainage. Vol.I(c), pp. 523-560. WB Sect.
Analysis of energy requirements of different Egyptian irrigation lifting devices and potential for improving their energy efficiency.

Batty, J.C.; Hamad, Safa N.; Keller, Jack. 1974. Energy Inputs to Irrigation. Report under AID Contract No. AID/csd-2459, Utah State University. December. 25 p. AID (PN-AAA-948).
Energy requirements calculated for nine different types of irrigation systems. Includes energy inputs to manufacture components of the system, and install, operate and maintain the systems. Some of the systems are very complex and expensive.

Brandt, Hartmut; Hendricks, Klaus-Michael; Rathey, Rainer. 1982. "The Planning and Evaluation of the Use of Wind Pumps in Small-Scale Irrigation: A Case Study in Kenya," Quarterly Journal of International Agriculture. 21(2) April-June, pp. 122-138. NAL.
Authors optimization modeling reveals that combinations of wind pumps and diesel pumps are economically preferable to wind pumps alone under most cost and efficiency assumptions.

I.T. Power Ltd. 1983. Economic Comparison of Solar and Diesel Pumps. I.T. Power, Ltd., Mortimer, Reading, UK. June. 70 p. E/DI.
This volume actually contains a half dozen thumbnail sketches of various aspects of solar and wind power. The article named by the title is too short to be very enlightening, but there is a good method for choosing between solar irrigation pumps, and briefs cover the basic technical characteristics and suppliers of: PV panels, solar-powered water pumps, windmills, and wind-powered water pumps.

Lovejoy, Derek. 1984. Comparative Costs of Solar, Wind, and Diesel Pumping at Village Sites in Nigeria, Somalia and Zimbabwe. Dept. of Technical Cooperation Working Paper, UNDP. October. 12 p. E/DI.
Indicates important variables in comparing the economics of three power sources, but data are much too simplified for this to be used as site evaluation procedure.

Tabors, Richard D. 1978. The Economics of Water Lifting for Small Scale Irrigation in the Third World: Traditional and Photovoltaic Technologies. MIT Energy Lab Working Paper #MIT-EL-78-015. August. 17 p. E/DI.
Short paper that attempts to determine on the scale of the whole Third World what power source to use for low lift irrigation and what is the minimum farm size for irrigation. Considers diesel, gasoline, electricity, photovoltaic, animal, and human power sources.

Disturbing use of world-wide figures for value and cost of cubic meter of water pumped. Determines that PV is the most attractive system for the Third World if the cost of PV arrays decline as expected.

Hurst, Christopher. 1985. Energy and Irrigation in India. Employment and Development Department, International Labour Office. June. 134 p. E/DI.
Chapter 3 contains rough technical and economic data for pumpsets in India powered by diesel, electricity, biogas, photovoltaic array, wind, bullock, and hand. Assessment of relative costs of different energy sources.

Stacy, David B.; Stoner, Roy F.; Carruthers, Ian D. 1984. "The Energy Budget - Alternative Strategies for Energy Conservation," Special Session: Twelfth World Congress on Irrigation and Drainage, Fort Collins. New Delhi: International Commission on Irrigation and Drainage. Vol.I(c), pp. 377-404. WB Sect.
Because energy inputs now comprise such a dramatic part of irrigation costs, authors pinpoint ways to reduce energy input per unit of agricultural energy output eg. conjunctive use of ground and surface water and load shedding during irrigation.

Bunting, A.H. 1981. "The Future of High Yielding Variety Technology in Relation to Energy Cost," Promoting Increasing Food Production in the 1980s: Proceedings of the Second Annual Agriculture Sector Symposia, January 5-9, 1981. Washington, DC: World Bank. 499 p. WB Sect.
Overview of trade-off between increased yields of high yielding varieties and the energy inputs necessary to irrigate, fertilize and cultivate them.

Additional Sources

ICID. 1984. "Impact of the Energy Crisis on Irrigation and Drainage," Special Session: Twelth World Congress on Irrigation and Drainage, Fort Collins. New Delhi: International Commission on Irrigation and Drainage. Vol.I(c), pp. 177-560. WB Sect.
11 articles on energy problems in irrigation.

