Water Resources Management in Asia

A Selective Bibliography with Introductory Essays

by
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East-West Environment and Policy Institute

East-West Center
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CONTENTS

		Page
LIST OF TABLES AND FIGURE		v
FOREWORD		vii
ACKNOWLEDGMENTS		ix
I.	INTRODUCTION	1
	The Historical Importance of Water in Asia	1
	External Influence on the Management of Asian Water Resources	3
	Evolution of River Basin Planning	4
	United Nations' Initiatives	6
	Water Resources Management: An Analytical Framework	6
	References	9
II.	GUIDE TO THE BIBLIOGRAPHY	11
	Objectives and Scope	11
	Organization of Materials	12
	Bibliography and Reference Index	12
III.	GENERAL SURVEYS OF WATER RESOURCES SUPPLY AND DEMAND, PLANNING, AND IMPLEMENTATION	15
	A. General	29
	B. South Asia	31
	C. Southeast Asia	38
	D. Northeast Asia	44
	E. General Planning and Implementation Problems and Issues	46
	F. River Basin Planning and Implementation	50
	G. Studies on Planning and Implementation of Alternative Water Uses	56
IV.	SPECIFIC STUDIES OF WATER RESOURCES MANAGEMENT EXPERIENCES	61
	A. General	65
	B. South Asia	68
	C. Southeast Asia	85
	D. Northeast Asia	102
V.	ENVIRONMENTAL QUALITY AND NATURAL SYSTEMS ASPECTS OF WATER RESOURCES MANAGEMENT	109
	A. General	115
	B. South Asia	119
	C. Southeast Asia	134
	D. Northeast Asia	153

		Page
VI.	SURVEY, PLANNING, AND IMPLEMENTATION METHODOLOGIES	163
	A. General Systems Analysis	171
	B. Benefit-Cost Analysis	174
	C. Optimization Models	182
	D. Simulation Models	185
	E. Technical Feasibility Studies	188
	F. Multiobjective and Multiattribute Models	197
	G. Evaluation (Ex-Post) Approaches	201
	1. Social and Economic Impact	201
	2. Performance or Efficiency	205
	3. Effectiveness of Government Projects and Programs	214
	4. Action Research	217
VII.	ORGANIZATIONAL, LEGAL, AND POLICY ASPECTS OF WATER RESOURCES MANAGEMENT	223
	A. Institutional and Organizational Factors	229
	1. General	229
	2. South Asia	234
	3. Southeast Asia	243
	4. Northeast Asia	252
	B. Legal Aspects of Water Resources Management	257
	C. Government Policies and Programs	261
VIII.	ALPHABETICAL AUTHOR LISTING OF REFERENCE MATERIALS	275
SUBJECT INDEX		369
COUNTRY INDEX		469
AUTHOR INDEX		473

TABLES

		Page
1.	Global Distribution of Water Resources	16
2.	Average Annual Water Balance of the World	16
3.	Regional Distribution of Irrigated Harvested Area and Gross Water Demand, 1974	17
4.	Information on Planning and Implementation of Asian Water Resources by Major Water Use and Region	22
5.	Basic Planning and Design Data for Ten Major River Systems in Asia	24
6.	Environmental and Natural Systems Effects of Water Resources Projects in Asia by Human Activities and Natural Systems	110
7.	Classification of Bibliographic Entries by Governmental Level and Region	224
8.	Classification of Bibliographic Entries by Organizational Components and Water Resources Management Activities and Tasks	225

FIGURE

1.	Water Resources Management Activities and Tasks for a Surface Water Irrigation System	8

FOREWORD

This bibliography is a product of the Asian Water Resources Management Project of the Environment and Policy Institute (EAPI) Natural Systems Assessment for Development program area. The Asian Water Resources Management Project was started in May 1982 with a reconnaissance study that culminated in a planning workshop held in September 1982. Following the workshop, activity has been concentrated on developing a long-term program of sustained and in-depth studies of selected water resources management problems in Asia by means of (1) case studies of past and ongoing experiences in water resources planning and implementation and (2) comparative cross-country analyses of important water resources problems and management experiences.

We view this bibliography as an important beginning to systematic documentation of the published literature on Asian water resources management, which should be helpful in conducting case studies, cross-country analyses, and other types of research on water resources management problems of Asia.

Frank Bollman, Fellow
Maynard M. Hufschmidt, Fellow

ACKNOWLEDGMENTS

Research work for the bibliography began in May 1982 as part of the reconnaissance phase of the Asian Water Resources Management Project. An initial draft was reviewed by participants at the September 1982 water resources management workshop, and the bibliography was revised substantially and extended in late 1982 and early 1983. It subsequently was published as an EAPI Working Paper in February 1984.

Several associates in the East-West Environment and Policy Institute (EAPI), and elsewhere, provided stimulating feedback on the initial draft of the bibliography--among them were Somluckrat Wattanavitukul, John Dixon, Terry Rambo, Bruce Koppel, Alan Early, and Gilbert Levine. We especially appreciate the detailed and perceptive comments and suggestions of Anthony Bottrall. We also wish to acknowledge the support of Richard Carpenter, program area coordinator of the EAPI Natural Systems Assessment for Development program area, and William Matthews, director of EAPI; the devoted work of the staff that helped in the preparation of this document: with special thanks to Betty Figel and Karen Ashitomi for their efforts in typing the drafts; Joan Nakamura and Carol Uyemura-Wong; the assistance of the Resources Materials Collection staff at the East-West Center, especially Terese Leber for doing the computer search and Phyllis Kagehiro, in providing access to water resources documents and abstracts, and finally to Helen Takeuchi, assistant editor of the Publications Office, for her work in final editing of the manuscript.

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I. INTRODUCTION

On an outer wall of a major canal in the ancient capital of Polonnaruwa (Padaviya), Sri Lanka, this inscription of the edict of the twelfth century, A.D., Sinhalese King Parakramabu the Great can be found:

> . . . not even a little water that comes from the rain must flow into the ocean without being made useful to Man.

A builder of large reservoirs and dams, Parakramabu the Great constructed the largest known ancient water system in the South Asian region. Called the Sea of Parakrama, it serviced an area of over 10,000 acres in Sri Lanka. This system is symbolic of the region's ancient heritage of elaborate public works for water resources management. These include, among others, the Cauvery delta canals of India built in the second century, A.D.; the large-scale dam projects of the Kingdom of Funan along the eastern delta of the Mekong River; and the 4,000-year old Ifugao rice terraces of the Philippines, an ingenious irrigation and drainage system covering an area of 400 mi^2, carved out of the mountain slopes.

These structures reflect the importance of water resources in the productive strategy of the civilizations of Asia. While this bibliography concentrates on a survey of contemporary materials on Asian water resources management, we start in this Introduction with an overview of the influence of water control on the history of the region. This will help put into perspective the development of techniques and organization for water resources management and the role of western influence in the modernization of these systems. We then focus on a specific approach that has gained popularity--the river basin planning framework--and subsequently discuss the recent role of the United Nations in water resources management.

In the remainder of Part I we present a brief historical introduction on Asian water resources, followed by a summary of the analytical framework that will serve as the basis for organizing the materials that we will review. Part II contains the reference guide to the bibliography, focusing on the organization of materials and the method of cross-reference employed. The actual bibliographical listings are presented in Parts III to VII.

The Historical Importance of Water in Asia

The topography of East, Central, and South Asia is characterized by the presence of a diverse watershed, the Himalayan range. From this mountain range flow the great rivers of this region: the Yellow and Yangtze of China, the Mekong and the Salween in mainland Southeast Asia, and the Ganges-Brahmaputra and

Indus of South Asia. Other lesser rivers--the Red, Chao Phya, Chindwin, Sittang, and Irrawaddy--form the outer southern approaches to the Himalayas. The geographic contribution of all these rivers in trade and navigation has been of incalculable significance, and the role of water control among the inhabitants of this region remains decisive. While sea routes carried some of the flow of population and commerce, it was probably the courses of these rivers and the manner of diversion and control of waters that served the bulk of the migrants (Williams 1976).

In general, major settlements in Asia were organized around a number of permanently nucleated agricultural and fishing communities located near water sources, usually on the flat alluvial floor of large river basins. Along the Mekong River, the Thais (establishing the State of Siam) settled in the valley west of the Lower Mekong Basin. The Vietnamese from the Nan Yueh and Red River valleys in China claimed lands east of the Mekong, while smaller kingdoms such as Lane Xang and Laos were located in the northern reaches of the Mekong River.

On the southern side of the Himalayas, Bengal and Kashmir became important frontiers of Indian culture. Powerful local states arose to govern the north Indian plains, but these states were not able to unite the Ganges and Indus valleys into a unified empire. Along the Ganges-Brahmaputra river valleys, the ancient Hindu empire of Vijayanagar was established, and further north the Sultanate of Gujarat controlled three major seaports and large tracts of land inundated by the Indus River.

In this setting indigenous techniques of water control were developed. Among the more important techniques used were the shaduf pole and water basket for lift irrigation, and the Persian wheel for irrigation and village water supplies. Iron tools introduced in 900 B.C. facilitated the clearing of jungle, especially in the Ganges valley of India, where the heavy rains of the monsoon sustained lush vegetation and made the soil, once cleared of its trees, unusually suited for cultivation. Rice, though first domesticated by garden cultivators in Southeast Asia and China, added greatly to the productivity of the Ganges valley. Permanent occupation of particular fields complemented rice cultivation, for the diking, digging, and terracing needed to bring irrigation water to the paddy were extremely laborious, thus making moving to new locations less attractive. Consequently sedentary agriculture, with permanent villages and town centers, all arose in the Ganges region following the introduction of iron tools and the establishment of rice cultivation (Spear 1961).

Other important production techniques included the use of concrete structures such as the ancient Sinhalese reservoirs of Padaviya, Pavatkulami, and Vavunikulam in Sri Lanka, and the tenth century Barrai Occidental irrigation dam of the Burmese King Anawratha. The discovery of ancient masonry weirs and stone gate canal structures in the Peshawar valley, Pakistan, and in the Kyankse district of Burma (Balu Chuang River) further reinforces

the belief in the diversity and sophistication of the systems of water diversion and sharing that evolved in many parts of Asia.

Traditional patterns of water management, specifically the allocation of irrigation water, also have been documented extensively as evidence of the long history of water management in Asia. A great deal of variation exists regionally--from the particular system of land parceling to ensure direct access to water in the zangjeras of Ilocos Norte, Philippines (Lewis 1971), and in Pul Eliya, Sri Lanka (Leach 1961), to the temple ritual of the Balinese subak (Geertz 1980), and the cooperative irrigation society of the Japanese burako (Beardsley et al. 1959). Other forms of water distribution practiced include the karahankota system in Sri Lanka (Leach 1961), the dap-ay politico-religious system of water control in the Mountain Province, Philippines (Bacdayan 1974), and the burning of incense sticks for timed rotations in Taiwan (Vandermeer 1968).

External Influence on the Management of Asian Water Resources

While these ancient irrigation societies and water resources management techniques are among the oldest in the world, comprehensive river basin planning is comparatively new to the region. When the British annexed the Punjab in 1849, they were the first among the colonial powers to promote a systematic water resources development program. Having full control of the Indo-Gangetic Plains in north India, the British set up a network of feeder canals from the Ganges River in Uttar Pradesh and the Yamuna, Sutlej, Ravi, Chenab, and Jhelum River systems in Central Punjab. In 1854, the Ganges canal was built, and in 1861, the Upper Bari Doab Canal in the Punjab was completed. These were followed by a series of major reservoir and canal feeder systems--among them, the Sidhnai Canal from the Ravi River in 1886, the Chenab Canal network of the Rechna Doab and Ravi River in 1892, the Jhelum and Triple canals from the Jhelum River in 1915, and the Sukkur Rohri Project in the East Punjab Plains in 1923 (Johnson 1979).

Expansion of modern irrigation also took place during this period on quite a large scale in Japan, Taiwan, and Indonesia (e.g., the Tadjum Irrigation Project, Serayu River, Indonesia, in 1929). However, large-scale river basin development throughout the rest of Asia came only after World War II, and was dominated by involvement of international agencies. For example, in 1951, the United Nations Economic Commission for Asia and the Far East (UN-ECAFE) conducted a full-scale survey of the Mekong River and its tributaries in peninsular Southeast Asia. This survey later led to the signing of the Geneva Accords in 1956 and the formation of a Committee for the Co-ordination of Investigations of the Lower Mekong Basin (or Mekong Committee) in 1957. The Mekong Committee, composed of representatives from Cambodia, Laos, Thailand, and

Vietnam, later funded the Wheeler Mission in 1958 to undertake a comprehensive survey of the hydrological and geomorphological resources of the Mekong River system. A series of sub-basin technical reports followed, culminating in the integrated Mekong River Plan in 1968 (Sewell 1968).

Elsewhere in the region, individual water resources projects were being funded on a much smaller scale than the Indus, Ganges, or Mekong river basin programs. These were largely single-purpose projects, for example, the Barrai Reservoir Flood Control Project of Burma in 1958 and the Ambuklao (Agno River) Hydroelectric Project of the Philippines in 1959.

International and bilateral aid agencies also were involved in single-purpose water projects. The Asian Development Bank (ADB), for example, financed the construction of the Andong Dam (for irrigation) in the Nam River of Korea in 1960. The United States Agency for International Development (USAID) supported the Damodar Valley Project (for irrigation) in India in 1953 and the Trisuli Hydroelectric Project near Kathmandu, Nepal, in 1954.

Lastly, Western influence was significant in resolving conflicts over the use of international water resources. Action by the British in 1905, for example, provided the physical basis for the postpartition sharing of water from the Indus River through construction of the Triple Canals Project, transporting water to drought-prone areas south of the Jhelum River. The World Bank initiated in 1960 the Indus Waters Treaty, which gave Pakistan full control of the western tributaries of the Indus River--Indus, Jhelum, and Chenab--while India had sole use of the eastern section--Ravi, Beas, and Sutlej rivers. The World Bank also created the Indus Basin Development Fund (generating US$895 million), which financed the construction of the Mangla Dam in 1968 and the Tarbela Dam in 1970.

Evolution of River Basin Planning

Initially, water resources projects in Asia were concerned with specific problem areas such as flood control, irrigation, or the provision of potable water. This was largely influenced by the type of water resources planning practiced initially in the United States and in Europe (Forbes and Hodges 1971), where single-purpose water projects were constructed from an identified water source. However, since the hydrologic characteristics of a river basin form a relatively well-defined natural system, river basin boundaries, especially in the United States, were often taken as planning units. As the concept of "basin as planning unit" was accepted (largely as a result of the analyses undertaken as part of the U.S. Conservation Movement of the early 1900s, culminating in the creation of the Tennessee Valley Authority in 1933), multipurpose, comprehensive planning and management approaches were developed. The integrated river basin model (IRBM) that followed sought to coordinate the various water resources elements from a single river

basin to include multiple uses of water (irrigation, hydroelectric power, recreation, domestic use), as well as related land resources such as forests, grazing, and agricultural lands (U.S. President's Water Resources Policy Commission 1950).

The inclusion of related land resources, and later, the consideration of social and environmental effects of river basin development, expanded the definition of water resources management both in terms of what is treated within the basin, and in terms of the direct and indirect effects of water resources development on areas and sectors both inside and outside the basin.

For example, studies of river basin programs have recently associated water resources structures development to predictable impacts on aquatic life and organisms transmitting water-borne diseases. Also, the role of watershed management is evaluated in terms of reduction in soil erosion and runoff control. Thus, scientific and recreational values of resources are examined and even problems of resettlement and land reclamation are now considered.

Furthermore, as the objectives of the IRBM were redefined to encompass interests other than the construction of major water facilities, the need to involve disciplines other than engineering and the water sciences in the planning process was recognized. At the same time, systems theory, in both its inductive (Bertalanffy 1968) and deductive (Ashby 1968) forms, had allowed the development of methodologies and approaches that enabled planning to be truly "holistic." Thus multidisciplinary planning teams were created so that "intangibles" not perceived by engineers or economists could be understood, for example, by anthropologists and other social scientists.

The second type of expansion that occurred within the IRBM is the systematic integration of environmental criteria into the process of project planning and implementation. Gilbert F. White's (1957) seminal work on environmental planning for natural resources initiated the drive for an increased interest in environmental issues. Initially dominated by public health and sanitary engineering professionals, the environmental sciences have grown to encompass such areas as ecology, physical sciences, environmental economics, and epidemiology.

One of the more common environmental issues that has attracted a significant amount of investigation is the problem of reservoir sedimentation. Dams act as barriers to movement of aquatic life both up and downstream and cause shifts in salinity in estuaries and adjacent marine areas. Secondly, any change in the watershed area will affect the flow of water and quantity of sediment carried into the reservoir. Thus, where upstream zones are subject to improper deforestation, overgrazing, or intense burning, erosion rates invariably accelerate, and the increased silt load deposited in streams usually lead to rapid sedimentation, loss of storage capacity, and consequently reduce the life span of reservoirs.

United Nations' Initiatives

Since the 1977 United Nations Water Conference in Mar del Plata, Argentina, the field of water resources management has experienced an unusually large amount of scholarly attention throughout the world. The conference proceedings, published as Water Development, Supply, and Management (Biswas 1980), stand out as a comprehensive review of the state-of-the-art of water resources management on a global level. The papers included in this 13-volume compilation provide a comprehensive review of the issues, problems, and solutions affecting water resources development with an emphasis on the developing countries.

The major policy and program concerns, as expressed in the Summary and Main Documents (Volume 2) of the conference, are outlined below:

1. Increase in food production through expansion of irrigated arable lands (irrigation accounts for 80 percent of total water consumed; approximately 1,000 tons of water are needed to grow one ton of grain; 3,000 tons to grow one ton of rice);

2. Improvement of domestic water supplies (30 percent of urban population worldwide lack access to safe drinking water; over five million people die every year from water-borne diseases such as cholera and typhoid); and

3. Reduction in levels of environmental and natural system effects from irrational use of water (around 200,000 to 300,000 hectares of irrigated lands are lost yearly due to salinization and waterlogging; irrigation efficiency worldwide is low with water losses of up to 70 percent to 80 percent due to conveyance structure inadequacies and overapplication of water).

Given these three major areas of concern of irrigation, water supply, and their environmental consequences, a number of important studies, both theoretical and applied, have been completed. For Asia, several detailed analyses of regional trends in water resources management in the last three decades already exist (e.g., the Asian Development Bank agricultural surveys [1976] and the UN-ECAFE studies [1972]). This bibliography will offer a more general view. In the next section we present the analytical framework that defines the guidelines upon which materials in the bibliography were organized and reviewed.

Water Resources Management:
An Analytical Framework

The guidelines according to which materials will be classified and evaluated in this bibliography complement the analytical framework for the study of water resources management in Asia

developed by Hufschmidt and Wattanavitukul (1983) and Bower and Hufschmidt (1983). It was proposed that analysis of the variety of approaches used for water resources management would have greater utility to both scholars and policymakers in Asia if an approach that could categorize, at the initial stage, the different problems involved in managing water resources were developed.

Toward this end, Bower and Hufschmidt (1983) have identified three essential elements to serve as a focus for the review of water resources management approaches in Asia. The first is the general process of water resources management, which includes the planning, design, construction, and operation and maintenance steps in management of water resources systems. The second is the specific set of linked activities and tasks associated with a particular water resources management system. For example, in Figure 1, a surface water irrigation system is viewed as a set of activities and tasks encompassing water impounding and release, delivery, and allocation to final users. The third element refers to the systems nature of water resources management, involving resource inputs, direct outputs, and direct and indirect environmental and social consequences.

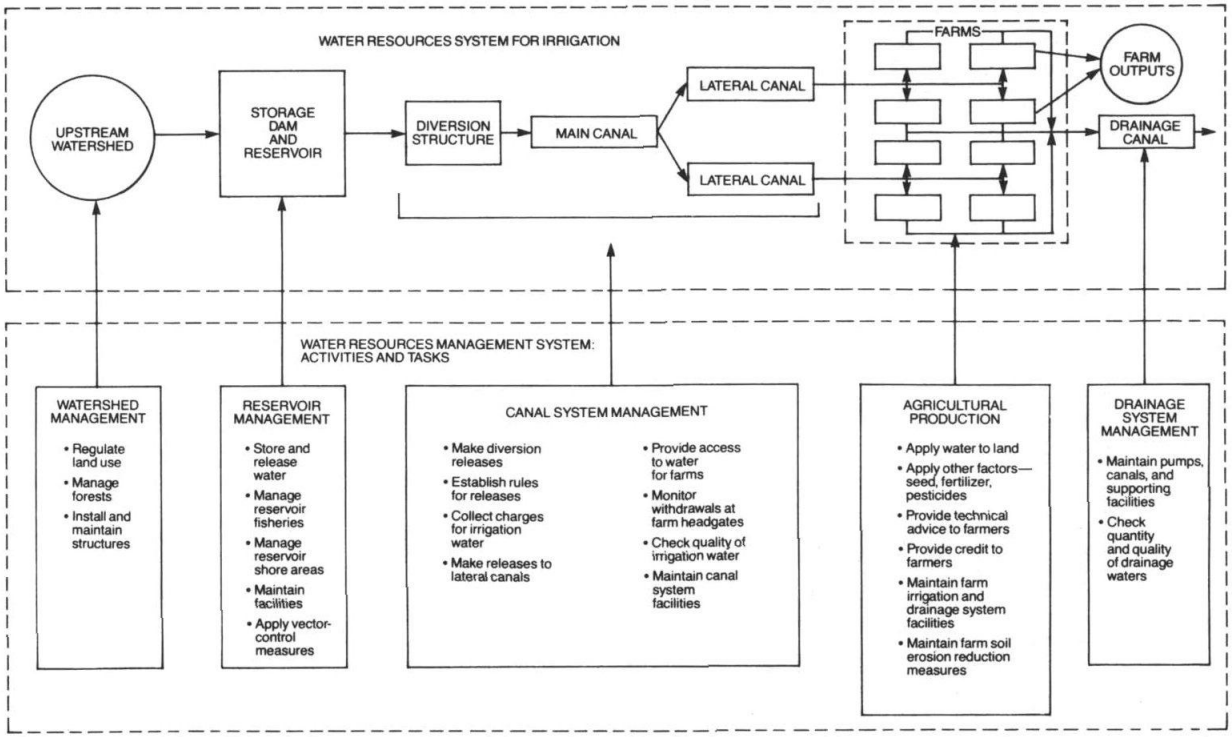

Figure 1. Water Resources Management Activities and Tasks for a Surface Water Irrigation System.

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II. GUIDE TO THE BIBLIOGRAPHY

The bibliography provides an overview of the current situation of water resources and their management in Asia. The sets of data pertaining to water resources supply and demand and the studies on the organizational arrangements for managing water resources provide comparative information concerning the interrelationships of technical, environmental, and institutional aspects of the water resources management process.

Objectives and Scope

This collection presents a regional overview of a wide range of topics in water resources management, and through the organization and review of materials, provide the reader with a convenient reference guide to the literature on selected Asian countries. The specific objectives are as follows:

1. To assess the current situation by presenting an inventory of water resources supply and demand in Asia;

2. To provide summary information on the environmental and natural systems aspects of water resources development; and

3. To present a survey of literature on approaches and methodologies used in the management of water resources in Asia.

Because of timing and space constraints, the bibliography concentrates on recent (1970-82) English-language literature on water resources management for selected Asian countries. While the specific geographic focus is on Asia, we recognize that parallels exist to other developing regions such as Latin America or Africa. The organization of materials is indicative of the broad range of topics in a study of water resources management approaches in the region. The reference categories are among the major concerns of professionals in the field and represent some of their various interests.

For the purposes of this bibliography, a geographic coverage and physical (natural resource base) scope was defined. The Asian countries included in this survey were divided according to the following classification: (1) South Asia--Bangladesh, India, Nepal, Pakistan, and Sri Lanka; (2) Southeast Asia--Indonesia, Malaysia, Philippines, and Thailand; and (3) Northeast Asia--China, Japan, South Korea, and Taiwan. Because of time and data limitations, the South Asian countries of Iran and Afghanistan, and the Southeast Asian countries of Burma, Cambodia, Laos, and Vietnam have been excluded. Also, Southwest Asia has been excluded as it lies outside the boundaries of the East-West Center region. The physical or natural resource base includes all freshwater surface

and groundwater, such as streams, rivers, and lakes, and related land resources in watersheds and drainage basin areas.

Organization of Materials

Reference materials in the bibliography are divided into five major subject categories (which correspond to Parts III to VII of this document): (1) general surveys of water resources supply and demand, planning, and implementation (Part III); (2) specific studies of water resources management experiences (Part IV); (3) environmental quality and natural systems aspects of water resources management (Part V); (4) survey, planning, and implementation methodologies (Part VI); and (5) organizational aspects of water resources management (Part VII). The first category (Part III) is subdivided into the general surveys of water resources supply and demand (Section A) and planning and implementation of water resources projects in the region (Section B). The materials in this category contain background information on water resources problems and potential for development, as well as an account of the planning process used, following the analytical framework's concept of linked activities.

The activities and tasks descriptions of management inputs and outputs are evaluated in materials presented in Parts IV to VII. In-depth analyses of Asian water resources management, embodying the scope of investigation defined in the framework, are contained in Part IV. The materials are classified into national or community level case studies and cross-country analyses. In Part V sources related to the management of the environment (specifically the natural system "outputs" or "side effects" of water resources projects) are included. Part VI examines different analytical and management approaches and techniques, such as the use of benefit-cost analysis in the economic evaluation of water resources projects. The last set of materials in Part VII relates water resources management activities and tasks to organizational structures and functions and to the other actors involved in the management process.

Bibliography and Reference Index

The individual bibliographic entries are arranged by geographic region and country for each of the subject categories described earlier. Each entry is composed of the formal bibliographic entry itself (author, title, publication) and, where applicable, an annotated description of the major features of the reference material relevant to Asian water resources management.

Each entry is organized as illustrated in the following example:

REFERENCE CODE: 328

AUTHOR: Parikh, J.K. (1977)

TITLE: Environmental Problems of India and their Possible Trends in the Future. Laxenburg, Austria: International Institute for Applied Systems Analysis.

ABSTRACT: Environmental problems resulting from increased industrial and agricultural activity in India are discussed. The report concentrates on problems related to water pollution and deforestation.

In this citation, the bibliographic reference code is 328. The author and subject matter will be cited in the alphabetical listing and index by code number.

Subject and country indexes, which are defined by category and code number, are included in the last section of the bibliography. An author index is also included. Entries not annotated were unavailable for review (i.e., because of recent publication or limited circulation) but were nevertheless considered important enough for inclusion in the bibliography. Finally, each entry in the alphabetical author listing incorporates the appropriate accession code: for University of Hawaii Hamilton Library (HL); Project Room (EAPI Room 3115); Environment and Policy Institute, Population Institute, and Resource Systems Institute--Resource Materials Collection of the East-West Center (RMC); the International Rice Research Institute Library (IRRI); and the computer abstract file numbers of the Water Resources Abstracts (WR) and the Commonwealth Agricultural Bureau (CAB) data base. While the inclusion of accession codes is of service mainly to the East-West Center and University of Hawaii community, it may also be useful elsewhere, as filing systems in other libraries follow essentially the same pattern of coding reference materials. Also, the computer abstract codes are available through any affiliate university data base computer system in the United States and Canada.

The materials in this bibliography were compiled during a five-month library research program at the Resource Materials Collection (RMC) of the East-West Center, the University of Hawaii Water Resources Research Center (WRRC) library, and the Hamilton (Asia Collection) Library; the computer search facilities from Dialog Water Resources Abstracts and the Commonwealth Agricultural Bureau (CAB) Rural Development Abstracts; and one month of library research in the International Rice Research Institute (IRRI) in Los Banos, Philippines.

III. GENERAL SURVEYS OF WATER RESOURCES SUPPLY AND DEMAND, PLANNING, AND IMPLEMENTATION

Although water is a renewable resource, the total amount of water worldwide remains relatively constant at 1.4×10^9 km^3, 97.3 percent of which is generally saline oceanwater, while only 2.7 percent is fresh water that can be productively withdrawn for agriculture, domestic water supply, and other uses (Table 1). Of the total available freshwater supply, 77 percent is stored as ice (glaciers and ice cap) and 22 percent in groundwater and soil moisture. Stream channels, from which a significant proportion of water for agriculture is drawn, comprise a mere one hundredth of one percent of total supply (M. Biswas 1978).

About 260 km^3 (ck) of precipitation fall daily upon the land, of which 100 ck are blown in from the sea and 160 ck evaporate from the land. The hydrologic cycle is balanced by about 100 ck of daily runoff from land to sea through rivers, streams, and underground water flow (Ehrlich and Ehrlich 1970). Although water circulates and is eventually replenished, however, the finite supply of fresh water places limits on the population that can be supported in any given area.

Plants constantly absorb water from the soil and evaporate it from their leaves. For example, a single corn plant may take from the soil and evaporate as much as 200 quarts of water in a growing season (Ehrlich and Ehrlich 1970). To produce a pound of dry wheat requires 60 gallons of water; a pound of rice, 200 to 250 gallons. The huge amounts of water required by plants are returned to the cycle directly through evaporation and cannot be reused by humans immediately.

Food Supply and Water Needs in Asia

Table 2 indicates the average annual water balance by region. As can be gleaned from the figures, Asia accounts for a significant percentage of water runoff (12 percent), which is applied mostly for agricultural uses. In Table 3 the regional distribution of gross water demand shows that Asia, excluding China and the Soviet Union, represents 54 percent of the total demand for irrigation water (70 percent, including China and other Asian centrally planned countries).

In terms of arable irrigable area, Gasser (entry 3) estimates that Asia (excluding China and the Soviet Union) comprises over 60 percent of potentially irrigable agricultural lands in the world. Within the Asian region (except for China and the Soviet Union), India accounts for 63 percent of the total arable irrigated lands. Sri Lanka has the smallest proportion of irrigable lands (less than one percent) but these lands comprise over one-third of total land area in the country. Among the Association of Southeast Asian

Table 1. Global Distribution of Water Resources

Location	Percentage
Ocean	97.3
Fresh	2.7
Distribution of fresh water:	
Ice cap and glaciers	77.2
Groundwater and soil moisture	22.4
Lakes and swamps	0.35
Atmosphere	0.04
Stream channels	0.01

Source: M. Biswas 1978:8.

Table 2. Average Annual Water Balance of the World

Regions	Volume in Thousand km^3		
	Precipitation	Evaporation	Runoff
Africa	20.7	17.3	3.4
Asia	30.7	18.5	12.2
Australia	7.1	4.7	2.4
Europe	6.6	3.8	2.8
North America	15.6	9.7	5.9
Latin America	28.0	16.9	11.1
Antarctica	2.4	0.4	2.0
Total land area	111	71	40
Oceans	385	425	-40
Total world	496	496	0

Source: A. Biswas 1978:11.

Table 3. Regional Distribution of Irrigated Harvested Area and Gross Water Demand, 1974

Region	Irrigated Harvested Area (million of hectares)	Gross Water Demand (billion* of cubic meters)
Africa (excluding Egypt, Libyan Arab Republic, Sudan)	2	14
Latin America and Caribbean	8	59
Near East (including Egypt, Libyan Arab Republic, Sudan)	16	109
Asia (excluding China and USSR)	75	899
Asia (China and other centrally planned countries)	78	1167
USSR and Eastern Europe	14	95
North America Australia and Oceania Western Europe	33	228
	226	2571

*The term "billion" means a thousand million.

Source: U.N. Secretariat 1978:57, Table 6.

Nations (ASEAN) member-countries, Indonesia has the largest irrigable land area (8 percent of total irrigable lands in Asia).

Rice is the primary crop grown in the wet environments of the Asian region. China grows about 35 percent of the world's rice supply; India and Pakistan, 7 percent; Japan, 7 percent; and Indonesia, 6 percent. Other countries in Southeast Asia grow about 20 percent. Next to rice, wheat is the largest staple food crop, and India produces 5 percent of the total world supply (Lappe and Collins 1977).

Potentially arable lands in the world are more than triple the area actually planned and harvested in any given year (President's Scientific Advisory Committee 1967). In Asia, the potentially arable lands could not be supported for one growing season without

irrigation. Entries (5), (6), and (7) provide a regional geographic distribution of water resources for use in different agricultural activities, mainly rice production. The survey of Gasser (3), in selected Asian countries, shows that subtracting arable lands that need irrigation leaves very little additional land available in the region.

When matched with food requirements, the U.N. conference papers edited by Biswas (1) show that although index numbers are, at best, crude indicators of the food situation, a clear trend towards famine is projected if present food production programs are not improved. In India, for example, food production has been increasing at an annual rate of 2.3 percent, but the current population growth rate is 2.5 percent per year. There are optimistic forecasts that India can reach and sustain grain production growth of 3 percent per year (see entry 14), but overall, large-scale programs are required simply to maintain present food production levels.

Lastly, the most promising and widely discussed approach to expanding production and bringing substantial amounts of new land into cultivation is in the development of irrigation to maximize the full production potentials of the new high yielding grain varieties (or HYVs). The new grains, which mature early and are relatively insensitive to sunlight, allow for multiple croppings that, when managed correctly, could fulfill food requirements in the region. In 1968, for example, with adequate water supplies, the Indian wheat harvest was 35 percent above the previous year, and Pakistan's harvest was 37 percent larger than the previous year. Rice production in the Philippines and Sri Lanka in the years 1966-68 also increased markedly. Also, in Sri Lanka, farmers were found to be growing high-yielding grain sorghum in the dry season when water for growing rice was inadequate. In India and Pakistan, alternate planting of rice in the summer and wheat in the winter was practiced in response to variations in water availability.

Inventory of Asian Water Resources

Water resources data, as reported in the collection of materials in this chapter, refer to those parts of the existing surface and groundwater that are directly manageable, and thus can be redistributed, temporally and spatially, by means of a dam and diversion structure, network of conveyance channels, or pumps.

The data are concerned with three principal water sources: (1) water from major rivers and streams, (2) water from minor sources such as lakes and ponds, and (3) water in underground storage. Runoff or streamflow is measured from surface water sources as the "instant" rate of flow or total volume of water that passes through a given water source cross-section, in a given time period (Klemes 1973). For purposes of water resources management, the three levels of streamflow data often used for planning and design are (1) mean annual runoff, (2) mean monthly flow, and (3) mean daily flow (Linsley and Franzini 1979). Average water flow for intervals less than a day are seldom

used in water resources planning and design, except for purposes of large-scale flood control or hydroelectric power production. In actual design of water resources projects, additional streamflow data are generated, such as flow velocity and cross-sectional area of the water source. The type and amount of data vary in terms of individual project requirements.

Conventional Data Collection Methods

Three field-level collection approaches to measuring streamflow are used. The first method, recording from a stream gauging station, is the primary source of information for estimating mean annual flow. This measurement is used in planning for the maximum potential quantity of water available from a basin in the long-run, or the upper limit of water supply used in calculating reservoir storage capacity (Klemes 1973).

The second method approximates direct station records for areas with inadequate daily recordings. Streamflow from nearby stations in the same river system, or data on precipitation, humidity, and temperature are used to make estimates of streamflow, as supplements to the available stream-gauge data.

The third method is used when no streamflow data at all are available. This method uses a hydrologic analogy of climatic and physiographic characteristics between similar basins in the calculation of "adjusted" streamflow for the river basin of interest. The bibliographic entries indicate, for each type of streamflow data, whether the flow estimates are primary or "adjusted."

Groundwater comprises that part of underlying strata of the ground that hold water from precipitation, seepage, or recharge. These water-bearing strata are called aquifers and consist mostly of consolidated sandstones, or unconsolidated sands, gravels, and glacial drifts (Lockwood 1976). Thus the amount of groundwater stored in a situated material depends upon the porosity and the structure and geological history of the material (as measured by permeability). Groundwater estimates for the countries included in this survey are based on detailed studies of soil porosity and permeability in the different water resources regions of each country.

South Asia

India has the largest number of studies on the supply and demand of surface and groundwater (see bibliographic entries 8, 9, 19, 23, 30, and 31). However, the large number of water resources inventories in India has resulted in a number of conflicting estimates of water availability. Among the major water resources studies conducted, three estimates of potential utilizable surface water flows are used by researchers and policymakers, and the differences are significant for project planning purposes. For example, Varma (30) argues that the total surface flow is in the range of 700 billion cubic meters

(bcm), and that 510 bcm can be used effectively for irrigation. Nag and Kathpalia (19) say that the annual average precipitation of 118 cm or 10,055 billion liters per day (BLD) would place total supply of surface water at 950 bcm, and that 250 bcm would go to storage in reservoirs, and 450 bcm could be diverted effectively for irrigation. Rao (23), whose studies have been the basis of most national irrigation forecasts in India, quantifies the surface water supply at 800 bcm, and agrees with Chaturvedi (8) that of this replenishable supply, 48 percent is lost through seepage and percolation and 15 percent is withdrawn unproductively through evapotranspiration (ET).

For Pakistan and Bangladesh, the authoritative sources on current supply and demand of water resources are those of the Pakistan Academy of Sciences (21) and the International Board for Reconstruction and Development Sector Study (17). Sri Lanka's report to the U.N. Water Conference (29) is the most recent assessment of current water supply for the country. Lastly, for Nepal, the most reliable water resources data are obtained from the U.S. Department of Interior Geological Survey (see Evett, 11) and the hydrological and hydrometeorological studies of Shankar (25).

Groundwater measurements for India are found in the comprehensive hydrogeological survey of the National Geophysical Research Institute in 1975 (see Deshmukh, 10, and the Indian National Science Academy, 16). Rao and Ramesan's study (22) estimates secular storage for groundwater to approach 11,000 bcm.

The other groundwater study in the South Asian region that is based on a nationwide hydrogeological survey is Sharma (26). He argues that 72 percent of rainfall in Nepal is lost as runoff, and the steep, hilly terrain and impervious rock surface allows for retention of only 8 to 10 percent of rainfall.

Southeast Asia

For Southeast Asia, the most comprehensive survey of water resources is found in the Mekong River Delta (34). Hydrologic and meteorologic data for this area cover a period of 20 years starting with the organization of the Committee for Co-ordination of Investigations of the Lower Mekong River (or Mekong Committee).

Unlike India, where several nongovernment publications have been made on water resources supply and demand, the Philippines relies on the hydrological results of the government's National Water Resources Council (NWRC). The inventories are classified by water resources region and "adjusted" data are used in the estimates (see entries 43, 44, 49, and 107).

For Thailand, the country report (53) submitted by the Ministry of Agriculture and Cooperatives to the U.N. Water Conference contains a summary of available water supply. Jaraswathana's study (38), although based on surveys conducted only at the Chao Phya River,

provides a good review of potential utilizable water supply from surface sources.

Keat, Still, and Scarf (40) constructed a water balance model that was translated and plotted into a surface water resources map (using isohyets) from 600 rainfall stations in Malaysia. The adjusted streamflow data were then used in the determination of water supply for irrigation and domestic use.

Northeast Asia

Background data for countries in the northeast region of Asia are limited both in number and in scope. The literature search, however, contains a few basic materials that allow a quick survey of water resources. In Japan, surface water is evaluated in the 1972 study of the Japanese Society of Irrigation (56), and Kudo and Ishizaki (58) discuss groundwater resources supply and recharge capacity. For Korea, Kim's (57) paper provides an overview, although incomplete for a national appraisal of available water resources.

In the People's Republic of China (or China), Chi's (55) work analyzes the development of "key economic areas" in terms of availability of water resources. Nickum's (59) report, however, contains a more comprehensive assessment of available water resources in the country.

Taiwan's groundwater resources are reported by the Taiwan Provincial Water Conservancy Bureau (60). A general discussion of surface water resources is presented in Wang (61).

STUDIES ON ASIAN WATER RESOURCES PLANNING AND IMPLEMENTATION

Table 4 classifies the bibliographic entries by region and type of water resources information used in the planning and implementation for major uses of water in Asia. Fewer studies are made on the planning and implementation of hydroelectric and domestic water uses than for irrigation or multiple uses. The categories of entries describe the (1) general issues and problems of planning and implementation of water resources projects, (2) approaches used in river basin projects, and (3) types of studies done for alternative or single-purpose water projects.

Table 5 contains a summary of planning and design information for the ten major river systems in Asia as compiled by UN-ECAFE (U.N. Secretariat 1966). The Mekong River in the Southeast Asian peninsula is the longest river system with a total length of 4,350 km. On the other hand, the Indus and Ganges rivers in India have the largest

Table 4. Information on Planning and Implementation of Asian Water Resources by Major Water Use and Region

Region	Classification by Use Water Resources Information for: General Information on Water Resources in the Region	Multiple Uses of Water	Irrigation	Hydroelectric Power	Drinking Water Supply
Asia (general)	5, 6, 7, 76	1, 84	3, 70		2, 4, 73
South Asia	8, 10, 11, 16, 17, 22, 23, 24, 25, 28	9, 12, 14, 15, 18, 19, 21, 29, 69, 75, 79	13, 26, 30, 62, 64, 96	20, 27, 100, 103, 105, 106, 109	31
Southeast Asia	35, 36, 38, 41, 42, 43, 44, 45, 46, 47, 49, 51, 52, 102, 104, 107	34, 40, 50, 53, 74, 82, 87, 91, 92, 93, 94, 95, 97, 98, 99	32, 37, 39, 48, 63, 72, 108, 110, 111, 112	88, 89	33, 54, 80, 81, 85, 86, 90, 114
Northeast Asia	55, 58, 59, 61	57	56, 113		60

Numbers refer to entries in the bibliography.

drainage basins with 970,000 km^2 and 977,000 km^2, respectively, while the largest discharge rate comes from the Brahmaputra River traversing India, China, and Bangladesh, with an average flow of 19,200 m^3 per second.