Anonymous. Irrigation Efficiency: A Bibliography. Water Resources Scientific Information Center, U.S. Dept. of the Interior. 3 vol. covering 1968-1978. NAL, NTIS.
Mostly technical articles analyzing systems in OECD countries as well as some in LDCs. Annotated, indexed, and indicates whether document can be ordered from National Technical Information Service.

V. AGRONOMY, SOILS AND SALINIZATION

Doorenbos, J.; Pruitt, W.O. 1977. Guidelines for Predicting Crop Water Requirements. FAO Irrigation and Drainage Paper No.24. Rome: Food and Agriculture Organization. 144p. UNIPUB.

Procedures for calculating crop water requirements by different methods, calculation of net irrigation requirements, and determination of field irrigation scheduling. Includes water requirement characteristics of many food crops.

Doneen, L.D.; Westcot, D.W. 1984. Irrigation Practice and Water Management, Revised edition. FAO Irrigation and Drainage Paper No. 1. Rome: Food and Agriculture Organization. 63 p. UNIPUB.

Practical guide for soil interactions with irrigation as they affect crop choice and irrigation method.

Yaron, Bruno; Vaadia, Yoash; eds. 1973. Arid Zone Irrigation. Ecological Studies 5. New York: Springer-Verlag. 434 p. WB Sect.

32 articles by specialists in agronomy, soil science, agrometeorology, water engineering, and plant physiology. A textbook in arid zone hydrology, soils, salinity, and crop water requirements as they affect irrigation design.

FAO. 1973. Irrigation, Drainage and Salinity: An International Sourcebook. Hutchison and Co., London. 510 p. NAL.

A large, thorough, highly technical volume. It explains in scientific detail the drainage and salinity problems described generally in Water Management on Small Farms (above, under Engineering).

Sanchez, Pedro A. 1976. Properties and Management of Soils in the Tropics. John Wiley and Sons, New York. 618 p. NAL.

"This book attempts to compile [all] the available information on the properties and management of tropical soils." Sections on physical properties, nutrients, fertility, and management practices. Many references.

Flack, T.E.; Podmore, T.H. 1985. African Irrigation Overview: The Soils Aspect. African Irrigation Overview Working Paper No.6. Water Management Synthesis II Project. Logan, Utah: Utah State University. March. 150 p. WMSII.

Soil descriptions for each of the sub-Saharan African

countries. Forty page annotated bibliography on the subject.

Ayers, R.S.; Westcot, D.W. 1976. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No.29. Rome: Food and Agriculture Organization. 97p. UNIPUB.
Water quality evaluation guidelines. Discussions of problems of salinity, permeability, toxicity, and others.

Shainberg, I.; Oster J.D. 1978. Quality of Irrigation Water. IIIC Publication No.2. Bet Dagan, Israel: International Irrigation Information Center. 65 p. WB Sect.
Describes chemical problems of salinity and heavy metal concentrations, and irrigation management necessary to control the problems. Bibliography.

Doorenbos, J.; Kassam, A.H. 1979. Yield Response to Water. FAO Irrigation and Drainage Paper No.33. Rome: Food and Agriculture Organization. 193p. UNIPUB.
Part A: Calculation of maximum and actual yield, and maximum and actual evapotranspiration.
Part B: Yield response data for 25 crops.

Humpal, Donald S. 1985. Agronomy and Irrigation in Sub-Saharan Africa. African Irrigation Overview Working Paper No.5. Water Management Synthesis II Project. Logan, Utah: Utah State University. January. 153 p. Draft Copy. WMSII.
Very thorough, detailed review focused on rice, sugar cane, and cotton. Discusses agronomic problems of soils, new varieties, pest management, etc. Second half of document is a bibliography on the subject.

Hanks, Ronald J.; Hill, Robert Wimmer. 1980. Modeling Crop Responses to Irrigation in Relation to Soils, Climate and Salinity. Bet Dagan, Israel: International Irrigation Information Center (Distributed by Pergamon Press). 70 p. WB Sect.
Describes crop yield equations as a function of evapotranspiration, of transpiration, and more complex formulations including salinity and upward flow effects. Some equation of this sort must be used if one is to calculate the marginal benefit of irrigation water.