Systematic hydrologic and meteorologic data are compiled at the national level and classified by region. The approaches used in creating a water resources data base are generally similar for the region. Documentation of the data processing method is presented for the Philippines in entries (43), (44), (46), (48), and (49).

The UN-ECAFE proposed a systematic evaluation of water resources projects in the region, and the documents leading to a regional design for water resources management are presented in entries (76) and (77). With respect to documentation of a water resources development program for a particular country, the work of Lieftinck, Sadove, and Creyke (69) for Pakistan contains a comprehensive review of the planning and implementation process used by international funding agencies.

The research studies on multipurpose, river basin projects are generally descriptive in nature. A good review of the actual streamflow and discharge control methods employed in river basin planning is discussed by the Yodo River Dams Control Office (83) of Japan, where problems of prediction of rainfall, flooding, and low-flow levels in the reservoir are discussed. For a general overview of river basin planning activities, Sherman's (97) description of the Bicol River Basin program of the Philippines elaborates on the technical and administrative procedures used in planning and implementation.

Planning and implementation for drinking water supply describing the survey, actual design, and administrative structure are extensively documented in the 100-Cities Project of the Philippine government by Camp Dresser and McKee International, Incorporated (101). The World Health Organization (114) uses a similar detailed investigation, but includes more studies on drainage and sewerage.

Government planning and implementation approaches for development of hydroelectric power are found in the articles by the Asia Society (100), Institute of Science, Tribhuwan University (105), and Rana and Shresta (109) for Nepal; the Central Board of Irrigation and Power (103), and Lahiri (106) for India; and the Ministry of Public Works and Electric Power (104) for Indonesia. The reports describe the sequence of activities leading to hydroelectric power design. Of the hydroelectric power studies completed, however, the reports on Nepal are the most comprehensive. This may be attributed to the fact that, although Nepal occupies less than one-tenth of a percent of the world's land area, its 83,000 megawatts of theoretically potential hydroelectric power capacity represents 15 percent of that of the world.

Regional planning and implementation approaches, mainly for irrigation, are documented for India in Ali (62), Chadha and Uppal (65), and Vohra (79); for Pakistan in Lieftinck, Sadove, and Creyke

Table 5. Basic Planning and Design Data for Ten Major River Systems in Asia

River	Riparian Countries	Total Length (km)	Total Drainage Area (km^2)	Precipitation and Runoff			Discharge		
				Maximum Annual (mm)	Mean Annual (mm)	Runoff Coefficient (%)	Maximum (m^3/s)	Minimum (m^3/s)	Average (m^3/s)
Mekong	China, Burma, Laos, Thailand, Cambodia, Vietnam	4,350	795,000	1,380	722	52.4	67,000	1,250	14,800
Red	China, Vietnam	1,200	120,000	1,500	1,090	72.7	35,000	700	3,900
Brahmaputra	China, India, Bangladesh	2,580	580,000	2,125	1,177	55.4	72,460	2,680	19,200
Meghna	India, Bangladesh	950	80,200	3,500	1,715	49.0	13,100	-	3,515
Ganges	India, Bangladesh	2,200	977,500	1,250	367	29.4	61,200	1,170	11,610
Kosi	Nepal, India	730	86,900	1,790	643	36.0	23,000	150	1,770
Gandak	Nepal, India	425	45,800	-	1,375	-	23,000	200	2,000
Gogra	Nepal, India	1,020	132,000	960	525	54.7	14,809	320	2,200
Indus	China, India, Pakistan	2,900	970,000	612	460	75.0	31,200	490	6,770
Sutlej	China, India, Pakistan	1,450	86,000	480	280	58.4	13,900	78	532

Table 5. Continued

River	Riparian Countries	Specific Flood Discharge ($m^3/s/km^2$)	Average Unit Discharge ($m^3/s/km^2$)	Silt Flow (by weight: 1 m^3 = 1.65 tons) Maximum Content (%)	Minimum Content (%)	Average Content (%)	Average Annual Silt Runoff 1,000 Tons	Average Annual Silt Runoff Per Unit Area Ton/km^2
Mekong	China, Burma, Laos, Thailand, Cambodia, Vietnam	0.014	0.0229	0.31	-	0.06	170,000	435
Red	China, Vietnam	0.31	0.0345	0.70	0.01	0.106	130,000	1,080
Brahmaputra	China, India, Bangladesh	0.149	0.0372	0.30	-	0.12	735,000	1,370
Meghna	India, Bangladesh	0.203	0.0543	-	-	-	-	-
Ganges	India, Bangladesh	0.0628	0.0119	0.30	-	0.13	480,000	492
Kosi	Nepal, India	0.265	0.0204	5.00	-	0.286	160,000	1,840
Gandak	Nepal, India	0.434	0.0386	-	-	0.312	196,000	4,275
Gogra	Nepal, India	0.112	0.0167	-	-	-	-	-
Indus	China, India, Pakistan	0.078	0.022	-	-	0.33	680,000	2,230
Sutlej	China, India, Pakistan	0.23	0.009	-	-	-	-	-

Source: U.N. Secretariat 1966.

(69), for Nepal in Pradhan (96); for Indonesia in Walker's studies (111, 112); for the Philippines in the series of studies by the National Water Resources Council (90 through 95) and Sherman (97); for Malaysia in the Muda Irrigation Scheme report (72); and for Japan in the Yodo River Dams Control Office report (83).

International Involvement in Water Resources

The review of water resources management problems presented in Bower and Hufschmidt (64) evaluates the major problems and issues in Asia and serves as a convenient guide for donor-agency assessment of water resources management in the region. The USAID appraisal of planning trends for water resources in Asia (Lowdermilk and Svendsen, 70) indicates a shift in investments to development of irrigation institutions, and this is supported by Keller's (67) conclusions for India.

Guidelines for donor-agency allocation of funds for water resources projects are discussed in Daneke and Priscoli (66), Mageed (71), and the UN-ECAFE report (76).

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A. GENERAL

1
Biswas, Asit K., series ed. (1980)
Water Development, Supply and Management, U.N. Water Conference, Mar Del Plata, Argentina. Oxford: Pergamon Press.

Asian water resources data are reported in Volume 2, U.N. Water Conference: Summary and Main Documents.

2
Fok, Yu-si (1982)
Community Water Supply and Sanitation Programs and Problems for Asian and Pacific Countries. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 29 pp.

The Environment and Health Division of the World Health Organization (WHO) has compiled, over the past decade, data from developing countries on the current status of drinking water supply and sanitation programs. The data generated provides background information on a global level of the extent of drinking water supply and sanitation problems. The International Drinking Water Supply and Sanitation Directory, published by World Water and WHO in 1981, contains a compilation of the data gathered--for example, each year 12 million children die from water-borne diseases. This paper summarizes the information available for Asian and Pacific countries. Detailed descriptions of the causes and extent of drinking water supply and sanitation problems for each country are not made. Rather, references are included after each section for those who want a more comprehensive discussion of drinking water and sanitation problems in the Asian and Pacific region.

3
Gasser, William R. (1981)
Survey of Irrigation in Eight Asian Nations. Foreign Agricultural Economic Report No. 165. Washington, D.C.: U.S. Department of Agriculture.

The countries included in the survey are India, Pakistan, Indonesia, Thailand, Bangladesh, South Korea, Philippines, and Sri Lanka. Each section discusses the climate, surface and groundwater resources, irrigation methods and cropping patterns, waterlogging and salinity problems, water management and pricing, and plans and prospects. The surveys provide an excellent review of recent studies on irrigation water management practices in the region.

4
Mehta, R.S. (1979)
Problems of Shelter, Sanitation Which Includes Water Supply and Industrial Effluent Disposal and Solid Waste and Refuse Disposal Transportation and Air Pollution Problems in Larger Urban Areas of ESCAP Region. United Nations Environment Program (mimeographed).

The author, who is with the Gujarat Water Pollution Control Board of India, reports on problems of shelter, water supply, sanitation, and transportation in major urban centers of the ESCAP region. Parts II and III, on water supply and sanitation, are directly relevant to water resources management. Table 4 contains a breakdown of the extent of water supply by type of water delivery system used for Bangladesh, Burma, India, Indonesia, Nepal, Sri Lanka, and Thailand. Detailed estimates of present and future domestic water demand for these countries also are discussed. For example, in Indonesia, per capita water consumption is 150 liters per day including 35 percent losses, with only 20 percent of total population having continuous water supply. In Thailand, 80 percent of urban population draw water from surface sources; Bangkok receives 30 percent of its water supply from deep tubewells. In Sri Lanka, only 31 out of 147 communities have adequate piped water supplies. Table 6 describes the sanitation facilities for these countries including a breakdown of investments needed for upgrading of existing facilities.

5
Thornwaite, C.W., et al. (1958)
Three Water Balance Maps of Southeast Asia. Thornwaite Assn. Pub. in Climatology, 57 pp.

6
United Nations, Educational, Scientific, and Cultural Organization (1974)
Natural Resources of Humid Tropical Asia. Paris: U.N. Educational, Scientific, and Cultural Organization, 456 pp.

Data on natural resources for humid tropical Asia are compiled with the view towards improving research in natural resources development. Data are classified by climate, geology, hydrology, and forest resources. A bibliography and list of institutions are also included for quick reference.

7
Yoshino, Mastositi S., ed. (1971)
Water Balance of Monsoon Asia: A Climatological Approach. Honolulu: University of Hawaii Press.

B. SOUTH ASIA

8
Chaturvedi, M.C. (1976)
Second India Studies: Water. New Delhi, India: The MacMillan Company.

The book provides the most comprehensive review of India's water resources (until 1975) covering such topics as surface and groundwater supply, climate, related land resources (forests, irrigated lands), and a chapter on the Indian government's water resources development program. Important baseline information is contained in the first chapter. A brief summary of relevant data is given below: (1) Rainfall--average annual precipitation of 118 cm or 10,055 billion liters per day (BLD); (2) water loss--of this total replenishable supply, 48 percent is lost through seepage and percolation (S&P), 15 percent of which are consumed unproductively through evapotranspiration (ET); (3) the residual 52 percent is estimated as runoff at a volume of 61.4 cm or 41,708 BLD.

9
Dakshinamurti, C., A.M. Michael, and Shri Mohan (1968)
Water Resources of India and Their Utilization in Agriculture. Water Technology Center, Indian Agricultural Research Institute, New Delhi, India.

10
Deshmukh, O.A. (1978)
Status of Groundwater Studies, Development, and Utilization in India. In Approaches and Methodologies for Development of Groundwater Resources, Proceedings of Indo-German Workshop, eds. R.N. Athavale and V.B. Srivastava. India: National Geographic Research Institute, 20 pp.

Contains the results of a systematic hydrogeological survey carried out in several regions of India in 1975.

11
Evett, W.W. (1969)
Hydrology and Water Resources Development in Nepal. Washington, D.C.: U.S. Department of the Interior Geological Survey, 104 pp.

In 1969, a nationwide network of hydrological stations was set up in Nepal to explore groundwater resources. This report discusses the history of the hydrological investigations and the relation of these studies to water resources development problems in the country. The hydrology of important river systems and the factors affecting the overall development of water resources of large river basins are evaluated. Proposed projects for groundwater development are also included.

12
Fernando, A. Denis N. (1973)
The Ground Water Resources of Sri Lanka. Colombo, Sri Lanka: Ministry of Irrigation, Power, and Highways, Planning Division.

In 1968 a Hydrogeology Map of Sri Lanka was completed through aerial photogrammetry. Together with the Mean Annual Rainfall Map produced by the Canada-Ceylon Colombo Plan Survey, gross mean annual groundwater recharge was estimated and with the aid of the River Basin Map of Ceylon (Sri Lanka) made by S.J. Boks, "catchment boundaries" of river basins were identified (totaling 111 river basins). From these, groundwater resources for Sri Lanka were estimated at 5.88 million acre-feet per year, about one-eighth of the country's surface water resources. To determine groundwater recharge, Fernando assumed that 40 percent of gross infiltration could be taken as the loss due to evapotranspiration (ET) and subsurface flow, which is equivalent to 60 percent of gross infiltration due to rainfall, as the reasonable estimate of net groundwater recharge. Table 5, containing the estimates of recharge for all the river basin areas in Sri Lanka, is presented by area, net recharge, and translated into a groundwater map classified by rainfall category. Table 6 then identifies the priority areas for groundwater development on the basis of groundwater availability and recharge. The document also provides an excellent description of Sri Lanka's water and related land resources.

13
Framji, K.K., and I.K. Mahajan (1969)
Irrigation and Drainage in the World: A Global Review. New Delhi: Caxton Press.

The reports form part of a World Bank study in the Indian subcontinent, although much of the data was obtained in Pakistan. They estimate that for the Indian subcontinent

about 75 to 80 billion cubic meters will be diverted for irrigation in the dry season and 35 to 40 billion cubic meters in the wet season.

14
India, Ministry of Agriculture and Irrigation (1976)
Report of the National Commission on Agriculture. New Delhi: Ministry of Agriculture and Irrigation (mimeographed).

Part IV contains a listing of water resources projects in India since 1965. Of the total 68 projects described in the report (cost, location, and major accomplishments), 78 percent are for major-medium irrigation.

15
India, Ministry of Agriculture and Irrigation (1977)
Water Resources Development in India: Current Activities and Future Perspective. Indian National Committee for the United Nations Water Conference.

This report was prepared by the Indian National Committee for the United Nations Water Conference in Mar del Plata, Argentina. It contains the latest information on the current status of water resources projects in India.

16
Indian National Science Academy (1967)
Proceedings of the Symposium on Ground and Lake Water Resources of India. New Delhi, India: Indian National Science Academy.

The first part of the report is an informative review of the ground and lake water resource potential in India. Tables 3 and 4 provide useful data for estimating total available and replenishable groundwater. The rest of the report details technical proposals for groundwater development and the preservation of lakes for recreation and limited navigation.

17
International Bank for Reconstruction and Development (1972)
Bangladesh Land and Water Resources Sector Study. Washington, D.C.: IBRD.

In May 1971, a cooperative project involving the International Bank for Reconstruction and Development (IBRD), the United Nations Development Programme (UNDP), and the Food and Agriculture Organization (FAO), together with the Harvard Center for Population Studies, was initiated as a follow-up of the 1966 mission of Bernard Chadenet of IBRD and the International Engineering Co., Inc. "to develop comprehensive

plans for agriculture and water development, and proposals for action programs." Soil and land capability surveys were made by UNDP and FAO, and a surface water hydrologic survey was conducted by UNDP. At the same time, new rice varieties were introduced in Bangladesh by the International Rice Research Institute (IRRI) and Ford Foundation. This nine-volume study contains the results of analyses undertaken with the Bangladesh government in 1971. Volume 7 focuses on overall water resources development--groundwater, international water aspects, and rainfall. Volume 8 concentrates on the flood problem, in particular, analyses of river flow and embankment maintenance.

18

Mathur, R.N., and Abhya Kumar Tosin (1981)
Assessment of water resources of the Basti Vikashand, Basti District, Uttar Pradesh, India. The National Geographic Journal of India 27(1,2):14-19.

19

Nag, B.S., and G.N. Kathpalia (1975)
Water Resources of India. Vol. 2, Water for Human Needs, Proceedings of the Second World Congress on Water Resources, 373-82, 12-16 December, New Delhi, India.

Nag and Kathpalia conducted a one-year hydraulic survey for the Indian National Commission. The results of this survey are contained in this report. They estimate that in addition to the potential utilization of 700 billion cubic meters, an additional 250 billion cubic meters could come from storage in reservoirs and tanks and 450 billion cubic meters from stream and river runoff.

20

Nepal Ministry of Water and Power (1971)
Hydropower Potentiality of Nepal. Kathmandu: His Majesty's Government.

21

Pakistan Academy of Sciences (1975)
International Conference on the Management of the Environment. University of Islamabad, Pakistan.

The first part of the conference proceedings provides a good description of Pakistan's water resources. The Indus River system discharges a volume of 171.5 billion cubic meters and serves an area of 15.4 million hectares and naturally became the focus of research undertaken for the conference. The conference participants, mostly engineers from the University of Islamabad and the Water and Power Development Authority (WAPDA) of the government of Pakistan, proposed the

development of 8.9 million hectares within the service area of the Indus River system for year-round irrigation. Environmental and natural system studies were limited to a brief discussion of sedimentation in the Rai and Chenab rivers.

22

Rao, A.A., and V. Ramesan (1978)
Groundwater Potential of India. Paper presented at the National Seminar on Ground Water and Lift Irrigation, India.

Rao and Ramesan define groundwater potential as the "replenishable reserve or average annual replenishment from rains, secular storage or groundwater available up to a given depth (300-600 m) beyond the zone of water table fluctuations" (p. 103). Secular storage is estimated to approach 11,000 billion cubic meters, but only a small fraction of this can be used for irrigation.

23

Rao, K.L. (1975)
India's Water Wealth: Its Assessment, Uses and Projections. New Delhi: Orient Longman Ltd.

Of particular relevance to the study of water management is Rao's discussion of the topographical, geological, and technological constraints affecting estimates of surface and groundwater potential in India. For example, Rao claims that less than half of the flow in the Ganges River can be used and that no more than 10% of water flow from the Brahmaputra can be diverted for multipurpose projects. Using the assumption that interbasin transfers are feasible, he estimates a slightly higher potential utilization of 800 billion cubic meters in the next ten years.

24

Rao, K.N. (1976)
The Climatic Water Balance of India. New Delhi, India: Controller of Publications.

25

Shankar, Kiran (1976)
Water Resource Development with Reference to Surface Water Hydrology in Nepal. Paper presented to Symposium on Water and Energy Resources, National Water Resources and Energy Commission, Kathmandu, Nepal.

The first part of the paper provides a concise description of the geography and hydrometeorological condition in Nepal. The rainy season provides 75 percent of total rainfall, with an

average precipitation level of 1,516 mm per year (250 mm in the dry regions). The second part classifies rivers in Nepal into three grades: (1) rivers with water sources coming from snow and glaciers in the Himalayas (Karnali, Narayani, and Sapta Koshi); (2) rivers coming from the Mahabharata mountain range with supplemental groundwater and springs (Bagmati, Rapti, Kaneala, Mechi, Kankai, Babai); and (3) rivers originating from the Chure or Siwalik mountain range (Tilawe, Vnagin, Sirsia, Manusmera, Hardinath, Sunsari and Banganya). The three major river basins identified are the Sapta Koshi, Gandaki, and Karnali in the east, central, and west portions of Nepal, respectively. In Part IV, results of the Hydrological Investigation Project (started in May 1962) are presented with proposals for water projects for the 1976-80 planning period.

26
Sharma, C.K. (1978)
Ground Water Resources of Nepal. Kathmandu, Nepal: Wonder Printing Press.

During the rainy season, almost 72 percent of total rainfall in Nepal is lost as runoff and with a very steep terrain and with an impervious rock surface, only 8 to 10 percent of rainfall is retained as groundwater. However, in the agricultural terai region, 20 to 30 miles in the eastern to the western region of Nepal, the flat topography and porous soil allow for the development of groundwater resources. Computations of potential groundwater supplies in different sections of the terai are presented, together with a discussion of the legal and organizational aspects of groundwater development.

27
Shristha, Hari Om (1976)
Hydro Potential--Nepal's Major Energy Resource. Paper presented at Symposium on Water and Energy Resources Development, United Nations Development Programme and Center for Economic Development and Administration, Kathmandu, Nepal.

The estimated hydroelectric potential of Nepal is about 83 million KW based on an average flow method. Major water sources are the Sapta Koshi, Sapta Gandali, and Karnali river systems, generating 22 million KW, 21 million KW and 33 million KW, respectively, or about 70 percent of Nepal's total surface water resources. At the Karnali river basin, ten power sites are proposed. Accompanying tables provide a good data base for estimating hydroelectric potential: Table 1 describes the method for measuring electric capacity while Tables 2 to 4 describe the energy production and installed capacity for selected sites; Table 5 shows the power exchange between India and Nepal.

28
Southeast Asia Development Advisory Group (1976)
Ad Hoc Seminar on Science and Technology for the Development of Nepal, Kathmandu, Nepal.

The Seminar on Science and Technology for the Development of Nepal had two objectives: (1) to make a comprehensive inventory of existing resources in Nepal and (2) to provide a framework for adaptive research, enabling imported technology to be more responsive to local needs. Water resources management was limited to a discussion of irrigation and hydropower development. Existing irrigation was limited only to 0.31 million hectares or 16 percent of total cultivated area. Hydroelectric power was viewed as an extremely underutilized resource--with a power potential of 83 million KW, 2.3 percent of the world's total water power. Only a small fraction of this had been developed and the per capita power consumption remains one of the lowest in the world. Proposed research and action programs were outlined in the last section.

29
Sri Lanka, Ministry of Irrigation, Power and Highways (1977)
Country Report From Sri Lanka. United Nations Water Conference, Mar del Plata, Argentina, 95 pp.

The country report of Sri Lanka, presented to the United Nations Water Conference in Mar del Plata, Argentina, contains (1) an assessment of water resources needs and problems, (2) potentials and limitations of alternative water resources management approaches, (3) policy options such as those embodied in water laws and institutional arrangements for water distribution, and (4) action proposals describing various national and international linkages.

30
Varma, C.V.J. (1978)
Efficiency in the use and reuse of water in India. Irrigation and Power Journal of Indian Central Board of Irrigation and Power 35(1):73-90.

Varma estimates that of the 700 billion cubic meters (projected for 2025) surface water flow in India, 510 bcm would be used for irrigation and 190 bcm. would go to other uses such as hydroelectric power, domestic water supply and livestock use, and industries.

31
Williams, Donald A. (1970)
Water in India: Decade of the Seventies. New Delhi: Ford Foundation.

C. SOUTHEAST ASIA

32
Booth, A. (1977)
Irrigation in Indonesia: Parts I and II. Bulletin of Indonesian Economic Studies 13(2/3).

33
Chainorong, L. (1977)
Water for Domestic Use in Rural Areas. Technical Paper No. 35. Bangkok: Government of Thailand Health Department and U.N. Water Conference.

A domestic water supply program that focuses on the provision of safe drinking water to consumers was developed for Thailand. This report discusses the administrative procedures of government agencies in the planning and implementation of rural water supply projects and the distribution system, source of water, and water treatment methods used.

34
Committee for Co-ordination of Investigations of the Lower Mekong River (1976)
The Water Situation in the Lower Mekong Basin. Bangkok, Thailand: Committee for Co-ordination of Investigations of the Lower Mekong River, 95 pp.

The Lower Mekong Basin, which includes Cambodia, Laos, northeast Thailand, and the highlands and delta areas of South Vietnam, covers a drainage area of 606,540 km^2. In this report data on the quantity and quality of streamflow in the basin are evaluated using hydrologic and meteorologic data collected over a period of 20 years by the Lower Mekong River Basin Committee (or Mekong Committee).

35
De Luna, E., and H.P. Quiazon (1976)
Groundwater in Cagayan Basin in Northeastern Luzon. Manila: Bureau of Mines, 43 pp.

The Bureau of Mines of the Philippine government conducts a yearly survey of the underground water resources as a corollary to the general geologic mapping of the Philippines. Survey results showed that the most dependable source of groundwater was the loose upper sandstone-conglomerate-clay stone sequence of the Pilocene to Pleistocene Ilagan formation in the Cagayan Basin in the northeastern Luzon area of the country.

36
Food and Agriculture Organization (1963)
Lands in Malaya. Rome: Expanded Technical Assistance Program Report, 1671:1-49, Part II: Water Resources. Rome: FAO.

37
Ienaga, Yasumitsu (1966)
Rice Culture and Irrigation Systems in the Philippines. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: The Center for Southeast Asian Studies, Kyoto University, 177-84.

Agricultural areas in the Philippines are classified by climate or rainfall distribution: (1) Type I, with a clearly defined wet and dry season, (2) Type II with maximum rainfall in November to January and with no dry season, (3) Type III with no definite season, but generally dry in November to December, and (4) Type IV where annual rainfall distribution is uneven. In Type I areas, rice is the dominant crop from June to September with hardly any dry season crop. Type II areas are mostly in the uplands where vegetable crops are grown. Type III lands in the Southern Philippines have a different rice planting calendar with a growth season starting in May.

38
Jaraswathana, D. (1977)
Current Use and Perspectives of Surface Water Resources in Thailand. Bangkok, Thailand: Royal Irrigation Department, Hydrology Division.

The present status and problems of implementing water resources projects in Thailand are evaluated in this report. Measures for solving administrative problems and for integrating present and future projects are discussed. The case study of the Chao Phya River system is included to provide a concrete example of implementation problems presented earlier.

39
Julian, Sebastian I. (1976)
Country Report of the Philippines. Paper presented to Symposium on Water Management in Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, pp. 33-40.

The water resources of the Philippines are being developed over a series of ten-year plans. For the 408 river basin and drainage areas (ranging in size from 40 to 25,000 km^2), 115 national or large-scale irrigation projects are being developed with a combined area of 443,778 hectares. A total

of 1,072 small-scale or communal systems, covering 200,188 hectares, is also being developed, especially through pump irrigation. The major dam projects are in Angat, Upper Pampanga, Jalaur, and Upper Magat multipurpose river basins. A map showing the regional research stations for irrigation development in the Philippines provides a good overview of the national coverage of irrigation projects in the Philippines.

40
Keat, T.S., D.C. Still, and F. Scarf (1976)
Average Annual Surface Water Resources of Peninsular Malaysia. Water Resources Publication No. 6. Kuala Lumpur, Malaysia: Ministry of Agriculture, Drainage and Irrigation Department.

The spatial availability of water for irrigation and domestic use in Peninsular Malaysia is determined from an evaluation of existing water resources. Previous estimates of water supplies from ungauged rivers use a water balance model to simulate mathematically the hydrologic process. This study computes daily water rates from rainfall records, actual evapotranspiration, water deficit, and runoff from 600 rainfall stations. The result is the construction of a surface water resources map for the region by plotting runoff data and mapping isohyets.

41
Philippines (Republic), Development Academy of the Philippines (1975)
Infrastructure/Utilities Development in the Philippines Report, Part II: Water Resources. Quezon City: Development Academy of the Philippines Task Force on Human Settlements, 72 pp.

Water requirements for different sectors in the Philippines are determined from an analysis of water supply and a projected estimate of water demand using population, crop area, streamflow, and rainfall data. Tables showing existing domestic, agricultural, and industrial water use are included in the report.

42
Philippines (Republic), National Hydraulic Research Center (1976)
Water Resources Data Bank: Progress Report. Quezon City: National Water Resources Council, 312 pp.

The National Hydraulic Research Center (NHRC) and the National Water Resources Council (NWRC) of the Philippine government started the Water Resources Data Bank Project in 1974 as a repository for all available data and literature on water and related land resources development. The compilation includes library and computer-generated materials. Guidelines and

classifications used for the data bank are described in this report.

43
Philippines (Republic), National Water Resources Council (1976a) Philippines Water Resources. Report No. 19. Quezon City: National Water Resources Council.

The water resources supply and demand up to year 2000 for the Philippines is estimated in this report by comparing available water supplies with that of current and projected water requirements. The country is divided into 12 water resources regions based on physiographic features and is matched with the amount needed for intake, onsite, and instream uses. Water adequacy is then estimated from the regional comparisons.

44
Philippines (Republic), National Water Resources Council (1976b) Principal River Basins of the Philippines. Report No. 4. Quezon City: National Water Resources Council. 28 pp.

The Philippines is divided into 12 water resources regions. Water data, drainage area, number of gauging stations, and estimated annual runoff for each river basin are summarized in this report and presented in tables.

45
Philippines (Republic), National Water Resources Council (1977) The Groundwater of the Paranaque Area. Quezon City: National Water Resources Council.

A regional analysis of the groundwater situation in Paranaque, Metro Manila, Philippines, and its surrounding areas is made by estimating the aquifer's regional inflow and outflow behavior and the total storage of fresh water. A proposed scheme, the Paranaque Spillway, is also discussed.

46
Philippines (Republic), National Water Resources Council (1978) Survey/Inventory of Water Impounding Reservoirs. Quezon City: National Water Resources Council.

A comprehensive overview of the existing water impounding projects in the Philippines was made to plan effectively for multipurpose development programs. The inventory was classified by region and gave a listing of all dams and reservoirs, potential, proposed, and ongoing projects, and a summary of relevant technical information for each project. Major river basins are classified by total capacity.

47
Philippines (Republic), National Water Resources Council (1980a) Groundwater of the Philippines. Report No. 34-1. Quezon City: National Water Resources Council.

Of the 2,256 mm/yr rainfall in the Philippines, 5 to 30 percent are retained as groundwater. Total estimated groundwater storage is 260,000 million m^3 but the rate of net groundwater inflow per year is only 33,000 million m^3. Thus groundwater storage is about 4 to 10 times the net inflow. Water supply facilities that rely on groundwater are divided into three types: (1) point source facilities from artesian wells or springs, (2) communal faucet systems, and (3) individual faucet systems. Organizational charts for the different agencies involved in groundwater resources development are included in the report.

48
Philippines (Republic), National Water Resources Council (1980b) Irrigation Inventory: 1977. Report No. 17-B. Quezon City: National Water Resources Council.

A comprehensive history of existing and proposed irrigation projects, classified by type of irrigation system (national, communal, and private), together with graphs and tables of relevant data by province and region is contained in this report. Maps using a scale of 1:50,000 are included to show the geographic location and other characteristics (such as topography) of the identified irrigation sites.

49
Philippines (Republic), National Water Resources Council (1980c) Philippines Water Resources Summary Data. Report No. 9. Quezon City: National Water Resources Council.

The information on water resources contained in this document includes data from 440 streamflow gauging stations in the Philippines. Details of station location, drainage area, and other relevant information are given for each area. Annual extremes and statistical parameters are also estimated.

50
Pohjakas, K., E. Livingston, and Y.M. Lubis (1976) Water Resources in East Indonesia. Jakarta, Indonesia: Ministry of Public Works and Electric Power.

51
Sandoval, M., and F.B. Mamaril, Jr. (1970)
Hydrogeology of Central Luzon. Report of Investigation No. 70. Manila: Department of Agriculture and Natural Resources, Bureau of Mines.

A description of the physiography, climate, general geology and hydrology, and chemical quality of groundwater in Central Luzon, Philippines, is presented in this report. Problems related to groundwater development are identified and solutions related to the development and conservation of groundwater resources are discussed. The appendices include stream discharges of selected rivers and logs of representative wells by province.

52
Seng, Goh Kiam (1974)
Hydrological Regions of Peninsular Malaysia. Water Resources Publication No. 2. Kuala Lumpur, Malaysia: Ministry of Agriculture and Rural Development, Drainage and Irrigation Department.

A partial inventory of water resources in Malaysia, classified by different regions of hydrologic similarity, is contained in this report. The classification is based on geological and climatic characteristics. The geological parameter used in the assessment is rock porosity (or lithology). The two climatic factors are annual rainfall and annual potential evapotranspiration.

53
Thailand, Ministry of Agriculture and Cooperative (1976)
Thailand Country Report. Bangkok, Thailand: Ministry of Cooperatives and the National Committee for the United Nations Water Conference.

This report provides an assessment of existing water resources utilization and management in Thailand for the UN-ESCAP Regional Preparatory Meeting to the United Nations Water Conference. Information on current supply and demand for surface and groundwater, alternative water development technologies used, and the administrative structure for implementing water projects are presented.

54
Tillson, D., and J.V. Sinogba, Jr. (1978)
Rinconada Integrated Area Development Project: Groundwater Study. Camarines Sur, Philippines: Bicol River Basin Development Program and Tams-Tae Joint Venture.

Based on a completed study of established formation classification and geologic mapping, an area-wide groundwater study for the Rinconada Project of the Bicol River Basin Development Program of the Philippines was made. The range of physical characteristics with respect to material content, continuity, and lateral extent of geologic formations was assessed in terms of groundwater potential. Pumping tests and geologic reconnaissance activities were also completed.

D. NORTHEAST ASIA

55
Chi, Ch'ao-Ting (1963)
Key Economic Areas in Chinese History (As Revealed in the Development of Public Works for Water Control. New York: Paragon Books Reprint Corp.

The development, construction, and operation of water control projects for agricultural production, transportation (mainly the transport of grain tribute), and recreation, was essentially a function of the state in ancient China. Successive dynasties used irrigation canals, surface tanks, drainage works, flood control, and artificial waterways as political and social instruments for maintaining power and prestige. Throughout Chinese history, therefore, certain regions flourished as a result of particular natural and topographic conditions. It is this concept of "key economic areas" that the author uses in presenting an overview of the role of public waterworks in cultural evolution in the tradition of Karl Wittfogel. A geographical and statistical analysis of major water regions is presented in Chapters I to III. Chapter IV describes the economic function of water control and serves as an introduction to the next three chapters, where specific water regions are evaluated--the Loess and Central Huang Ho basins, the Yangtze Valley, and the Sui and Yuan canals of the Yangtze.

56
Japanese Society of Irrigation (1972)
Irrigation and Drainage in Japan. Tokyo: Japanese Society of Irrigation, Drainage and Reclamation Engineering.

57
Kim, Ke Ho (1982)
Some Water Resources Management Problems in Korea. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 38 pp.

An overview of water management programs in Korea, specifically the operation of the Chungju Multipurpose Dam Project in the Han River Basin and the salinity problems of the Nakdong River Basin is presented. Government resources in Korea are concentrated in the development of four major river basins--the Han, Nakdong, Geum, and Yung San rivers. The Industrial Sites and Water Resources Development Corporation (ISWACO) was involved in the construction of the Chungju Multipurpose Dam that had a total capital cost of US$816 million. It has the largest reservoir capacity in the Han River Basin and the lowest cost per unit of water storage. Almost complete regulation of runoff from 26 percent of the basin is projected. With respect to salinity problems in the Nakdong River, a UNDP/FAO Nakdong River Delta study was completed in 1977, resulting in the construction of the Nakdong Estuary Barrage and the development of a Nakdong River protective program.

58

Kudo, H., and K. Ishizaki (1978)
The Present Status of Technological Development of Artificial Groundwater Recharge in Japan. In Proc. ICID Symposium, Athens, Greece.

Reviews the present status of technological development of artificial groundwater recharge in Japan; gives three instances in the field: (1) the planning of converting river surplus water to groundwater by way of infiltration channels, (2) the construction of underground reservoir with cut-off walls using grout, and (3) research on the operation of a combined surface dam and an underground reservoir.

59

Nickum, J.E. (1977)
Hydraulic Engineering and Water Resources in the People's Republic of China. Report of the U.S. Water Resources Delegation. California: Stanford University,

A U.S. Water Resources Delegation was sent to the People's Republic of China (or China) from August to September 1974 to visit various water resources development projects, especially those projects involving hydroelectric power, irrigation and drainage, and flood control. This report describes the study tour's observations with respect to (1) China's water problems and the solutions adopted, (2) an overview of river systems and existing projects, (3) the organization of water control, and (4) technical and economic programs for water resources development.

60
Taiwan Provincial Water Conservancy Bureau (1971)
An Economic Evaluation of Underground Water Irrigation in Touliu and Pintung Areas. Water Economic Studies Series No. 18. Taipei, Taiwan.

61
Wang, C.C. (1979)
Regarding water resource activities in the Republic of China. Industry of Free China 52(6):9-18.

The views of an environmental engineer and economic planner on water resource development in Taiwan are reported. The article was first addressed to the Regional Conference on Water Supply in Eastern Asia.

E. GENERAL PLANNING AND IMPLEMENTATION PROBLEMS AND ISSUES

62
Ali, Syed Hashim (1981)
One Season of Integrated Water Management. Paper presented to the International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University. (See reference 814 for summary of contents.)

63
Attanato, C. (1974)
Policy Review of Irrigated Agriculture in Northern Thailand. Agricultural Development Council National Seminar Report No. 5 (mimeographed).

64
Bower, Blair T., and Maynard M. Hufschmidt (1982)
A Conceptual Framework for Analysis of Water Resources Management in Asia. EAPI Working Paper. Honolulu: Environment and Policy Institute, East-West Center.

In addition to the conceptual framework, the paper presents a number of important problems relating to water resources management in Asia. Eight problem areas are identified as especially significant: (1) the underemphasis given to implementation compared to planning, (2) narrow definition of water resources management that includes only physical control of water; (3) the narrow definition of outputs of most components; (4) emphasis on primarily engineering and

techno-economic evaluation; (5) the overconcentration of irrigation agencies on conveyance and control of water; (6) the absence of local participation in the planning, design, and operation of water resources development projects; (7) little if any enforcement of water quality regulations; and (8) lack of recognition of linkages among water quantity, water quality, air quality, and land quality management.

65
Chadha, O.P., and B.K. Uppal (1981)
Planning Approach for Irrigation Systems of the Future. Water and Power Consultancy Services (India) Ltd., 26 Kosturba Gandhi May, New Delhi, India.

66
Daneke, Gregory A., and Jerry Delli Priscoli (1979)
Social assessment and resource policy: Lessons from water planning. Natural Resources Journal 19(2):357-75.

67
Keller, Jack, et al. (1981)
India/USAID Irrigation Development Options and Investment Strategies for the 1980s. USAID Water Management Synthesis Project.

The USAID Water Management Synthesis Project team visited India in November 1980 to evaluate irrigation development options and investment strategies for India. This monograph contains the study team's report. Appendix 1, the American Embassy Report on Water Resources Development in India (by Garry S. Posy, Bodh Roj, and Dean F. Peterson), provides a comprehensive review of existing irrigation resources, programs, and policies for India. Some of the major recommendations of the team are: (1) to set up a model irrigation management system in a medium command area of from 4,000 to 10,000 hectares as a pilot (test) site; (2) to introduce technical innovations such as the use of PVC pipe distributaries other than lining canals; (3) to develop adequate feedback information links; and (4) to conduct diagnostic surveys, especially in the development of tubewell irrigation.

68
Lee, S.C., C.Y. Lee, and Y.J. Yang (1968)
An Investigation on the General Economic Situation for Water Resources Planning in Kaohsiung-Pingtung Watershed Area, Taiwan. Taichung, Taiwan: Research Institute of Agricultural Economics, Chung Hsing National University.

69
Lieftinck, Pieter, A. Robert Sadove, and Thomas C. Creyke (1968) Water and Power Resources of West Pakistan: A Study in Sector Planning, Vols. 1-3. Baltimore: The Johns Hopkins University Press.

The Indus Basin in West Pakistan, which includes the great Indus River and its six main tributaries (Kabul, Jhelum, Chenab, Ravi, Beas, and Sutlej), is the subject of this three-volume report. An historical analysis of the development of the basin and the region that it serves is contained in Chapters II-IV (Vol. 1). Water resources potential for surface water storage, electric power, and other uses is evaluated in Chapters (V-VI). In Chapters VII and VIII, policy recommendations and principal findings on the feasibility of dam construction at Tarbela are presented. Volume 2 focuses on the impact of the project to agricultural development, in particular, the improvements of food grain production. Volume III consists of supplemental papers--(1) the noneconomic implications of the project, (2) economic efficiency criteria, and (3) power simulation studies.

70
Lowdermilk, Max K., and Mark Svendsen (1982) Planning Concepts for a Flexible Irrigation Water Management Strategy in Asia. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 24 pp.

Changes in budgetary allocation in the United States Agency for International Development (USAID) show that in the past three years, investments in irrigation projects in Asia have increased following irrigation development trends in the region. Of the total irrigated area in the world, 70 percent is located in Asia, and 60 percent of new irrigation capacity is found in the region. For the developing countries, 90 percent of irrigated areas is found in Asia where major efforts in agricultural development are concentrated on the improvement of irrigation facilities. Suggestions for future USAID research and planning approaches for irrigation are outlined. For example, the authors recommend the use of flexible water delivery standards and diagnostic, long-term evaluation of irrigation farming systems, and the emphasis on institutional development through training programs and farmer participation activities.

71
Mageed, Yahia Abdel (1982) The U.N. water conference: The scramble for resolutions and the implementation gap. Mazingira 6(1):4-13.

72
Muda Irrigation Scheme (1970)
Implementation Report of the Muda Irrigation Scheme. Telok Cengai, Alor Star, Malaysia.

73
Pescod, M.B. (1976)
Criteria for Improving Rural Water Supply Systems in Asia. Bangkok, Thailand: Asian Institute of Technology and UN-ESCAP Regional Preparatory Meeting for the U.N. Water Conference.

The paper discusses the various issues, both economic and technological, affecting the design and implementation of rural water supply projects in Asia. Operating criteria and water allocation and pricing policies are evaluated using a few case studies from Thailand.

74
Philippines (Republic), National Economic and Development Authority (1978)
Five year development plan (1978-1982): Water resources. Philippine Development 6(7):36-45.

A listing of water resources projects for the Philippines for the period 1974 to 1977 is contained in this report. It outlines the accomplishments of the program, largely irrigation, flood control, and water supply. It provides a guide to investments in the water resources sector vis-a vis other resources (such as land), but it fails to incorporate an economic evaluation of benefits and costs from the projects identified.

75
Prasad, T. (1974)
Imperatives of water resources planning in the developing economy of India. Indian Journal of Power and River Valley Development.

76
United Nations, Economic Commission for Asia and the Far East (1971)
Proceedings of the Ninth Session of the Regional Conference on Water Resources Development in Asia and the Far East. Water Resources Series No. 40, 202 pp. Bangkok, Thailand: UN-ECAFE.

A review of water resources development projects for irrigation, reclamation and drainage, flood control, and soil conservation was made cooperatively in the Ninth Session of the Regional Conference on Water Resources Development. Other topics discussed were (1) scope of water resources development

to accelerate food production, (2) efficiency in water resources project management and water use, and (3) long-term water requirements in relation to global strategies of the Second United Nations Development Decade.