FAO. 1973. Drainage of Salty Soils. FAO Irrigation and Drainage Paper No.16. Rome: Food and Agriculture Organization. 84 p. UNIPUB.
Five articles by the European Commission of Agriculture Working Party on Water Resources and Irrigation. Covers techniques for reclaiming saline-alkali soils and drainage experience in Spain and Turkey.

Skogerboe, Gaylord V.; Walker, Wynn R.; Evans, Robert G. 1979.

Environmental Planning Manual for Salinity Management in Irrigated Agriculture. Office of Research and Development, Environmental Protection Agency. NTIS.

Francois, L.E.; Maas, E.V., eds. 1978. Plant Responses to Salinity: An Indexed Bibliography. U.S. Dept. of Agriculture, Berkeley, California. NAL.
An unannotated bibliography with over 2000 entries from 1900 to 1977 on salt and boron effects on plants. Computer searches on this bibliography can be made through USDA.

Additional Sources

ICID 1980. Subject C: Cropping Patterns to Suit Soil and Climatic Conditions. Proceedings of the Third Afro-Asian Regional Conference of the International Commission on Irrigation and Drainage, New Delhi. 23-28 October. NAL.
18 articles address this subject.

VI. CLIMATOLOGY AND HYDROLOGY

Hargreaves, George. 1977. World Water for Agriculture. Report under AID Contract No. AID/ta-c-1103, Utah State University. January. 177 p. AID (PN-AAF-056).

30-year climatic records were used to develop country tables of precipitation probabilities, temperature, humidity, sunshine percentage, potential evapotranspiration, and potential evapotranspiration deficits. A classification of climate for agricultural purposes is proposed.

Vincent, Linden. n.d. (1985). Prospects for Irrigation Development in Hydrological Environments of Africa: A Literature Review and Annotated Bibliography. African Irrigation Working Paper No.4. Water Management Synthesis II Project. Logan, Utah: Utah State University. 162 p. WMSII.

Comparison of rainfed vs. irrigated farming, assessment of African climatic resources, surface water resources, and groundwater. Second half of document is an annotated bibliography on the subject.

Dastane, N.G. 1974. Effective Rainfall in Irrigated Agriculture. FAO Irrigation and Drainage Paper No.25. Rome: Food and Agriculture Organization. 62 p. UNIPUB.

Includes measurement of effective rainfall, use of rainfall data in irrigation project design, and means of increasing effective rainfall. 60 reference bibliography.

Jones, K.R. et al. 1980. Arid Zone Hydrology for Agricultural Development. FAO Irrigation and Drainage Paper No.37. Rome: Food and Agriculture Organization. 271p. + append. UNIPUB.

Covers rainfall, evaporation and evapotranspiration, surface water, sedimentation, and groundwater. Technical.

Manning, H.L. 1956. "The Statistical Assessment of Rainfall Probability and Its Application to Uganda Agriculture," Proceedings of the Royal Society. B144, pp.460-80. NAL.

The first major article to try to model risk in small farmer agriculture.

Rudloff, W. 1981. World Climates. Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart. 632 p. NAL.

For every country, there is data for at least one

location. Includes mean monthly data for: temperature, precipitation, days with precipitation > 1 mm., hours of sunshine duration, percentage ratio of total sun duration to sun duration on cloudless days. Data apparently comes from the German Weather Service.

Additional Sources

Pisa, Maria G. 1984. Groundwater Irrigation: 1970-1984. Quick Bibliography Series, National Agricultural Library. 15 p. NAL.

Unannotated bibliography compiled from database search on AGRICOLA using only English language sources. 224 citations.

VII. ENVIRONMENT AND HEALTH

Worthington, E. Barton, ed. 1977. Arid Land Irrigation in Developing Countries: Environmental Problems and Effects. Oxford: Pergamon Press. 460 p. NAL, WB Sect.

An overview of the main environmental effects and problems of irrigation in the first section, and then about forty articles covering different environmental problems.

White, Gilbert F., ed. 1978. Environmental Effects of Arid Land Irrigation in Developing Countries. MAB Technical Notes No.8. Paris: UNESCO. 67 p. UNIPUB.

Good overview of different environmental problems.

Pal, S.P. and Roy, C.R. 1982. "Environmental Implications and Economic Evaluations of Large Scale Irrigation Projects: Some Methodological Issues," Margin: Quarterly Journal of the National Council of Applied Economic Research (New Delhi). 14, July, pp.29-40. IMF/WB.

This paper discusses how far conventional tools of economic analyses are applicable in the evaluation of environmental impacts of river basin projects.

Jewsbury, J.M. 1985. "Small Scale Irrigation Projects and their Implications for Health," African Regional Symposium on Small Holder Irrigation. University of Zimbabwe 5-7 September 1985. pp. 41-56. WB Sect.

Review of major disease problems that are often aggravated by irrigation development. Describes biological hosts and vector control techniques.

Finkel, Herman J. 1983. "Health Hazards of Irrigation," in CRC Handbook of Irrigation Technology. CRC Press, Boca Raton, Florida. Vol. 2 pp. 47-59. NAL.

Summary of major diseases encouraged by irrigation, hazards of irrigation with sewage water, ground water pollution, and surface runoff pollution.

Mather, T.H.; That, Trinh Ton. 1984. Environmental Management for Vector in Rice Fields. Irrigation and Drainage Paper No.41. Rome: Food and Agriculture Organization. 152 p. UNIPUB.

Describes disease control measures concentrating in 3 areas: snail control, mosquito control, and domestic water use and sanitary facilities. Irrigation scheduling is the most important element for controlling snails and mosquitos and is generally

beneficial for rice production.

Rafatjah, H.A.; Kuo, Chen. 1981. "Health and Irrigation Development," in Transactions: Eleventh Congress on Irrigation and Drainage, Grenoble. Internal Commission on Irrigation and Drainage, New Delhi. R. 56, pp. 913-928. NAL.

Evans, A.C. 1983. "Control of Schistosomiasis in Large Irrigation Schemes by Use of Niclosamide: A ten-year study in Zimbabwe," American Journal of Tropical Medical Hygiene. 32(5):1029-1039. NAL.

Assessment of cost per hectare to control Schistosomiasis with pesticides in large projects in Zimbabwe.

Choudhry, A.W. 1979. "Schistosomiasis Control in the Bunyala Irrigation Scheme: A Pilot Project in the Yala Swamp of Western Kenya," East African Medical Journal. 56(2):71-75. NAL.

Emphasizes importance of project planning that prevents snail or schistosomiasis infestion.

VIII. MANAGEMENT

Sagardoy, J.A.; Bottrall, A.; Uittenbogaard, G.O. 1982. Organization, Operation and Maintenance of Irrigation Schemes. FAO Irrigation and Drainage Paper No.40, Rome: FAO. UNIPUB.

Management and planning guide for establishing water user associations, operating project and pumping system, maintaining the irrigation system, and administration.

Bottrall, Anthony. 1981. Comparative Study of the Mangement and Organization of Irrigation Projects. World Bank Staff Working Paper No. 458. Washington, DC: World Bank. 274 p. WB Bookstore, WB Sect.

Defines the function of irrigation project management, the usefulness and equity of different organizational structures, the farmers' role in management, and makes recommendations for project management improvements.

Tiffen, Mary. n.d. (1985). Land Tenure Issues in Irrigation Planning Design and Management in Sub-Saharan Africa. African Irrigation Overview Working Paper No.2. Water Management Synthesis II Project. Logan, Utah: Utah State University. 80 p. WMSII.

A review of water law and land tenure in Africa. Second half of the document is an annotated bibliography.

General Accounting Office. 1983. Irrigation Assistance to Developing Countries Should Require Stronger Commitments to Operation and Maintenance. U.S. General Accounting Office, Washington. 48 p.

The GAO presented three main recommendations: require identification and funding plan for operation and maintainance costs, reduce recurrent costs in project design, and require that water user associations be formed before construction is carried out.

Easter, K. William. 1985. Recurring costs in Irrigation in Asia: Operation and Maintenance. USAID (ASIA/TR/ARD), Washington. 46 p.