77
United Nations, Economic Commission for Asia and the Far East (1976)
Glossary of Hydrologic Terms Used in Asia and the Far East. Flood Control Series No. 10. Bangkok, Thailand: UN-ECAFE.

To facilitate information exchange among country experts in water resources in Asia, a program for standardizing the hydrologic terms used in planning water resources projects was sponsored by the UN-ECAFE. Approximately a thousand terms, their definitions, and their relation to hydrology are contained in this report.

78
Verma, Rameshwar D. (1977)
Technology Transfer for Irrigation Planning of Arid Lands. Center for Population Studies, Harvard University (mimeographed).

79
Vohra, B.B. (1975)
Land and Water Management Problems in India. New Delhi, India: Training Division.

F. RIVER BASIN PLANNING AND IMPLEMENTATION

80
Adan, B.L., and E.W. Lee (1977)
Development and Protection of the Water Resources of Laguna de Bay Basin. Mar del Plata, Argentina: United Nations Water Conference, 12 pp.

The experience of the Philippine government in regional planning for a drainage basin such as the inland Laguna de Bay Basin near Metro Manila is discussed in this report. A brief examination of government projects and the results of water quality studies are also included.

81
Arbhabhirama, A., et al. (1976)
Surface Water Supply Study: Bicol River Basin. Report No. 54. Bangkok, Thailand: Asian Institute of Technology.

An analysis of water supply quantity and quality for the Bicol River Basin in the Philippines was made to provide information for irrigation planning and improvement. Geological and seasonal variations in rainfall and streamflow, the available supply in the dry season, and future conditions of water (especially pollution) were evaluated.

82
Cotabato-Agusan River Basin Development Project (1976)
Cotabato-Agusan River Basin: Profile. Davao City, Philippines: Cotabato-Agusan River Basin Development Project Technical Staff, 319 pp.

The Cotabato-Agusan River Basin in northern Mindanao, Philippines, is one of the largest multipurpose projects for the southern Philippines region. This report contains a summary of (1) water and land resources potential, (2) social and economic conditions, (3) irrigation, hydroelectric power, flood control, and domestic water supply projects, and (4) impact on regional development.

83
Japan, Yodo River Dams Control Office (1974)
Outline of Integrated Management of Reservoirs in the Yodo River Basin. Japan: Yodo River Dams Control Office, Kinki Regional Construction Bureau, 58 pp.

This paper analyzes the problem of water management in the Yodo River Basin in Japan with respect to design flood discharge, controlled reservoir storage, and maintenance of water quality. Research problems related to prediction of rainfall, flooding, low flow in the reservoir, and water quality control are reviewed.

84
Lakshminarayana, C., and S.P. Rajagopalan (1977)
Optimum cropping patterns in a river basin. Journal of Irrigation and Drainage, ASCE, March.

85
Philippines (Republic), Laguna Lake Development Authority (1977a)
Land Use Plan: Laguna de Bay Watershed, Northeast and Southeast Areas, Vols. 1 to 3. Manila: Laguna Lake Development Authority.

The development plan for the Laguna Lake in the Philippines is discussed in this three-volume report on the dominantly rural eastern and southern portions of the Laguna Lake Basin. A regional scheme for land development that considers urban expansion trends from the Manila growth center, and detailed community plans affecting the preservation and development of lake water and related land resources are examined.

86
Philippines (Republic), Laguna Lake Development Authority (1977b) Land Use Plan: Laguna de Bay Watershed, Northwest and Southwest Areas, Vols. 1 to 4. Manila: Laguna Lake Development Authority.

The development plan for the Laguna Lake in the Philippines is discussed in this four-volume report on the urbanized northwest and southwest segments of the lake. The plan includes an estimate of Manila's urban expansion up to Year 2000, a general description of infrastructure requirements, and land-use policy considerations, especially those affecting surrounding watersheds and grasslands.

87
Philippines (Republic), National Economic and Development Authority (1979)
The Magat Multi-Purpose Project. Manila: National Economic and Development Authority, 19 pp.

The report outlines the Philippine government's program for the development of the Magat River Basin area with respect to its potential for multipurpose usage. The expected outputs from the project are irrigation (comprising the major portion of water use), flood control, water supply, and hydroelectric power. The report is limited to a description of the government's program. The tables included in the last section outline the extent of capital formation for the project over a ten-year period.

88
Philippines (Republic), National Power Corporation (1976)
Lower Agno Development Plan Multipurpose Project. Manila: National Power Corporation and Electroconsult, Italy, 153 pp.

The Lower Agno Development Plan of the Philippine government covers the Agno River Basin in Benguet-Pangasinan, the Tabu multipurpose project in Benguet, and the San Roque reservoir in Pangasinan. The results of the comprehensive study of these projects are presented in this report. It is divided into (1) the natural features of the projects, (2) needs and requirements for multipurpose development, (3) identification

of technical projects, and (4) definition of investments and benefits from the projects.

89
Philippines (Republic), National Power Corporation (1979) San Roque Multipurpose Project. Manila: National Power Corporation and Electroconsult, Italy, 246 pp.

The National Power Corporation and the Electroconsult Firm of Milan, Italy, completed the feasibility study of the San Roque hydroelectric and irrigation project in Lower Agno River Basin, Pangasinan Province, Philippines. Field explorations, basic design of major structures, electrical and mechanical equipment analyses, and economic feasibility of the project were made. Supporting technical papers accompany the main report. Appendices C and D discuss the hydrology and flood control components and contain data on the operational capacity of the Ambuklao Dam.

90
Philippines (Republic), National Water Resources Council (1979a) Eastern Visayas: Samar Basins. Report No. 24-8A, 199 pp. Quezon City: National Water Resources Council.

Thirty-eight potential water impounding projects in the Samar Basin, eastern Visayas, Philippines, have been identified, but only the small reservoir in Catarman has been fully developed. This study establishes the planning framework for the basin using all 38 sites to adequately supply water to the 68 municipalities and one chartered city included in the basin area. The types of water uses are domestic supply, sewerage, irrigation, flood control and drainage, hydroelectric power (limited capacity), and transportation and fisheries. A hydrologic survey of surface and groundwater is used to supplement water demand projections.

91
Philippines (Republic), National Water Resources Council (1979b) Ilocos: Laoag River Basin. Report No. 24-1-A, 205 pp. Quezon City: National Water Resources Council.

This report examines the framework plan for the Laoag River Basin in the Ilocos Region of the Philippines, a largely agricultural and heavily forested area. Projections of water requirements and available water supply from surface and groundwater resources indicate a wide margin of surplus water up to year 2000. Plans for the development of irrigation, hydroelectric power, flood control, and water supply are also discussed. A brief description of the institutional aspects of project implementation is contained in the last section.

92
Philippines (Republic), National Water Resources Council (1980a) Abulog River Basin. Report No. 24-2A, 116 pp. Quezon City: National Water Resources Council.

A planning framework for the development of the Abulog River Basin in Cagayan Province, Philippines, is presented in this report. The elements of the framework include (1) an inventory of available land and water resources, (2) potential for development of these resources, specifically for irrigation, (3) projection of water demand up to year 2000, (4) identification of water resources projects, (5) environmental and social impact assessment of future development, (6) determination of development thrusts for various sectors, and (7) determination of possible areas for improvement.

93
Philippines (Republic), National Water Resources Council (1980b) Leyte Basins. Report No. 24-8B, 212 pp. Quezon City: National Water Resources Council.

The subregions of Leyte Province, Philippines, that comprise the Leyte basins are Leyte, Biliran, Pana-on islands, and the Poro island ground (west). This report elaborates on the planning framework for the basin. It includes an assessment of existing water and related land resources and projections of water demand up to year 2000.

94
Philippines (Republic), National Water Resources Council (1980c) Lower Cagayan Basins. Report No. 24-2C, 188 pp. Quezon City: National Water Resources Council.

A water resources development plan for the Lower Cagayan basins in the Philippines was made to improve the data base for subsequent planning efforts. The following topics were covered in the study: (1) current situation and trends in water and related land resources development, (2) potentials of these resources for hydroelectric power and irrigation purposes, (3) forecasting of water demand up to year 2000, (4) identification of projects, (5) environmental and social impact assessment of future development efforts, and (6) development and improvement of basic data.

95
Philippines (Republic), National Water Resources Council (1981) Abra River Basin. Quezon City: National Water Resources Council, 200 pp.

A study of water resources potential for Region 1 in the Philippines, focusing on the development of the Abra River Basin in Ilocos province, is presented in this report. Projections for water demand up to year 2000 are estimated by means of an inventory of existing development projects and by an analysis of available data on current land and water resources in the region.

96
Pradhan, B.K. (1976)
Irrigation Development in Nepal. Kathmandu, Nepal: Department of Irrigation, Hydrology, and Meteorology.

The report forms part of a Council for Science and Technology Seminar in Kathmandu, Nepal, where alternative programs for water resources development were proposed. In this paper, minor and medium-sized irrigation projects in the Terai, covering 146,000 hectares, were proposed alongside the development of groundwater in the Terai alluvial plains. In the hill areas, erosion is a serious problem and measures to control landslides were discussed. Table 2 provides a useful listing of irrigation districts and their corresponding minor and medium diversion projects. The Appendix consists of a comprehensive list of irrigation projects and area covered from 1956 to 1965.

97
Sherman, L. (1978)
An approach to comprehensive planning: Water resources management study. Bicol Research Journal 1(1):12-13.

The article describes the water resources plan for the Bicol River Basin in the Philippines. The plan includes a flood control and irrigation program for approximately 16,000 hectares of ricelands; improvement of some 2,500 hectares of waterlogged rice paddies through drainage improvements; and elimination of saline intrusion to some 900 hectares of land in the coastal areas of Camarines Sur Province.

98
Sugarawa, Michitaro (1966)
Some Technical and Economic Problems on Agricultural Development in the Mekong Basin. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: The Center for Southeast Asian Studies, Kyoto University, 31-36.

In the initial planning phase for the development of the Mekong River Basin, eight major issues and problems emerged from which subsequent studies have been conducted partly to resolve some of the basic problems identified. These are (1)

the absence of an international standard for soil classification in the tropics, (2) the presence of inadequate irrigation soil maps and surveys that are used in the canal design and layout, (3) the viability of using pilot farm experiments to simulate overall soil and topographic conditions on the basin, (4) the process of standardizing farm size, cropping systems, and production intensification, given existing farming trends, (5) lack of a clear definition of direct, indirect, and nonmaterial benefits and costs, (6) the difficulty of arriving at a fixed interest rate and terms of payment for capital investments, (7) the need to compute a uniform water fee based on actual water use, and (8) the lack of support infrastructure, in particular, drainage facilities.

99
Takeda, Kunasaki (1966)
Comprehensive Development of Lower Mekong Basin. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: The Center for Southeast Asian Studies, Kyoto University, 145-52.

Agricultural lands in the lower Mekong basin are classified as (1) rainfed fields, or areas of high altitude not directly affected by floodwaters; (2) valley plains and deltas, or areas affected by flooding with a suitable depth of water; (3) flooded or floating rice fields, or areas with water depths beyond 4 to 5 cm, but whose flow is manageable; and (4) ponded water or areas that cannot be cultivated. A comprehensive plan for the lower Mekong basin area includes flood control, irrigation, low-cost electricity, and limited domestic water supply.

G. STUDIES ON PLANNING AND IMPLEMENTATION OF ALTERNATIVE WATER USES

100
Asia Society (1977)
Report of the Seminar on Small-Scale Hydroelectric Power and Fertilizer Production in Nepal. New York: Asia Society.

The Asia Society, in coordination with the National Council for Science and Technology of Nepal, sponsored a seminar (28 February to 3 March 1977) on the development of small-scale hydroelectric power facilities and fertilizer production in Nepal. The recommendations of seminar participants and a summary of proceedings and technical reports are contained in this document. The major conclusions are the following: (1) to develop small hydroelectric power projects jointly with a

program of afforestation, (2) the estimated scale would be about 16-18 kw for a typical hill village of 250 persons and a forest area of 30-40 hectares, and (3) supplementary uses such as irrigation, fertilizer, domestic water supply, and small industries can be generated from the project. The appendices provide an excellent data base of Nepal's forest and water resources since 1963.

101

Camp Dresser and McKee International, Incorporated (1976)
Planning Survey of 110 Water Systems. Vols. 1 to 6. Boston, Massachusetts: Camp Dresser and McKee International Inc. and Local Water Utilities Administration, Philippines.

The so-called 100-Cities Project of the Local Water Utilities Administration (LWUA) of the Philippines was started in 1975 with a survey of 131 cities serviced by 110 water systems. The survey found that 65 of these water systems were qualified for interim capital assistance for water supply improvements and that 16 projects were ready for partial improvements. Also, 48 of the 110 systems required special technical studies, especially in the development of groundwater resources.

102

Hanam, Z. (1975)
Investigation of Groundwater Resources. Quezon City: Local Water Utilities Administration.

The hydrological and hydrogeological characteristics of wells and aquifers in Batangas City, Philippines, are evaluated with respect to ground water development potential. This report, which is part of a series of water district reports for urban areas in the Philippines, discusses the data collection methods, the standards for estimating water quality, and the preliminary evaluation of aquifer response to withdrawal.

103

India, Central Board of Irrigation and Power (1979)
Water Resources Research in India. Publication No. 78, 249 pp. New Delhi, India: Central Board of Irrigation and Power, Indian National Committee for the International Commission on Large Dams.

The activities related to the effective utilization of water resources for agriculture and hydroelectric power for India are discussed in this report. Research activities in river valley projects are also described.

104
Indonesia, Ministry of Public Works and Electric Power (1977)
The Development of Water Resources in Indonesia. Country paper presented to the U.N. Water Conference, Argentina, 114 pp.

The First Five-Year Development Plan in 1968 for Indonesia's water resources focused on two conditions: (1) the effects of population growth on water resources and (2) the structure and pattern of the present conditions of water resources management.

105
Institute of Science, Tribhuwan University (1976).
Nepal: The Energy Sector. Kathmandu, Nepal: Tribhuwan University (mimeographed).

This year-long study on Nepal's energy problem consists of three parts: (1) current energy situation, (2) problems of energy development, and (3) proposals for energy projects. Chapter VIII of Part II focuses on hydroelectric power and provides an excellent review of Nepal's hydropower potential. Nepal comprises only 0.094 percent of total land area of the world but has 2.27 percent of the world's hydropower supply. Potential hydropower generation at full capacity is estimated at 58,000 Mw and Table 8.1 gives a comparative breakdown of the power potential for the three major river basins in Nepal for selected countries in Asia. Table 8.3 outlines the proposed hydropower program--installed annual energy capacity and construction and operating costs.

106
Lahiri, Supriya (1976)
Investment Planning for the Irrigation and Power Sector in the Eastern Region of India. Center for Population Studies, Harvard University (mimeographed).

107
Philippines (Republic), National Economic and Development Authority (1974)
Water Resources. Vols. 1-9. Manila: National Economic and Development Authority and Department of Public Works, Transportation, and Communications.

The National Economic and Development Authority (NEDA) of the Philippines conducted a project entitled "Physical Planning Strategy for the Philippines." Part of this project was a review of water resources development. The emphasis was on the large-scale, major waterworks such as hydroelectric power, irrigation for over 1,000 hectares, water supply and sewerage serving at least 10,000 people, and flood control and drainage

for cities and large municipalities. The report recommends the use of watershed conservation approaches and the effective control of sedimentation.

108

Philippines (Republic), National Irrigation Administration (1979) Irrigation Development Plan for Central Luzon. Quezon City: National Irrigation Administration and Engineering Consultants, Inc., Denver, 151 pp.

An appraisal of irrigation potentials in Central Luzon, Philippines, was made by the National Irrigation Administration (NIA) to explore the possibilities of expanding beyond irrigation (e.g., water supply and hydroelectric power). Approximately 34 projects are planned through regulation of surface and groundwater and diversion of direct streamflow and irrigation return flow.

109

Rana, Mahendra M., and B.B. Shresta (1976) Planning Energy Needs of the Future. Paper presented at Symposium on Water and Energy Sources Development. United Nations Development Programme and Center for Economic Development and Administration, Kathmandu, Nepal.

While the focus of this paper is on energy, the major resource base identified for fulfilling energy needs is water. Section 5.5 discusses in detail the hydroelectric power development program. Total hydropower generation would be 146,000 kw including present capacities from the Gandak, Kulekhani, and Derighat hydroelectric power plants. It is proposed that mineral based, power intensive industries (such as iron and steel, cement, lead, and zinc) be located near the hydroelectric power plants.

110

Resources for the Future, Inc. (1971) Agricultural Development in the Mekong Basin: Goals, Priorities, and Strategies. Baltimore, Maryland: The Johns Hopkins Press, 108 pp.

Using a vast amount of available data on the Mekong River Basin, Resources for the Future (RFF) compiled a demand-supply study of the physical and human resources of the Mekong River Basin. The chapter on water resources potential and the issues involving water quality control as affected by modernization of agriculture is especially significant for water resources management.

111
Walker, S.H., et al. (1980a)
Development of Water Resources of Bali: A Master Plan, Vol. 1, No. 31. Executive Summary. Land Resources Study, Ministry of Overseas Development.

The possibilities for increasing water storage by means of reservoirs are limited as a result of topographic and siltation problems. An increasing use of groundwater appears to be feasible. Efficiency of water use, although relatively high in the irrigation of rice, could be substantially improved to increase yields of other crops. Various projects and schemes are described.

112
Walker, S.H., et al. (1980b)
Development of Water Resources of Bali: A Master Plan, Volume 2, No. 31. Main Report. Land Resource Study, Ministry of Overseas Development.

After a summary of the physical environment, administration, and agroeconomic structure of Bali, an account is given of available water resources, present water use, and development proposals and priorities. Supporting reports contain details of the climate and hydrology, soil and land classification, agriculture, subak (local irrigation society) survey and inventory, irrigation water requirements, and proposals for developing unused surface water resources.

113
Wang, Y.T. (1973)
Water resources development for agriculture and irrigation water management in Taiwan. Industry in Free China (Taipei) 39(6):14-31.

114
World Health Organization (1977)
Philippines: Water Supply and Sewerage Sector Study. Vols. 1 and 2. Geneva: World Health Organization and International Bank for Reconstruction and Development.

The current situation and proposed projects for water supply, sanitation, and sewerage disposal are presented in this two-volume report. The proposed projects include (1) the development of a geographic and demographic data base, (2) improvement of institutional arrangements, (3) construction of drinking water wells, and (4) personnel training. Volume 2 contains a detailed description of groundwater resources and projections for future water demand based on population growth estimates.

IV. SPECIFIC STUDIES OF WATER RESOURCES MANAGEMENT EXPERIENCES

The bibliographic entries and abstracts in this section are arranged by region and, within each region, by authors in alphabetical order. Several subclassifications can be applied depending on the discipline of the author, the subject matter analyzed, and the unit of analysis used. We chose to focus on the analytical framework of the study and classified the entries by the planning and implementation process defined in Part II of the bibliography.

The following points should be considered when studying the bibliography:

1. An attempt was made to be comprehensive in the bibliographic search for materials, at least for case studies reported over the past five to ten years;

2. Non-Asian sources were omitted, although we recognize that there are important water resources management studies in other regions that are of significant relevance to the Asian context; and

3. Given the voluminous literature on water resources management and the variety and diversity of analytical approaches used, we have had to be very selective. Frequently, the choice of entries reflects our personal interests, as well as some of the more important issues that emerged in the East-West Center Asian Water Resources Management Workshop held in September 1982.

Issues Arising from Case Studies

Several issues have emerged in the process of collecting and classifying case studies on Asian water resources management. We summarize these issues and list relevant bibliographic entries.

1. A wide reading of Asian water resources management case studies provides fuller understanding of the social, political, economic, and cultural aspects that can be found in "water-based" societies (163, 173, 200, 201, 208, 213, 216).

2. Several papers argue strongly for a shift to institutional approaches to water resources management rather than purely technical, engineering solutions (115, 116, 118).

3. Several countries in Asia (as well as other regions) share common water resources management problems; accordingly, communication among these countries will facilitate

planning for solutions. An example is the problem of the "tail-end syndrome" (115, 116, 125).

4. Practical solutions to water resources management problems for a particular country actively seeking alternative approaches are likely in the future to be of utmost significance to other countries. Numerous sources in the entries included in this chapter describe attempted solutions, but of particular interest is the participatory approach used in the Philippines (203, 224, and 239).

5. The effects of demographic and nondemographic factors on changes in water allocation and control are raised. The debate is far from concluded, and the bibliography focuses on the interactive, rather than causal, processes (159, 174, 193, 218, 262, 270).

6. Special topics related to these issues are enumerated below together with some references.

   a. Case studies that analyze particular social, economic, political, and cultural aspects of water resources management--116, 117, 118, 125, 131, 132, 143, 161, 173, 187, 189, 190, 198, 203, 207, 213, 216, 220, 221, 226, 230, 232, 233, 235, 238, 239, 245, 246, 250, 265.

   b. Case studies using an anthropological (enthnographic) approach--159, 174, 193, 218, 247, 249, 262, 263, 264, 269, 270, 271.

   c. Case studies quantifying social and economic variables affecting water resources management--123, 163, 199, 200, 201, 208, 261, 267.

      Case studies quantifying economic benefits from water resources management--145, 158, 182, 209, 211, 236, 256, 258.

   d. Case studies on institutional arrangements for irrigation water distribution and scheduling--133, 135, 139, 146, 149, 184, 205, 272.

   e. Case studies on technical approaches to solutions to water resources management problems--115, 120, 121, 122, 123, 126, 127, 129, 130, 140, 141, 148, 151, 152, 156, 160, 164, 166, 167, 172, 175, 176, 181, 183, 191, 192, 195, 196, 197, 202, 204, 214, 215, 217, 219, 227, 228, 231, 234, 237, 240, 243, 244, 248, 251, 252, 253, 254, 255, 257, 259, 260, 266, 268; alternative low-cost technologies--128, 137, 140, 142, 151, 157, 204; tertiary level improvement--119, 121, 126, 127, 129, 136, 172, 185, 194, 219, 252; groundwater studies--141, 142; water supply and sanitation--124.

f. Case studies on changes in water resources management approaches--159, 174, 193, 218, 262, 270; increase in conflict over water use--139, 145, 149, 199.

A. GENERAL

115
Asian Productivity Commission (1980)
Farm Level Water Management in Selected Asian Countries. Report of a Multi-Country Study Mission. Tokyo, Japan: Asian Productivity Commission.

The Mission was a follow-up of a symposium on the same subject held in Tokyo in 1976. The volume includes observations of the participants in the countries visited and their individual reports on the status and problems of irrigation and on-farm water management in their countries. The study mission comprised three phases implemented in Thailand, Japan, and Taiwan.

116
Coward, E. Walter, Jr. (1977)
Irrigation management alternatives: Themes from indigenous irrigation systems. Agricultural Administration 4:223-37.

The article discusses three management alternatives for gravity irrigation systems using case studies of indigenous irrigation systems as models of locally derived organizational approaches. The management schemes evaluated are the (1) accountability model, (2) mini-unit organization approach, and (3) canal-based organizational unit. Three social contexts are used as examples. The first context is when irrigation development policy includes the improvement of existing traditional systems. The second context refers to the development of new small-scale systems, while the third context is where small subunits are created from existing large-scale systems but operate independently of the main system organization.

117
Easter, K. William (1980)
Capturing the Economic Surplus Created by Irrigation. Staff Paper P80-14. St. Paul, Minnesota: Department of Agricultural and Applied Economics, University of Minnesota.

118
International Rice Research Institute (1978)
Irrigation Policy and Management in Southeast Asia. Los Banos, Philippines: International Rice Research Institute.

A compendium of materials on Southeast Asian irrigation systems is contained in this volume. It is divided into four sections: (1) planning and design, (2) management, operations,

and maintenance, (3) economic analyses, and (4) organization and behavior of irrigators.

119
Irrigation (Special Issue) (1981)
International Water Power and Dam Construction 33(8):13-41.

This special issue marks the meeting of the International Commission on Irrigation and Drainage in Paris in August 1981. Short articles of economic interest discuss Java's Rentang barrage; development of pumps for the Third World; integrated agricultural development in the Philippines; the small schemes using appropriate technology favored by the Asian Development Bank; the Chambal Project in India's Madya Pradesh; and sun pumps on remote farms in Pakistan.

120
Joint Commission on Rural Reconstruction (1961)
Proceedings of the Far East Regional Irrigation Seminar. Taipei, Taiwan.

121
Kung, Peter (1976)
Water Management for Paddy Fields in Tropical Asia. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 69-79.

Providing complete irrigation and drainage systems for paddy cultivation in Asia is difficult given topographic, climatic, and economic considerations. In many areas, supplying water is not much of a problem as controlling its flow at a predictable manner. Thus, of the total irrigable area in Asia, only about 15 to 20 percent is irrigated, and only a small fraction of this is fully irrigated. The main problem is the lack of regional control of water that affects large tracts of land in northeast India, central Bangladesh, Lower Burma, Central Plain of Thailand and the Philippines, Mekong River Basin, and the large river systems of India and Pakistan. Costs of water development at the regional level are also high. The irrigation projects in Thailand cost US$92 per hectare. In Malaysia and Taiwan, the costs are much higher at US$520 to $652 and US$1,500 to $2,500, respectively.

122
Levine, G. (1971)
The Water Environment and Crop Production. In Some Issues Emerging From Recent Breakthroughs in Food Production, ed. Kenneth L. Turk, 378-95. Ithaca, New York: Cornell University Press.

Water management for crop growth is a major requirement for moisture control both for analyzing the potential of various tropical environments and for providing the necessary condition on which sustained increases in production can be attained. The author argues the viewpoint (mainly of Hsieh and Ruttan) that new high yielding varieties (HYVs), fertilizers, and pesticides have contributed little to yield increases is valid since the responsiveness of newly developed grain varieties depends largely on improved production conditions. Secondly, investments for infrastructure and organization for irrigation and drainage systems require cooperative action between governments and water users. A graph showing water requirements as a function of controlled inputs provides a useful guide for estimating irrigation efficiency levels.

123
Maruyana, E. (1968)
Water Balance and Rice Culture in Southeast Asia. Proceedings of a Symposium on World's Rice Situation 2:15-41.

124
Thomson, J.F. (1981)
Toward an Asia Bureau of Water and Sanitation Policy Statement. Arlington, VA: Water and Sanitation Health Project (WASH) Coordination Information Center, Camp Dresser and McKee International, Inc.

The relationship between primary health care improvements in water supply and sanitation is examined in relation to the formulation of health care policies and strategies for the U.S. Agency for International Development (USAID) and the Asia Bureau. Case studies evaluating health problems caused by poor water supply and sanitation are also included in the report.

125
Wattanavitukul, Somluckrat, and Ma. Concepcion Cruz (1983)
Irrigation Water Management at the Village Level in Selected Asian Countries. Revised version of a paper presented to Workshop on Asian Water Resources Management, Honolulu: Environment and Policy Institute, East-West Center, 73 pp.

The majority of case studies of Asian irrigation systems at the village level were done on relatively isolated systems with minimal government inputs. A review of some studies done on village irrigation systems located within large-scale projects is presented in this paper. Four major types of organizational arrangements are identified: (1) direct state management where no village organization exists, (2) state coordination with existing local, village administration units, (3) state coordination with pan-village organizations, and (4) joint state-village organizational set-ups. Studies completed in

India, Pakistan, China, Sri Lanka, Thailand, and the Philippines are reviewed.

126
Wickham, T.H. (1971)
Water Management in the Humid Tropics: A Farm Level Analysis. Unpublished Ph.D. dissertation, Cornell University, Ithaca, New York.

127
Wickham, T.H. (1972)
A Farm Level Analysis of Water Management for Rice in the Humid Tropics. Paper presented to Seminar on Water Management at the Farm Level, Bangkok, Thailand.

Field experiments conducted in the Philippines show that the mean yield benefit attributable strictly to supplemental irrigation in a season of average rainfall is about 0.87 tons/ha. With controlled water supplies, an additional 0.14 tons/ha can be expected, the combined effect being 15 times larger than the water fee charged in the wet season. Thus a first step in improving water management would be to ensure uniform water supplies along the length of lateral canals, where water distribution is dependent on farmer-to-farmer cooperation.

B. SOUTH ASIA

128
Arif, Mohamed Taufiqul (1977)
A Study of Bamboo Tubewell for Irrigation. Bogra, Bangladesh: Rural Development Academy, 45 pp.

The report details the construction, installation, development, and cost of bamboo tubewell projects in the Bogra District (Sheyner Failure Area) of Bangladesh. The tubewell provides an alternative to gravity irrigation. The use of bamboo tubewells is recommended in areas where alternative resource materials such as bamboo are abundant. The report does not provide an institutional mechanism for carrying out the project and no detailed comparative costs for alternative methods for irrigation (e.g., pump vs. tubewell) are presented.

129
Asopa, V.N., et al. (1978)
Irrigation System On-Farm Development and Extension Service in Chambal Project, Rajasthan. Ahmedabad, India: Indian Institute of Management.

This study examines the Chambal Valley Development Program in the Kata and Bundi districts of Rajasthan and the state of Madhya Pradesh in India with respect to the on-farm development of physical structures. Water scheduling, pricing, and delivery policies are examined in reference to a new agricultural extension program in the region. The authors recommend a new water management approach that improves upon the transportation and communication facilities, and the education and training of village extension workers. A close interaction with state irrigation offices is also recommended.

130
Bangladesh (Government of) (1980)
Report on Irrigation Management, Pilot Programme (1979-1980). Ministry of Local Government, Rural Development and Cooperatives, Dacca, Bangladesh.

131
Barnard, R.E. (1970)
Organization of Production in a Kedah Rice Farming Village. Ph.D. thesis, Australian National University, Canberra.

132
Basu, D.N. (1976)
Farmer's Practices, Performance, and Attitude: With Particular Reference to Irrigation Development in Gujarat. Center for Population Studies, Harvard University.

133
Bhuiyan, S.I., C.A. Khan, and I. Islam (1979)
Irrigation System Performance in Bangladesh: Two Case Studies. Paper presented at the Summer Meeting of the American Society of Agricultural Engineers and Canadian Society of Agricultural Engineers, Winnipeg, Canada.

The paper provides a comparative analysis of overall system performance of two different types of irrigation systems. One is a lift with gravity irrigation system (the Ganges-Kobadak or G-K) and the other is a lift system, drawing water from a river through a series of pumps and delivered to fields by gravity along a network of earthen channels (called the Dacca-Narayanganj-Demra or D-N-D). Both projects have operated for at least ten years and plant rice as the dominant crop. Field results show that the average effectively irrigated land area

is below 50 percent of the designed area, and the maximum efficiency acquired so far is 57 percent in the 1968 to 1969 crop seasons.

134
Biswas, M.R., et al. (1978).
An Investigation Into the Factors Affecting the Command Area of Different Irrigation Facilities in Bangladesh Mymensingh. Bangladesh: Bangladesh Agricultural University.

This is the final report of a research project of the Bangladesh Agricultural University on the analysis of command areas of existing irrigation units. Coverage per unit of pump was reported to be very low and causing low productivity in the small-scale irrigation projects. Acreage increased in areas where operations of tubewells were undertaken through group action. Factors responsible for low irrigation coverage appear to be a combination of socioeconomic and engineering problems that merged with the introduction of intensive cropping in the traditional environment.

135
Buddhasa, S.V.A. (1973)
Design and Operation of an Irrigation Canal System. Paper presented to FAO/Sri Lanka Water Management Seminar. Colombo, Sri Lanka: Irrigation Department, 75-96.

A method of incorporating into the upstream water control system local, village water needs is through routing of canals through village tanks or intermediate reservoirs in the canal system. Such an approach was done in the Kalawewa Left Bank Main Canal of the Mahaweli Stage II Project in Sri Lanka. Total irrigable area was 18,000 acres, upland crops comprising 11,400 acres and lowland river, 6,600 acres. An irrigation calendar based on an optimal cropping pattern was also made, coinciding with the rainfall pattern.

136
Caprihan, S.P. (1975)
Development of Irrigation Systems at the Farm Level in India Through Scientific Land and Water Management. Paper presented at Ninth Congress on Irrigation and Drainage, Moscow, USSR.

137
Clay, Edward (1974)
Planners Preferences and Local Innovation in Tubewell Technology in N.E. India. IDS Discussion Papers 40. University of Sussex (mimeographed).

138
Corey, Gilbert L., and Wayne Clyma (1974)
The Importance of Farm Water Management in Pakistan. Fort Collins, Colorado: Colorado State University.

139
Dastane, N.G. (1972)
Summary of Important Research Findings in the Field of Water Use in India. Advanced Agriculture 2:78-82.

140
Dhawan, B.D. (1977)
Tubewell irrigation in the Gangetic Plains. Economic and Political Weekly, Bombay.

141
Dhawan, B.D. (1978)
Groundwater exploitation in India. Water Resources Journal 116:36-51.

142
Dhawan, B.D. (1980)
Underutilization of groundwater resources: A case study of east Uttar Pradesh. Economic and Political Weekly 15(39):A113-20.

The article reviews the development of groundwater resources in the east Gangetic Plain, Uttar Pradesh, India. The author argues that rural electrification will have a marginal impact on the improvements of groundwater use unless major infrastructural improvements such as flood control, drainage, and communications are undertaken. Part 1 of the article reviews past and present programs in groundwater development in India. Tables 1 and 2 provide a sufficient background on groundwater resources in India and the Gangetic Plains. Part II examines farmers' preferences for tubewells and compares the use of groundwater between large and small farms. Part III analyzes the factors that affect groundwater exploitation in relation to government programs in the area.

143
Dixon, John A. (1975)
Some General Notes on Nepal with Emphasis on Agricultural Production and Resource Allocation in the Terai. Center for Population Studies, Harvard University.

144
Early, Alan C. (1980)
Irrigated Crop Production in Pakistan: Problems and Prospects for the Indus Food Machine. Paper presented to the International Rice Research Institute Thursday Seminar. Los Banos, Philippines: International Rice Research Institute.

Physical irrigation constraints, in a field study of Punjabi watercourses in Pakistan, are identified as closely related to water supply, farm location, field levelness, and the condition of the watercourse conveyance structure. Field efficiency measurements reveal that conveyance efficiency in the tertiary subsystem is only 54 percent and field application efficiency is 55 percent. An average of 41 percent of all irrigation deliveries are incomplete leaving an overall irrigation system efficiency of 30 percent. Mean wheat yields are also low, ranging from 0.81 to 2.61 tons/ha, rice yields from 0.91 to 2.75 tons/ha, and cotton from 0.28 to 1.02 tons/ha.

145
Edwards, C., S. Biggs, and J. Griffith (1978)
Irrigation in Bangladesh: On Contradictions and Underutilized Potential. Development Studies Discussion Paper No. 22. University of East Anglia, U.K.

In the small-scale irrigation systems of Bangladesh, manually operated shallow tubewells (MOST 1) are used. However, most of the benefits accruing to tubewell use go to large farmers since the extended life of public tubewells is limited by the shallow water table, especially during the dry season.

146
Gill, Mushtaq A., and Alan C. Early (1979)
Irrigation Scheduling in Punjab of Pakistan. Paper presented to the Joint Meeting of the American Society of Agricultural Engineers and Canadian Society of Agricultural Engineering. Winnipeg, Canada: University of Manitoba.

The Indus Basin system has a mean annual surface water flow of 17.2 million hectare meters (MHM), of which 11.1 MHM are used for irrigation. Conveyance losses from the storage dam and diversion weirs to the tertiary level turnout are in the magnitude of 33 percent, having only 7.4 MHM available to watercourses. This study forms part of the Colorado State University 40-watercourse survey and is designed to predict potential evapotranspiration as a basis for irrigation scheduling in the Punjab of Pakistan. The results show that practical irrigation schedules on leveled land for wheat saved up to 10 cm of water, improved irrigation application

efficiency by more than 20 percent, and increased crop yield by 0.88 tons/ha. In the case of maize fodder, 10 cm of water was saved, efficiency improved by 38 percent, and crop yield increased by 20 tons/ha.

147
Goel, A.C., and B.N. Rao (1980)
Evaluation of sprinkler irrigation system and comparison with surface system: A Case Study. Haryana Agricultural University Journal of Research 10(3):348-51.

148
Gomez, G.E.M. (1976)
Present Status and Problems of Water Management in Rice Fields in Sri Lanka. Paper presented to Symposium on Water Management in Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 45-50.

Irrigation development in Sri Lanka is composed of five types of projects: (1) major works--consisting of large reservoir (or anicut schemes) and restoration of ancient water projects, (2) village schemes--small reservoirs affecting 50 to 100 families and covering a total of 400,000 acres, (3) minor flood protection--mainly in the lower basin of major rivers in the wet zones, (4) drainage and reclamation works--mostly located in the low-lying coastal strip in the south and southwest sections, and (5) lift irrigation schemes--concentrated in the well-drained soils in the highland areas. The major works are constructed as colonization projects, where landless peasants are settled and allotted irrigable lands (from two to five acres) in the highlands. Extent of major works as of 1975 is approximately 580,000 acres, the largest reservoir project (Mahaweli) having an irrigable command area of 110,000 acres.

149
Gustafson, Eric W., and Richard B. Reidinger (1971)
Delivery of canal water in north India and west Pakistan. Economic and Political Weekly 6(52):157-62.

In most of the canal systems in north India and west Pakistan, the principal problem affecting water delivery is the lack of predictability, certainty, and controllability of canal water supplies. The practice of water trading and sale is viewed as a way in which water deliveries can be controlled, especially if a water users' association is organized to negotiate with government agencies or with large landowners.

150
Haque, Fazlul Md. (1973)
A Comparative Analysis of Small Scale Irrigation Systems in Bangladesh. Mymensingh, Bangladesh: Bangladesh Agricultural University.

The study provides a comparative analysis of the alternative types of small-scale irrigation technologies with respect to cropping pattern and intensity, labor use, and costs and returns. The various types of irrigation evaluated are shallow tubewells, deep tubewells, and low lift pumps. Primary data were collected from 166 farms in 1970. Average landsize of farms owning private shallow tubewells is under 9.2 acres, compared to 5.5 acres and 6.8 acres for farms under cooperative deep tubewell (DTW) and low lift pumps (LLP), respectively. Shallow tubewells (STW) and LLP farmers cultivated 94 percent of gross cropped areas for rice production while only 70 percent of cropped area is planted to rice by DTW farmers. With respect to cropping intensity, STW farms exhibited the highest rate (206 percent), which was attributed to the farmers' personal control and management of water supplies.

151
Holmes, D.W., and R. Wooldridge (1980)
Water Management Study at Kaudilla Irrigation Scheme, Sri Lanka. Report No. 0029. Wallingford, England: Hydraulics Research Station.

Initial results of an irrigation management study for the first four cropping seasons in the dry zone of Sri Lanka are presented in this report. Two paddy crops in the maha (wet) and yala (dry) seasons are evaluated with respect to the effects of tank water levels, irrigation and drainage channel flows, groundwater levels, and evaporation over the area. Field experiment stations were set up at Kaudilla near Polonnaruwa in the north central province of Sri Lanka to regulate water flow under normal operating conditions. Some recommendations include shortening land preparation during the yala season and the storage of water in the maha season through reservoirs. To carry out the suggested schemes, the authors urged the institutionalization of modified operating procedures at both the main and tertiary levels.

152
Hosain, Aolad (1970)
Water Resources Development in East Pakistan. In Proceedings of the Central Treaty Organization Seminar on Evaluation of Water Resources with Scarce Data, Tehran, Iran.

The long-range water resources development master plan prepared by Water Power and Development Authority for East Pakistan is discussed in terms of an overall water improvement program--which includes 51 hydrological projects concerning flood control, drainage, irrigation, navigation, and hydroelectric power. Projects proposed until 1985 include flood protection, irrigation, and drainage affecting 8 million acres.

153
Hossain, M.A. (1978)
Report on Ulashi: A Self-Help Project. Bogra, Bangladesh: Rural Development Academy.

The Ulashi project in Bangladesh is a canal excavation plan to utilize the region's main resource--labor. The emphasis is on "self-help work," and 92 percent of the excavation was performed through local initiative. Six points were raised concerning replication to other areas: (1) pre-planning must be complete, (2) self-help involvement has to be the limiting factor or scope, (3) all participants must agree on the potential benefits, and (4) local leaders must be used to motivate people on subsequent programs.

154
Jansen, Elrick G. (1979)
Choice of irrigation technology in Bangladesh: Implications for dependency relationships between rich and poor farmers. Journal of Social Sciences 5:61-84.

155
Jayaraman, T.K. (1982)
Labour absorption in irrigated agriculture: Some empirical evidence from a surface irrigation project in Gujarat State. Margin 14(2):40-45.

156
Johnson, S.H., III, A.C. Early, and M.K. Lowdermilk (1979)
Water problems in the Indus food machine. Water Resources Journal 1-14.

The article presents the results of a survey conducted by Colorado State University in seven different agricultural climatic zones and 19 watercourses in Pakistan. The authors estimate that from 20 to 70 percent of water is lost along the channel, giving an average overall irrigation efficiency of about 44 percent.

157
Kanshik, C.R., and A.C. Gangwar (1980).
Optimum Utilization of Irrigation Water on Farms in Jui Lift Canal Area of Haryana State. Haryana, India: Haryana Agricultural University, Department of Agricultural Economics.