A critique of project management, especially operation and maintenance, in India, Nepal, Philippines, Sri Lanka, and Pakistan.

Hotes, Frederick L. 1983. "World Bank Irrigation Experience," International Journal of Water Resources Development. 1(1).

Reprinted in: ODI Irrigation Management Network Paper 9d, April 1984. London: Overseas Development Institute. 14 p. WB Sect.

Irrigation Advisor for the World Bank reviews the management and project design factors he found crucial in the success of irrigation projects.

Bromley, Daniel. n.d. Irrigation Institutions: The Myth of Management. Department of Agricultural Economics, University of Wisconsin, Madison. 15 p. E/DI.

"As long as new irrigation projects are available to countries, that management effort is undermined. A moratorium on new irrigation projects would properly concentrate the collective mind on improved management of existing systems." Paper is very general - the above is the main point.

Additional Sources

Commonwealth Secretariat. 1978. Proceedings of the Commonwealth Workshop on Irrigation Management, Hyderabad, India, 17-27 October, 1978. London: Food Production and Rural Development Division, Commonwealth Secretariat. 264 p. WB Sect.

10 papers on the subject.

IX. CASE STUDIES

Botswana

Turral, H. 1981. An Investigation into the Cost Effectiveness of Wind Pumps for Irrigation in Botswana. RIIC, Kanye, Botswana. 49 p. VITA.

An assessment of wind as an energy source for vegetable irrigation. Explains the basic principles of windmills, and the agroclimate, soils and water supply in Botswana. Economic analysis made of when wind-powered irrigation is viable.

Mitchell, A.J.B. 1976. The Irrigated Potential of Soils Along the Main Rivers of Eastern Botswana: A Reconnaissance Assessment. Land Resources Division, Ministry of Overseas Development, Surbiton, Surrey, England. 220 p. NAL.

Egypt

Abdel Al, Farouk; Lybecker, Donald W.; Martella, David. 1984. Farming System Analysis of EWUP Case Studies. Project Technical Paper No.50. Fort Collins, Colorado: Colorado State University. May. 49 p. EWUP.

Summary of extensive farm-level data from Egyptian farms over a three year period and calculation of rates of return on various factors. Data on land used, crops grown, crop income and expenses, livestock income and expenses, etc. Missing the quantity yields of specific crops or crop prices. No analysis of reasons for trends.

Abdel Al, Farouk; Skold, Melvin. 1982. Farm Record Summary and Analysis for Case Studies at Abyuha, Mansuriya and Abu Rava Sites. Project Technical Report No.23, Egypt Water Use and Management Project. Fort Collins, Colorado: Colorado State University. April. 104 p. EWUP.

Raw data from each farm on the study sites that were used for Farm System Economic Analysis of EWUP Case Studies (above). Also missing certain prices and quantities implicitly used to calculate the values reported. No analysis.

More Case Studies of Egyptian irrigation can be found in other Egypt Water Use and Management Project publications.

Ethiopia

Makin, M.J. et al. 1976. Prospects for Irrigation Development around Lake Zwai, Ethiopia. Land Resource Study 26. Surbiton, England: Land Resources Division, Ministry of Overseas Development. 316 p. + volume of maps. WB Sect.

Large, thorough study of irrigation by region and by site. A good economic analysis has detailed price, yield and cost data.

The Gambia

Dey, Jennie. 1982. "Development Planning in The Gambia: The Gap Between Planners' and Farmers' Perceptions, Expectations, and Objectives," World Development. 10, May, 377-396. IMF/WB.

Challenges the view that irrigation development largely depends on engineering, agricultural and managerial inputs and argues with reference Gambian irrigation projects that new technologies may be adapted by farmers in ways that are incompatible with planners' objectives.

Kenya

Chambers, Robert; Moris, Jon; eds. 1973. Mwea: An Irrigated Rice Settlement in Kenya. Munchen: Weltforum Verlag. 539 p. NALDC.

15 articles about the long-running and well documented Mwea irrigation scheme including a social cost-benefit analysis.

Hogg, Richard. 1983. "Irrigation Agriculture and Pastoral Development: A Lesson from Kenya," Development and Change. 14, pp.577-591.

Comparison of capital intensive, centrally administered Malka Dakaa irrigation scheme with labor intensive, farmer-run Gafarsa project. High cost of Malka Dakaa has not had commensurate returns and the author recommends that lower cost locally-initiated irrigation efforts are more productive and successful.

Baarspul, J.A. 1971. "The Tana Irrigation Scheme: an integrated development project." Netherlands Journal of Agricultural Science. 19:76-84. NAL.

Outlines six steps toward improving yields for farmers on project: mechanized soil preparation, advanced sowing date, better weed control, increased feritlizer application, pest control, and irrigation and drainage.

Cursory cost-benefit analysis.

Singleton, Carey Bryan. 1974. A Case Study of the Effect of Organized Irrigation: The Mwea Irrigation Settlement, Kenya. Ann Arbor, Michigan: University Microfilms International. 374 p. NALDC.

Doctoral dissertation on a comparatively successful large scale state-run irrigation scheme. Includes extensive questionaire results on tenant practices.

Baum, Gerhard A.; Migot-Adholla, Shem. 1982. "South Kano Irrigation Scheme - Socio-Economic Adjustments in Rural Development Planning," Quarterly Journal of International Agriculture. 21, January/March, pp. 37-51. IMF/WB.

Assessment based on the experience of a recent working assignment in Kenya.

Nigeria

Ansell, Alison; Upton, Martin. 1979. Small Scale Water Storage and Irrigation: An Economic Assessment for South West Nigeria. Development Study No.17, Department of Agricultural Economics and Management. Reading: University of Reading. 97 p. NALDC.

A particularly clear presentation of an economic analysis. Has data covering a wide range of crops.

Wallace, T. 1981. "The Kano River Project, Nigeria: The Impact of an Irrigation Scheme on Productivity and Welfare," in Heyer, Judith; Roberto, Pepe; Williams, Gavin; eds. Rural Development in Tropical Africa. pp.281-305. NALDC.

Failure of project management to be interested in farmers' welfare caused the irrigation scheme to fail. The project made the farmers participating in it worse off.

Senegal

Franzel, Steven. 1979. An Interim Evaluation of Two Agricultural Production Projects in Senegal: The Economics of Rainfed and Irrigated Agriculture. Dept. of Agricultural Economics, Michigan State University. Working Paper No. 28. June. 65 p. AID.

One of the few evaluations to explicitly recognize that the trade-off in irrigation development is not between the returns to irrigation and leaving the land fallow, but between irrigation and the returns to rainfed or recession farming. Franzel finds that the rate of return on investing in improvements in rainfed farming techniques is considerably greater than the returns to

irrigation development.

Keller, Jack, et al. 1982. Project Review for Bakel Small Irrigated Perimeters. Water Management Synthesis Project. Utah State University, Logan, Utah. Report No. 9. 107 p. WMSII.

An example of the value of good interdisciplinary evaluations. The report focusses on those factors which are hindering the project from being as productive as planned. Most of the detailed technical information is not included.

USAID/RBDO. 1983. Integrated Development Project Papers. USAID/OMVS Project No.625-0621. many volumes. E/DI.

This project analysis fills a bookshelf with all its volumes. Although the project was not approved, the documents provide a wealth of detailed data on the Senegal River Valley. Unusually extensive economic analysis (vol.III, Section 1.0) for an African irrigation project.

Nesgos, George; Teagan, Peter W.; Carroll, Frank P. 1984. Assessment of Relative Economy of Alternative Options for Irrigation Pumping in Identified IDP Project Areas. Energy/Development International for AID Project No. 698-0424. 150 p. E/DI.

An extensive engineering and economic technical assessment of diesel and electric pumps in the Senegal River basin. Limited to the pumping aspects of irrigation and consequently considers only costs, not benefits.

LeBloas, Jean. 1983. Perimetres Irrigues de la Region de Bakel. USAID/RBDO Dakar. 29 July. 100 p. E/DI.

Concise analysis of present state of the Bakel perimeters and SAED, the Senegalese irrigation authority. Substantial technical data on the pumping systems used and the irrigation civil works.