Results from a sample survey of 132 cultivators in the Jui Canal command area in Haryana, India are presented in this report. Production data are reported for the 1977-78 wet season, and linear programming was used to "develop synthetic farm plans and to study returns to scale from irrigation." The major conclusions are (1) water use at the farm level was inefficient, (2) relaxation of capital and labor restrictions increased water use efficiencies and diversified crop production, and (3) the elasticity of production of irrigation water was significant for all farms, gross income depending largely upon intensity of irrigation in the region. Tables accompany the text. Appendices elaborate on the methodology used.

158
Kumar, P. (1974)
An economic study of water management program in Sambalpur District (Orissa). India Journal of Agricultural Economics, Bombay 29:43-51.

159
Leach, Edmund R. (1980)
Village Irrigation in the Dry Zone of Sri Lanka. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 91-126. Ithaca, New York: Cornell University Press.

A detailed investigation of an irrigation system in Pul Eliya, a village in the north central province of Sri Lanka (Ceylon), is summarized from a larger study in this chapter. About 135 acres irrigated by a village tank comprise the entire cultivated area. Decisions on which field should be planted are made communally, then reported to the village cultivation officer (VCO). The collective decision on land allocation is based on the level of water in the tanks and the estimate of rainfall during the crop season. Aside from lowland rice cultivation, house sites and gardens, and "highland" shifting cultivation sites are also assigned. Water distribution is done from the source by means of numerical proportions or allowing water to flow through a device called the karahankota, a miniature weir consisting of a log of wood into which two or more flat-bottomed grooves of equal depth have been cut. The length of the grooves is proportional to the required ratio of water division. The other important distribution system

observed is the bethma, an arrangement whereby shareholders in a field agree to cultivate only a proportion of the field, then share the produce among themselves.

160
Lewis, J.A. (1976)
On-Farm Supplementary Irrigation Requirements for Rice in the Dry Zone of Sri Lanka. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Reseach Center, Ministry of Agriculture and Forestry, 131-38.

Approximately 135,000 hectares of irrigable land in the dry zone of Sri Lanka are not cultivated in the dry season due to inadequate water supplies. Overapplication of water from storage tanks in the rainy season accounts for the shortage of water. To estimate actual crop water needs at varying water depths, surveys were conducted in the dry zone. The major findings show that water needs are dependent upon soil and slope conditions since they affect seepage and percolation losses. Also, water requirements for upper slopes in the dry zone are much higher than for lowland soils and thus water must be applied at a pre-determined soil moisture stress level.

161
Lowdermilk, Max K., Wayne Clyma, and Alan C. Early (1979)
Physical and Socio-Economic Dynamics of Irrigation in Pakistan. In Proceedings of the Specialty Conference on Legal, Institutional, and Social Aspects of Irrigation and Drainage and Water Resources Planning and Management. Blacksburg, Virginia: American Society of Civil Engineers.

An interdisciplinary approach to problem identification in irrigation water management has been carried out in a case study of an outlet command area in Pakistan by Colorado State University. The outlet command area, located 11 miles from Lahore, Pakistan, services a village area of 577 hectares, and a command area of 96 hectares. Three sets of studies explaining farmer behavior are included: (1) socioeconomic subsystem, (2) institutional arrangements, and (3) physical aspects of water management. A significant finding regarding the definition of rules and regulations for system operation is presented in Table 1 (p. 840), contrasting de jure with de facto procedures. For example, the law states that it is illegal to "steal" water while de facto "rules" allow farmers near the canal outlet to irrigate small rice fields at their own convenience.

162
Mendis, M.W.J.G. (1973)
Mahaweli Development Project in Sri Lanka. Colombo, Sri Lanka: Lake House Investments Ltd., Publishers.

In 1963 the United Nations Development Programme (UNDP) conducted a comprehensive survey of the Mahaweli River Basin and the dry zone areas of the north central provinces of Sri Lanka. Field investigations were completed in 1967, the principal output being a master plan for the full development of water resources for irrigation and hydroelectric power. In 1968 additional studies were made and this included actual design layout for the reservoir, main, and lateral canal systems. Then a Food and Agricultural Organization (FAO) and International Bank for Reconstruction and Development (IBRD) mission was organized to review the first phase of the project and the mission strongly recommended the study of the organizational and institutional aspects of the project. This report presents some of the findings from the joint FAO and IBRD study and examines in greater detail the settlement and land consolidation subprojects.

163
Merrey, D.J. (1979)
Irrigation and Honor: Cultural Impediments to the Improvement of Local Level Water Management in Punjab, Pakistan. Colorado State University Water Management Technical Report No. 53.

A village-level study of irrigation organization in Punjab, Pakistan, was undertaken by a team of sociologists from Colorado State University and Pakistan. The report forms part of a larger local social organization project that examines the influence of the concept of Izzat ("honor") on the behavior of water users, particularly the level of cooperation and competition over water. The implications of Izzat on the mobilization of labor for the construction and maintenance of watercourses were also examined. Some recommendations for future research topics and policy and program changes are contained in the last part of the report.

164
Mohan Rao, J.S.R. (1980)
Some Experiences Gained in the Maintenance of N.S.P. Right Canal System. Paper presented at Symposium on Operation and Maintenance of Canal Systems. New Delhi, India: Central Board of Irrigation and Power.

165
Mohan Rao, J.S.R. (1981)
Remodelling Ongole Branch Canal of Nagarjuna Sagar Right Canal System for the Introduction of Rotation System. Paper presented at the 49th Annual Research and Development Session of the Central Board of Irrigation and Power, Ooty, India.

166
Mohanakrishnan, A. (1980)
Preparatory Efforts for Efficient Water Use in Irrigated Agriculture: Tamil Nadu Experience. Workshop Paper, Indian Institute of Management, Bangalore. Madras, India: Public Works Department.

167
Nachappan, K.M., R.K. Sivanappan, and G. Balashbramanian (1980)
Large Scale Field Water Management: A Pilot Project. Paper presented to the 17th Annual Convention, Indian Society of Agricultural Engineers. India: Tamil Nadu Agricultural University.

168
Padhye, M.G. (1979)
Labour Intensive Technology in Water Resources Development Projects. Publication No. 139. New Delhi, India: Central Board of Irrigation and Power.

The factors influencing the decision on choice of technology for construction of irrigation projects in India are the following: (1) nature of alternative technologies, (2) target dates for completion, (3) relative costs of alternative technologies, (4) investments in equipment, (5) availability of labor, and (6) management problems. In the Beas project in Sundan Nagar Himachal Pradesh, India, machinery intensive techniques were used in constructing an earth dam, concrete spillway, diversion and pressure tunnels, and deep chute, although labor employed was 36,000. In masonry dams or smaller-sized earth dams, more labor intensive techniques (with the use of small equipment) can be used when completion dates are flexible. As the size of construction work increases, however, the use of machinery becomes more economical as skilled labor becomes scarce. In the India Sixth Plan for major and medium irrigation projects, Rs 25,000 million is geared for equipment and a larger budget of Rs 42,000 million is allocated for labor intensive technologies. This implies an additional 5 million work force. Examples of labor intensive projects are also included in the report.

169
Pai, A.A. (1982)
Rotation System in Indian Agriculture. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 16 pp.

In India, the Irrigation Ministry and the Central Water Commission (CWC) are responsible for all inter-state water resources problems. Controlled irrigation systems are planned, designed, constructed, and maintained by state irrigation and agriculture agencies from the head (or command) to the 40-hectare block (in some cases up to the 5-hectare block). Water is released by the government through an outlet by means of a fixed rotation (called warabandi) that is based on soil type and crop variety. Rotational water supply (RWS) in the northern states of Punjab and Haryana is discussed in detail.

170
Pal, S.P. (1981)
Economics of state tubewell irrigation: A case study of state tubewells in Bihar. Margin 14(1):29-45.

171
Pande, H.K. (1976a)
Present Status and Problems of Water Management of Rice in India. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry.

The first part of the paper provides an overview of irrigated lands in India by region and state, and by type of crop planted. Of the 39 million hectares of gross irrigated area in India, 27 million hectares (approximately 70 percent) are planted to cereals, with rice occupying 14 million hectares. Of this only 45 percent is irrigated riceland--41 percent, 17 percent, 34 percent, and 9 percent, respectively, from canals, tanks, tubewells, and other minor schemes. For rainfed rice, water management relates to the removal of excess water causing flooding while in irrigated fields, the approach concentrates on minimizing water losses.

172
Pande, H.K. (1976b)
Water Management Practices and Rice Cultivation in India. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 231-45.

Water management in India has been adjusted recently to accommodate the new high yielding rice varieties. A wide

choice of local hybrid varieties also exists with varying growth duration and sowing time. Of these varieties, the 130-140 days duration exhibits the largest yield potential and is thus preferred by farmers. Selection, however, of early or late maturing varieties depends upon water availability. In areas of unpredictable water supply, short duration varieties like Bala, Cauvei, Krishna, and Pusa 2-21, are used, while longer-duration varieties like Pankaj and Jagannath are planted in regions with later rains and longer submergence periods. Another adaptation to varying water levels is multiple cropping. When a rice crop is followed by potato or wheat during winter and maize in summer, a higher return of 94 to 628 percent could be achieved in water use, and a saving of irrigation water from 39 to 120 percent. When jute crops were grown in place of autumn rice, the savings in irrigation water was 390 percent, although this did not show much increase in net profit.

173
Pandey, M.P. (1979)
The Impact of Irrigation on Rural Development: A Case Study. New Delhi, India: Cincept Publishing Company.

Pandey examines the macroeconomic implications of irrigation development, particularly the effects of irrigation in increasing productivity and the multiplier effects from a rise in agricultural production. Chapter IV provides some estimates of alternative irrigation technologies (e.g., tubewells).

174
Roberts, Michael (1980)
Traditional Customs of Irrigation Development in Sri Lanka. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 186-202. Ithaca, New York: Cornell University Press.

In the latter period of British colonial rule in Sri Lanka (Ceylon), irrigation development was given high priority through rehabilitation of ancient tank systems and formation of local irrigators' organizations. The Paddy Lands Irrigation Ordinance of 1856 provided the guidelines for the rehabilitation program and for the use of gansabhawas (village councils) or by vel vidanes (irrigation headmen). The success of the program was felt more in conflict resolution rather than actual improvements in the physical aspects of irrigation delivery.

175
Shepherd, A.W. (1980)
The Jamu'iya Scheme: Report on a Field Project. Publication No. 146. New Delhi, India: Central Board of Irrigation and Power.

176
Shrestha, M.M. (1977)
Farm Management for Rice Cultivation, Country Reports: Nepal. Kathmandu, Nepal: Asian Productivity Organization.

The report forms part of the Asian Productivity Organization Conference in Tokyo, Japan (1977), involving selected Asian countries. The case study area presented is the Terai region of Nepal where over 50 percent of total rice production and around 15 percent of irrigated lands is located. Irrigation systems from medium- and small-sized rivers are utilized under a joint government-private financing scheme. Part of the report centers on the development of tubewell irrigation.

177
Sivanayagan, T. (1973)
Soil-Plant-Water Relationship and Water Use by Crops in the Environment of the Dry Zone of Ceylon. Paper presented to FAO/Sri Lanka Water Management Seminar. Colombo, Sri Lanka: Irrigation Department, 44-63.

Soils in the highland regions of the dry zone of Sri Lanka were analyzed with respect to soil moisture tensions of 25 to 60 centimeters. Yield effects and stress levels were computed for each pilot area. The results showed that for maize, chili, and onions, 50 percent depletion of available water was optimum while 75 percent depletion was optimum for leguminous crops.

178
Thormann, Peter H. (1972)
Labour-intensive irrigation works and dam construction: A review of some research. International Labour Review 106:157-66.

The first part of the article evaluates available literature on the selection of projects in the construction sector. A number of studies (mostly in India) are cited where costs of manual and mechanized methods are compared. Studies that suggest ways of raising labor productivity and encouraging social benefit-cost analysis in the choice of techniques are included. In the second part the author argues that the overall increase in employment to be expected from encouraging labor-intensive techniques in irrigation and dam construction is uncertain. He suggests that governments should shift part of public investment expenditures to small-scale irrigation and

dam construction and to study problems of labor recruitment.

179
United Nations Economic Commission for Asia and the Far East (1960)
A Case Study of the Damodar Valley Corporation and Its Projects. Flood Control Series No. 16. Bangkok: UN-ECAFE.

The Damodar Valley Corporation in India was set up initially for flood control but later expanded to cover multiple purposes such as irrigation, hydroelectric power, and, more recently, domestic water supply. Irrigation structures were situated predominantly in the lower portions of the valley where dam sites for hydroelectric power are not located. In addition to water supply, a malaria control and afforestation program were introduced.

180
Vaidya, G.M. (1980)
Administrative Structure and People's Participation. Paper presented to Seminar on Strategy for Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 13-16.

Traditional irrigation systems in India used small-scale water diversion techniques to draw water from a river or stream. The katcha bund made of sand and earth, and "rice" tanks like the malgujari in western Vidharbha, India, are examples of such localized approaches. Villages were governed by a local council and water distribution was communally managed, such as the phad distribution system in northwestern Maharashtra, India. In the large-scale irrigation projects, local participation is not encouraged since government agencies take charge of distribution and allocation rules.

181
Van Aart, R. (1979)
Minor Irrigation in Madhya Pradesh State, India. In Annual Report, 1979. Wageningen, Holland: International Institute for Land Reclamation and Improvement.

182
Vander Velde, Edward J. (1971)
The Distribution of Irrigation Benefits: A Study in Haryana. Unpublished Ph.D. dissertation, University of Michigan.

183
Vander Velde, Edward J. (1980)
Local Consequences of a Large-Scale Irrigation System in India. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 299-328. Ithaca, New York: Cornell University Press.

Field survey results in the village of Dhabi Kalan, Bugar region of Haryana, India, are presented in this chapter. Irrigation is provided by a network of watercourses from the Second Bhakra Main Line of the Bhakra-Nangal Multipurpose Project. Acreage irrigated from the main lines, however, has consistently declined in the past years due to large water losses from seepage in unlined canals and high evaporation rates in the region. Weaknesses in project design also account for low irrigation efficiency. For example, crop water allowance computations are rigidly fixed without considering environmental changes, primarily relief and soil fertility.

184
Venkataraman, A. (1980)
Water Management Problems and Procedures at Farm Level in the Gravity Irrigation Systems. Workshop Paper, Indian Institute of Management. Bangalore, India: Tami Nadu Agricultural University.

185
Wade, Robert (1978)
Managing irrigation canals in South India. Development Research Digest 2:52-55.

The article focuses on the organization and operation of irrigation bureaucracies, specifically the management and control of water distribution on the sublateral canal level. The author suggests that the training, promotion, and motivation of irrigation engineers must be developed in terms of their relationship with the field staff. Case studies of irrigation schemes from South India provide the empirical base upon which the author outlines a set of administrative factors that can be used in improving water distribution systems. (The article has subsequently been incorporated as a chapter in a forthcoming book on administrative systems for canal irrigation in South India.)

186
Walker, H.H., and P. Kampe (1980)
Improving Irrigated Agriculture in India: The Introduction of a Rotational Water Supply system (Warabandi) Into Irrigation Command Areas. Stuttgart, West Germany: University of Hohenheim.

187
Walker, Synn R. (1979)
Simulating Cropping Pattern and Water Management Alternatives in the Punjab Pakistan: Model Development. Fort Collins: Colorado State University.

188
Wells, K.S. (1979)
Mahaweli: The Implications of a Major Project for Migration, Labor Use, and Employment Opportunities in Sri Lanka. Unpublished M.S. thesis, University of Reading, U.K.

The study considers ways in which the Mahaweli Ganga irrigation scheme in Sri Lanka might be better used to achieve the national goals of reducing unemployment and achieving selfsufficiency in paddy rice production. The thesis argues that the project cannot provide the benefits originally hoped for, but taking the pragmatic view that implementation is going ahead anyway, it suggests some ways in which it might be made more effective. These include intensifying dry zone paddy production, more rational water use and coping with problems of seasonal irrigation, improved cultivation practices, and a more labor intensive approach.

C. SOUTHEAST ASIA

189
Aart, R. van, and H.L.M. van der Hoff (1981)
Small-scale Pump Irrigation in Aceh Utara, Indonesia. In Annual Report. Wageningen, Holland: International Institute for Land Reclamation and Improvement. (See also reference 240.)

Rice is the staple food in Indonesia but its yield lags behind the total demand. The government is making great efforts to alleviate the situation, largely based on the use of irrigation. An extensive gravity irrigation system was developed in the early twentieth century and about 15,000 ha in Aceh Utara are now under semitechnical irrigation and about 10,000 ha under simple irrigation. The paper discusses the present state of pump irrigation, which is considered supplemental to major irrigation development and rehabilitation. The introduction of pump irrigation has already caused rice yields to increase from an average annual production of 2.0 tons/ha to 8.8 tons/ha. Further possibilities are average yields of 10 tons/ha, and five rice crops in a 2-year period. The major problem is shortage of funds to cover the first period after the scheme is launched. A solution has been found in making an initial payment to the

farmer prior to his first rice harvest, an initial loan to the operator, and credit for the running of the pump.

190
Agarwal, M.C. (1964)
An account of the Tanjong Karang Project. Malayan Economic Review 9(2):64-74.

191
Atthayodhin, Charin (1976a)
Improvement of Irrigation and Drainage System of Rice Fields in Thailand. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 173-92.

An inter-farm, low-cost "crash" program, the Ditches and Dikes Project, was initiated by the Royal Irrigation Department (RID) of Thailand in 1962. Ditches at approximately 400-meter intervals along main supply canals were constructed to allow for water flow from laterals to the field. As ditches were built as straight as possible according to the slope of the land, however, landholding patterns and boundaries were disregarded, and in many cases, individual holdings were divided causing several on-farm problems that were unanticipated. Design criteria were then developed. For example, ditches were to carry a minimum capacity of 9 mm/day and the minimum bed width and slope would be 0.5 m and 20 cm/km, respectively. Aerial photographs, cadastral surveys, and soil suitability classifications were made to supplement actual ditch design and layout. Maps containing survey results for a specific project are included in the report.

192
Atthayodhin, Charin (1976b)
Water Management of Rice Fields in Thailand. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 51-58.

The Royal Irrigation Department (RID) of Thailand is the major government agency in charge of development of river systems. The Chao Phya Diversion Dam, completed in 1956, is an example of a large-scale dam project controlling water flow in the Chao Phaya river. The Bhumiphol Dam in 1964 and the Sirikit Dam in 1972 are used for power generation, flood control, and water storage. To handle the operation and maintenance of these projects, command structures at the project level were created. A water operation center (WOC) was established in 1967 as the executive agency for the collection and processing of hydrologic data for the different large-scale water

projects. Charts for the command structure and setup, and of the WOC, are included in the report.

193
Bacdayan, Albert S. (1980)
Mountain Irrigators in the Philippines. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 172-85. Ithaca, New York: Cornell University Press.

The famous Ifugao rice terraces in northern Luzon, Philippines, is the general setting of this study. One of the mountain tribes, the Tanowongs, is evaluated with respect to changes in village organization and water distribution following expansion of the water supply for irrigation from a new source. The dynamics of creating a new water distribution system through traditional dap-ay (organized sub-units of village administration) rules and regulations and the processes involved in inter-village negotiation over new water use-rights are analyzed.

194
Bach, Kenneth W. (1972)
Preparation of Land for Irrigation and Water Management of Upland Crops. Paper presented to Seminar on Water Management at the Farm Level, Bangkok, Thailand, 65-73.

Land preparation and water management are two important factors in increasing water use efficiency and yield, especially for upland crops. Some field experiments in Thailand show that average yields of nonirrigated crops, compared to irrigated crops, significantly increased: alfalfa, from 2.0 tons to 4.4 tons; corn, from 101 bu to 139 bu; wheat, from 21 bu to 48.6 bu; and potatoes, from 350 sacks to 450 sacks. Varying cost levels affecting yield grains, however, are conditioned by the location and type of water source and the legal rights to access. If a well must be drilled, it may cost more than if water is merely diverted from a stream.

195
Bolle-Jones, Evan W. (1977)
Water Management at the Farm Level in Burma. In Proceedings of a National Workshop on Water Management and Control at the Farm Level, 38-47, Rangoon, Burma.

196
Brannon, R.H., C.T. Alton, and J.T. Davis (1980)
Irrigated dry season crop production in Northeast Thailand. Journal of Developing Areas 14(2):191-200.

The paper investigates the characteristics of dry season farming and farmers, and suggests tests of some hypotheses for explaining the extremely low utilization of dry season irrigation in northeast Thailand, based on a case study of an area, the Lam Pao irrigation project in Kalasin province, which is considered to be typical of that region. The analysis suggests that northeast farmers are motivated by profit opportunities. If an expansion of dry season irrigated cropping is desired by government planners, then policy actions designed to enhance profitability should play a major role in the development plan for the region. A positive relationship between the amount of fixed assets owned and the amount of irrigated land cropped during the dry season was revealed. Level of fixed assets represents a measure of capacity to bear risk, which suggests the need for policies designed to minimize the risk associated with the use of new technology (insurance, subsidies, price supports).