De Rafols, W. 1982. Projet Action Ble - Dire: Economic Analysis. AID PD-BAG-096. 37 p. E/DI.

Cost-benefit analysis of this Malian project. Includes sensitivity analysis on some of the important variables.

LeBloas, Jean. 1984. Amenagement Hydro-Agricole de la Plaine de Dirol: Avant-Projet Sommaire. USAID/RBDO Dakar. March. 80 p. E/DI.

A well-researched project proposal full of data. The economic evaluation (from IDP project proposal, by Benjamin Stoner) is unusually extensive.

GERSAR. 1984. Rehabilitation, Feasibility and Detailed Design Studies of the Irrigation Project Areas on the Left Bank of the Senegal River: Podor Project Area, Synthesis Report.

GERSAR, Paris. January. 20 p. E/DI.

A short technical report mostly filled with data tables on costs and irrigation techniques. Nevertheless, data is sketchy for the evaluation attempted.

Ministry of Economy and Finance, Islamic Republic of Mauritania. 1981. Irrigated Agriculture. RAMS Project. Financed by USAID with cooperation of Checchi and Company, Louis Berger International, and Action Programs International. 102 p. E/DI.

Assessment of irrigation along the Senegal River with detailed data on cultivation techniques and costs, and market prices.

Diemer, Geert; van der Laan, Ellen C.W. 1983. Using Indigenous Skills and Institutions in Small-Scale Irrigation: An Example from Senegal. ODI Irrigation Management Network Paper 8b. London: Overseas Development Institute. October. 11 p.

Discussion of reasons for success of small-holder irrigation when large-scale SAED projects have performed so poorly.

Weiler, Edward M.; Tyner, Wallace E. 1981. "Social Cost-Benefit Analysis of the Nianga Irrigation Pilot Project, Senegal," The Journal of Developing Areas. 15, July, pp.655-670. NAL.

A rare ex post cost-benefit analysis that is compared with the ex ante feasibility study for the project. Finds the Nianga project to be marginally profitable. Most of the background data are not included.

Adam, Adrian. 1981. "The Senegal River Valley," in Heyer, Judith; Roberto, Pepe; Williams, Gavin; eds. Rural Development in Tropical Africa. pp.325-353. NALDC.

Instructive history of irrigation development under SAED describing institutional causes of widespread failure.

van der Laan, Ellen. 1984. "Factors Contributing to the Rapid Development of Small-Scale Irrigation Schemes along the Senegal River," Agricultural Administration. 17(4), pp.203-213. IMF/WB.

Sudan

Benedict, Peter et al. 1982. Sudan: The Rahad Irrigation Project. AID Project Impact Evaluation No.31. Washington, DC: Agency for International Development. March. 150 p. AID (PN-AAJ-610).

Large scale centrally administered irrigation project. 19 p. assessment plus extensive appendices. Economic analysis suffers from insufficient data, but

concludes: "costs of production are higher than returns from crop sales, leaving both the corporation and its tenants in poor financial condition." Bibliography.

Ibrahim, Abdullahi Mohamed; Berkoff, Jeremy. 1978. "An Economic Evaluation of the Rahad Irrigation Project," Transactions of the Tenth Congress on Irrigation and Drainage. New Delhi: International Commission on Irrigation and Drainage. Vol.III, pp.33.689-33.711.

Considerable data on costs and benefits on a large-scale mechanized irrigation scheme. Sensitivity analysis highlights the dependence of the rate of return on cotton price and yield assumptions.

Tanzania

Keller, Jack, et al. 1984. Assessment of Rift Valley Pilot Rice Project and Recommendations for Follow-On Activities. Tanzania/USAID Project #698-0410.03. Water Management Synthesis II Project, Utah State University. 37 p. WMSII.

Assessment resulted in a number of specific conclusions and recommendations: there is no support capacity for the introduction of paddy; new perimeters are financially attractive to farmers, but they don't have the credit; leveling of fields and control structures are needed; repair of heavy machinery is feasible; there is no monitoring of pest and disease problems.

Weaver, Thomas, et al. 1984. Rapid Mini Appraisal of Irrigation Development Options and Investment Strategies for Tanzania/USAID. Water Management Synthesis Report #23, Utah State University. January. 57 p. WMSII.

The team had doubts that irrigation would provide good protection against drought, they endorsed the emphasis on small scale projects, extension services should be expanded, and solar schemes are risky until they have been demonstrated.

Zimbabwe

Rukuni, Mandivamba. 1984. "Organization and Management of Smallholder Irrigation: The Case of Zimbabwe," Agricultural Administration. 17(4), pp.215-229. IMF/WB.

General

Weber, Fred R. 1984. Irrigation in Sub-Saharan Africa: A Review of Field Experience. African Irrigation Overview Working

Paper No.3. Water Management Synthesis II Project. Logan, Utah: Utah State University. October. 63 p. WMSII.
Assessment of reasons for success and failure of 34 African irrigation projects.

Barnett, Tony. 1984. "Small Scale Irrigation in Sub-Saharan Africa: Sparse Lessons, Big Problems, Any Solutions?" Public Administration and Development (Chichester) 4, January/March, pp.21 47.
Identifies from studies made of specific schemes the major social and administrative problems confronting the improvement and extension of small-scale irrigation in Africa.

Moris, Jon R.; Thom, Derrick; Norman, Ray. 1984. Prospects for Small-Scale Irrigation Development in the Sahel. Water Management Synthesis Report #26, Utah State University. June. 160 p. WMSII.
Describes conditions distinctive to the Sahel: high variability of rainfall, high population growth causing a food deficit, major river basin projects, small scale projects appear to be more productive than large scale projects.

Coolidge, Philip S. et al. 1981. Irrigation Project Document Review, WMS Report 1, Appendix C: Near East and Africa. Logan, Utah: Utah State University. February. 12 p. WMSII.
Summaries of AID, FAO, and World Bank irrigation
t proposals without any critical assessment.
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X. BIBLIOGRAPHIES, DATABASES AND DICTIONARIES

Bibliographies

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Most extensive source for African irrigation documents. Annotations are often very good. Entries headed by subject and by country studied.

Wells, John; Norman, William. 1984. Sahelian Irrigated Agriculture: A Review of French Literature Sources. Water Management Synthesis II Project. Ithaca, New York: Cornell University. 47 p. WMSII.

This bibliography is not exhaustive, but the compilers have chosen those documents which are most useful and authoritative. There is a discussion of the strength and weaknesses of the particular documents, an annotated bibliography, and then an unannotated bibliography. The bibliographies are very usable, divided by subject and by country.

Abbott, Lisa T.; Bronars, Lori; Rholes, Julia M. 1985. Water and Water Policy in World Food Supplies: A Selected Bibliography. College Station: Texas A&M University. 172 p. E/DI.

Bibliography is broken into the subject headings: general, water supply, water salinity, water management, integrated ecosystem management, energy and water interrelationships, and technology. Not annotated.

Humpal, Donald S. 1985. Agronomy and Irrigation in Sub-Saharan Africa. African Irrigation Overview Working Paper No.5. Water Management Synthesis II Project. Logan, Utah: Utah State University. January. 153 p. Draft Copy. WMSII.

Very thorough, detailed review focused on rice, sugar cane, and cotton. Discusses agronomic problems of soils, new varieties, pest management, etc. Second half of document is an unannotated bibliography on the subject.

Flack, T.E.; Podmore, T.H. 1985. African Irrigation Overview: The Soils Aspect. African Irrigation Overview Working Paper

No.6. Water Management Synthesis II Project. Logan, Utah: Utah State University. March. 150 p. WMSII.

Soil descriptions for each of the sub-Saharan African countries. Forty page annotated bibliography on the subject.

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Comparison of rainfed vs. irrigated farming, assessment of African climatic resources, surface water resources, and groundwater. Second half of document is an annotated bibliography on the subject.

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Databases

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AID Database includes AID documents that have been put on microfiche. Available at:

AID Library, Development Information Center
PPE/E/DIU/DI, Room 105 SA18
U.S. Agency for International Development
Washington, DC 20523
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Lists extensive manufacturer-supplied information on equipment and services. Indexed by manufacturer and by equipment.

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