197
Cerdan, Tito A. (1975)
Water Management Plan for the Upper Pampanga River Project. In Water Management in Philippine Irrigation Systems: Research and Operations, 77-83. Los Banos, Philippines: International Rice Research Institute.

The Upper Pampanga River Project of the National Irrigation Administration (NIA) is the largest irrigation infrastructure drawing water from the Pampanga River in Nueva Ecija province, Philippines. It is expected to control, regulate, and distribute water flow from the Pampanga river and its tributaries for multiple purposes, mainly, irrigation and hydropower. A total of 77,000 hectares in the wet season and 72,000 hectares in the dry season are targeted for irrigation. A rotation system of 50-hectare units is controlled by gated turn-outs discharging 75 liters/second or the approximate water depth for 10 hectares of land for five days. In a pilot 30-hectare area with terminal facilities, a 46-day interval of actual water use was estimated, revealing a 32 percent field efficiency level and an overall project efficiency of 47 percent.

198
Cruz, Federico A. (1975)
The Pinagbayanan Farmers' Association and Its Operation. In Water Management in Philippine Irrigation Systems: Research and Operations, 243-57. Los Banos, Philippines: International Rice Research Institute.

A case study of a barrio included in the Social Laboratory Project of the University of the Philippines at Los Banos College of Agriculture and the Southeast Asia Regional Center for Graduate Studies and Research in Agriculture (SEARCA) is

presented in this paper. The barrio, Pinagbayanan in Pila, Laguna Province, Philippines, has 57 farmers cultivating 67 hectares of ricelands at an average of 1.3 hectares per farmer. In July 1970, a technician from the Social Laboratory organized an irrigator's association to manage a 6-inch pump with a rated capacity of 56.6 liters/second and covering a contiguous area of 30 hectares. Problems of payment, registration, allocation, and organizational structure are analyzed. Some projects proposed by the association are (1) the training of members and officers in record keeping and accounting, (2) purchase of small farm implements, and (3) construction of a drying pavement and warehouse for storage.

199
Cruz, H.A. (1974)
Conflict Among Farmers in an Irrigation System in Iloilo Province, Philippines. Unpublished Ph.D. dissertation, Cornell University, Ithaca, New York.

200
Cruz, Ma. Concepcion (1982a)
Social and Institutional Factors in Differential Access to Canal Irrigation: A Study of a Philippine Communal System. Unpublished Ph.D. dissertation, University of Wisconsin, Madison.

Because of physical and topographic conditions, unequal access is prevalent in most irrigation systems (e.g., tail-end syndrome) where social and institutional factors play an active role in the determination of access conditions and in the development of countervailing practices that serve to lessen inequality in water distribution. These relationships are investigated for a particular gravity irrigation system in Pangasinan Province, Philippines, through time series comparisons of agricultural production and water distribution before and after outside (semigovernment) intervention. Ethnographic interviews and multiple regression are used in explaining the effect of physical and institutional factors to water access, as observed in number of stress days and perceived water adequacy.

201
Cruz, Ma. Concepcion (1982b)
Water Management for Gravity Irrigation: Case Study of a Philippine Communal System. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 51 pp.

This paper is based on the author's Ph.D. dissertation listed as entry 200 above. A major source of difficulty in developing improved water management systems is the problem of

differential access to water. Problems of water distribution associated with the so-called "tail-end syndrome" and social and institutional factors affecting uneven water allocation are analyzed through a case study of a rice-producing community in Pangasinan Province, Philippines. A summary of the study findings, including the organization and management of water of the migrant zanqjera (irrigation society) water users, is presented in this paper.

202
David, W.P. (1982)
Consultants' Report on Nong Wai Irrigation Management Project. World Bank Fact Finding Mission and Nong Wai Irrigation Management Technical Assistance Project, Government of Thailand.

The World Bank approved in 1974 a $5 million loan to finance the foreign exchange costs of the Nong Wai Pioneer Agriculture Project (NWPAP) in the Lower Mekong Basin of Thailand. Upon recommendation of a World Bank Review Mission in 1980, an irrigation management pilot area of 800 hectares was selected for in-depth study by an irrigation management expert, an agronomist, and a rural institutions (cooperatives) sociologist. In Part II a detailed description of the project area's topography, soil profile, and climate is presented. Cropping systems and recommended cropping patterns for various segments of the project are discussed in Part III. Policy recommendations for inputs, extension work, and agency level reorganization are presented in Parts IV and V. Appendices contain measurement approaches and tables indicating daily agronomic records of crop samples (height, water capacity, and others).

203
De Los Reyes, Romana, et al. (1980)
Communal Gravity Systems: Four Case Studies. Quezon City: Institute of Philippine Culture, Ateneo de Manila University.

204
Djojoadinato, Desman (1978)
Indonesia's Simple (Sederhana) Irrigation and Reclamation Program. In Irrigation Policy and Management in Southeast Asia, 25-30. Los Banos, Philippines: International Rice Research Institute.

The U.S. Agency for International Development (USAID) financed in 1974 the Indonesian government's simple sederhana irrigation and reclamation program, covering a total of 550,000 hectares that was included in the Indonesian Second Five-Year Development Plan, Repelita II. Each sederhana system is 2,000 hectares or less, with irrigation structures

constructed within one or two years through labor-intensive methods. The irrigation structure, a diversion weir of river-stone masonry, is relatively short-lived (10-year life span). Average cropping intensity is expected to increase yield from 1.6 to 1.8 tons/ha. Farmers have primary responsibility for tertiary development and the district chief or bupati coordinates local construction with provincial agencies.

205
Djunaedi, Soekarso (1976)
Tertiary Pilot Unit. Paper presented to Symposium on Water Management in Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 25-30.

The provincial public works department in Indonesia is in charge of operation and maintenance of tertiary units--the smallest irrigation unit of about 100 hectares, receiving water from a turnout at the main or lateral canal. The tertiary unit is divided into quarternary subunits of 10 to 20 hectares each. Both continuous and rotational irrigation is used in the quarternary canals, which are the main distribution links to fields through a system of connecting dikes. Water requirements vary from 1 to 2 liters/s/ha, and drainage capacities from 5 to 7 liters/s/ha. A water distributor or ulu-ulu is responsible for water distribution for each tertiary unit. An irrigation committee, consisting of all farmers included in the unit, decides upon land preparation and transplanting dates and the amount of water to be delivered to each quarternary unit. In areas with existing organizations (e.g., the Dharma Tirta in Central Java and the subak in Bali), the village administration replaces the farmer's organization. In many tertiary units, however, village boundaries are not recognized and thus a new organization under the management of an ulu-ulu is set up.

206
Dozina, G., Jr., M. Kikuchi, and Y. Hayami (1979)
Mobilizing Local Resources for Irrigation Development: A Communal System in Central Luzon, Philippines. In Irrigation Policy and the Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham, 135-42. Bangkok, Thailand: Agricultural Development Council.

This report contains the results of a case study of the Cavite Communal Irrigation System (CCIS) in Naybayon, Zambales Province, Philippines. Local community resource mobilization (particularly labor) is evaluated with respect to capital formation for rehabilitation of irrigation structures, comprising about 50 percent to 75 percent of total government subsidy. Estimated benefit-cost ratios ranged from 2.6 to 6.9

and internal rates of return (IRR) from 54 percent to 122 percent. The computed daily return to communal labor use was ten times the prevailing farm wage rate and the individual labor contributions were uniform regardless of land ownership and tenurial status.

207
Dwyer, D.J. (1964)
Irrigation and land problems in the Central Plain of Luzon. Geography 49:236-46.

A comparative evaluation of two Filipino farmers, one with and one without irrigation, is used to examine the effect of technological improvements in the rural sector. The study in Central Luzon, Philippines, shows that unless technical change is introduced, particularly improvements in irrigation facilities, adoption of new production technologies will be slow. One of the strongest factors affecting adoption is social custom, reinforced by kinship ties in the barrio. The other variable is land tenure, where significant improvements in the pattern of land ownership are viewed as motivating factors in the adoption of new techniques and the improvement of irrigation water use.

208
Geertz, C. (1972)
The wet and dry: Traditional irrigation in Bali and Morocco. Human Ecology 1:23-29.

209
Giron, O., et al. (1974)
A Field Comparison of Rotational and Continuous Irrigation in the Upper Pampanga River Project. Los Banos, Philippines: International Rice Research Institute.

The Upper Pampanga River Project (UPRP) of the Philippines uses a form of rotational irrigation for water distribution. Water is delivered among 20 to 30 farmers within 50-hectare blocks. Project officials measure desired levels of water diversion by controlling common turnouts. This paper reviews the implementation of the rotational arrangement in one block, then compares water use efficiency levels with that of a continuous system. Comparisons of grain yield and cost are also made.

210
Gittinger, J.P. (1973)
Kemubu Irrigation Project in Malaysia. In Agricultural Projects: Case Studies and Work Exercises, ed. J.P. Gittinger, 11-51. Washington, D.C.: World Bank.

211
Goldman, R.H., and L. Squire (1982)
Technical change, labor use, and income distribution in the Muda Irrigation Project. Economic Development and Cultural Change 30(4):753-75.

212
Hafid, Anwar, and Y. Hayami (1978)
Mobilizing Local Resources for Irrigation Development: The Subsidi Desa Case of Indonesia. In Irrigation Policy and Management in Southeast Asia, 124-33. Los Banos, Philippines: International Rice Research Institute.

In 1969, the Indonesian government sponsored a nationwide village subsidy program, the subsidi desa. Under the program, villages wishing to apply for irrigation loans, prepare proposals that are sent through the subregency kecamatan for review by provincial kabupatens or heads. Subsidies of US$500 in 1973 and US$750 in 1975 were given through the Community Development Office of the Department of the Interior. During 1969-70 and 1973-74, total government subsidies amounted to $59 million and locally mobilized resources to $79 million. The mean government investment-inducement ratio (of total project cost to government subsidy) was 2.3, indicating that every $1 government subsidy induced local investment of $1.30. Two communal irrigation systems--the Saebah in West Java, and the Takkapala in South Sulawesi, Indonesia--were selected for detailed study. The findings showed that the subsidies were effective in mobilizing local resources, particularly village labor, where leadership was important in the organization and operation of the system.

213
Illo, J.F.I. (1980)
The Farmers in Communal Gravity Systems: Rice Yields, Work, and Earnings. Quezon City: Institute of Philippine Culture, 107 pp.

This report forms part of a National Irrigation Administration (NIA)-funded project on small-scale, communal irrigation systems in the Philippines. The report is based on results of a survey of 51 gravity communal systems located in the three major regions of the Philippines. The data base consists of demographic and related baseline characteristics, farming structures such as land distribution and tenure, and production activities including irrigation water management functions.

214
Institut Pertanian Bogor, and Proyek Irrigasi IDA (Irrigation Rehabilitation Programme) (1974)
Study on diversification crops for irrigation efficiency at Rentang Irrigation Area. Djakarta, Indonesia: IPB.

215
International Commission on Irrigation and Drainage (1978)
Water Management in Land Consolidation Area and Rice Production in Thailand. Paper presented to the Second Regional Afro-Asian Conference.

216
Kaufman, H.K. (1971)
Socio-Economic Factors in Farmer Responses to Irrigation in Northeast Thailand. Bangkok, Thailand: USOM.

217
Kung, P. (1974)
A Review of Irrigated Cropping in Northern Thailand. In Irrigated Agriculture in Northern Thailand, 103-14. Agricultural Development Council, National Seminar Report Number 5 (mimeographed).

218
Lewis, Henry T. (1980)
Irrigation Societies in the Northern Philippines. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 153-71. Ithaca, New York: Cornell University Press.

Irrigation societies operate simply to procure a reliable supply of water through various organizational methods. In Ilocos Norte, Philippines, a total of over 17,000 hectares of land is operated by irrigation societies called zangjeras. Several types of the zangjera are found in the region. Some zangjeras restrict membership to a single barrio or village. However, most zangjeras are composed of two or more barrios with members coming from different tenure classes. Sometimes formal ownership of the land is vested in the zangjera and members merely acquire use-rights to the land. In some societies, a dominant family controls the use of resources, and still in another society, the zangjera sells or leases water for a percentage of harvest. When the water source is large, different zangjeras form federations and elect leaders from the individual zangjeras. Two zangjeras in Buyon, the homeland barrio, and Mambabanga, the newly settled barrio in Ilocos Norte, are studied by comparing differences in institutional arrangements of the two barrios.

219
Miranda, S.M., and G. Levine (1978)
Effects of Physical Water Control Parameters on Lowland Irrigation Water Management. In Irrigation Policy and Management in Southeast Asia, 77-91. Los Banos, Philippines: International Rice Research Institute.

Three physical parameters of water control--method of water delivery, degree of control at the turnout, and size of the turnout area--are examined in 22 turnout areas in the Angat, Penaranda, and Santa Cruz irrigation systems in the Philippines. Water use efficiency in the dry season was found to be higher in areas serviced by farm ditch rotation irrigation. Lower irrigation efficiencies were also prevalent in the intermediate-sized (10 to 20 hectares) areas. Rotational irrigation as practiced in Taiwan was not found to be effective in the wet season.

220
Pandyahibya, B. (1961)
Irrigation Development in the Central Plain of Thailand and the Country's Stages of Economic Growth. Unpublished Ph.D. dissertation, Oregon State University, Corvallis.

221
Pant, Niranjan (1981)
Management of Major Canal Systems in Bihar: A Kosi Case. Working Paper No. 32. Lucknow: Giri Institute of Development Studies.

222
Pasandaran, Effendi (1978)
Water Management in the Pekalen Sampean Irrigation Project, East Java, Indonesia. In Irrigation Policy and Management in Southeast Asia, 47-59. Los Banos, Philippines: International Rice Research Institute.

The technical aspects of water management decision-making in the 274,000 hectare Pekalen Sampean Irrigation Project in East Java, Indonesia, are presented. The research is based on field experiments and interviews of 16 ulu-ulu desas or local village ditchtenders and 9 juru pengairan or irrigation subsection heads. Planning and operation decisions are influenced by what Javanese call the pasten, a local understanding of the relationship between water supply at the turnouts and crop water needs. Cropping patterns called golongan are used at the irrigation block level through an estimate of the pasten ratio (technically, the level of the discharge curve and its rate of change in the wet season). This decision-making system has been quite effective resulting

in high cropping intensities of 2.5 to 3 crops per year in 9 of the 12 tertiary blocks studied.

223
Philippine Council for Agriculture and Resources Research (1981) Directory of Researches in Agriculture, Forestry, Fisheries, and Mines in the Philippines. Vols. 1 and 2. Los Banos, Philippines: Philippine Council for Agriculture and Resources Research.

National research projects in the Philippines for the period 1980-81, classified by research institution, are compiled in this report to guide research agencies, universities, and funding agencies in the monitoring and evaluation of ongoing researches. Of particular interest is the listing of irrigation projects. Volume 2 classifies the projects by implementing agency.

224
Philippines (Republic), National Irrigation Adminstration (1977) National Irrigation Systems Improvement Project: Package II. Quezon City: National Irrigation Administration and Sanyu Consultants, Inc., 100 pp.

The National Systems Improvement Study Project Package II of the National Irrigation Administration (NIA) covers an area of 75,700 hectares in Southern Luzon, West Visayas, and Mindanao regions in the Philippines. Twenty-five irrigation systems are studied with respect to their (1) potential for rehabilitation and upgrading of existing irrigation and drainage systems, (2) capacity to absorb new facilities, and (3) flexibility in adjusting to new operation and maintenance procedures. Results of a special substudy program on the control of schistosomiasis are included in the report.

225
Philippines (Republic), National Irrigation Administration (1981) Investment Decisions for Irrigation: Philippine Conditions. Paper presented to Agricultural Development Council Workshop on Investment Decisions to Further Development and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

226
Philippines (Republic), National Water Resources Council (1979) Western Visayas PHI/77/003--United Nations Development Programme Assistance to the National Water Resources Council: Ilog-Hilabangan River Basin. Quezon City: Philippines.

This report is a summary and documentation of the United Nations-funded Ilog-Hilabangan River Basin Project in the

Western Visayas region of the Philippines. It consists of descriptions of land and water resources in the region and their potential for crop production and fisheries. Flood control is included as a supplementary activity. The report is divided into three parts: (1) irrigation, (2) power, and (3) wildlife and fisheries.

227
Poolsup, Maitri (1972)
Surface Drainage Systems in the Chao Phya Irrigation Project. Paper presented to Seminar on Water Management at the Farm Level, Bangkok, Thailand, 98-102.

A two-phase drainage program for the nine tracts of land in the Chao Phya irrigation project was developed in 1965. The first phase was implemented in the northern Chao Phya area where secondary crops are grown in the Banlek, Chainat-Pasak, Noi River, and Upper Suphan river tracts. In phase II the remaining drains were installed in the southern Chao Phya area at a depth of 3 meters for main drains and 1.5 meters for lateral drains.

228
Prasad, V.N. (1972)
Cotabato-Agusan River Basin Development Project. Consultant's Report to the United Nations Development Programme, 60 pp.

This report, prepared for the United Nations Development Programme (UNDP), contains a brief description of the Cotabato-Agusan River Basin Development Project in Mindanao, Philippines. The project aims to monitor existing water resources projects and identify new projects for hydroelectric power, domestic water use, and irrigation. Results of the physical surveys conducted by the U.S. Bureau of Reclamation are examined in this report. The project funding, consisting of UNDP contributions and Philippine government counterpart funds, is discussed and evaluated separately.

229
Resosudarmo, S. (1977)
Climatic Water Balance and Agricultural Production in Northern Plains of West Java. Unpublished Ph.D. dissertation, University of Hawaii, Honolulu.

230
Sanders, William (1980)
The impact of two communal irrigation projects in the Philippines. Journal of Agricultural Economics and Development (Philippines) 10(1):110-30.

The article evaluates the performance of two small-scale, communal irrigation systems in the Philippines--the Sibul and Talaksan projects in Bulacan Province. From an economic viewpoint, the author argues that the projects are sound, especially in their capacities to mobilize surplus labor. Problems related to tenure and ensuing debt relations with moneylenders have led to the conclusion that institutional credit be re-examined if a redistribution of benefits from irrigated agriculture is to be achieved.

231
Small, L.E. (1973)
Historical development of the Greater Chao Phya Water Control Project: An economic perspective. Journal of the Siam Society 61:1-24.

232
Srivardhana, Ruangdej (1982)
The Nam Pong Case Study: Some Lessons to be Learned. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 24 pp.

The Mekong Committee in Thailand conducted in 1976 an evaluation of the 10-year operation of the Nam Pong Basin program. The research was done in three phases. Phase 1 (September 1976 to January 1978) was for data collection, reconnaissance survey of the basin, an "audit" of socioeconomic aspects, and an annotated bibliography. In Phase 2 (June 1977 to November 1979), surveys were made to identify important social, economic, and ecological changes related to water quality and land use, fisheries, health, and insects and pests. In September 1980, Phase 3 was started, consisting mainly of an environmental impact assessment of the project. This paper reports on the author's contribution to the study team's activity in Phase 3, together with a brief description of the organization and administration of the Nam Pong Project.

233
Stansby, I., and S. Stisen (1973)
The development of the Diezmo irrigation system: A case study. In Water Management in Philippine Irrigation Systems: Research and Operations, 85-95. Los Banos, Philippines: International Rice Research Institute.

234
Tabbal, D.F., and T.H. Wickham (1978)
Effects of Location and Water Supply in Water Shortages in An Irrigated Area. In Irrigation Policy and Management in Southeast Asia, 93-101. Los Banos, Philippines: International Rice Research Institute.

A joint project by the National Irrigation Administration (NIA) and the International Rice Research Institute (IRRI) was made to study water management practices, such as rotation of water delivery and systematic distribution of water through checks and flashboards for the Lateral C segment of the Penaranda River Irrigation system in the Philippines during the 1973-74 and 1974-75 agricultural years. A total of 411 sample paddies were used as observation sites, each paddy having an area of 13 hectares. The significant factors affecting degree of moisture stress were location of farms along the lateral and sublateral canals and overland distance from the turnout. Stress day buildup was highest during transplanting or early vegetative and early reproductive growth stages.

235
Tantigate, K. (1979)
Conflict Between Rice and Sugarcane Farmers Over Irrigation Water: A Case Study in Thailand. In Irrigation Policy and the Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham, 175-83. Los Banos, Philippines: International Rice Research Institute.

The economic impact of conflicts between rice and sugarcane farmers over water distribution in the Mae Klong Irrigation Project in Thailand's Central Plains is examined. Three main findings are as follows: (1) water conflicts have discouraged rice farmers along the mixed ditches from transplanting and cultivating a second crop in the dry season; (2) mixed ditches generate significantly lower rice returns than do homogeneous ditches, if shadow prices that correct tax-induced price distortion are taken into account; and (3) water conflicts in sugarcane production lead to lower yields and returns. Elimination of the conflicts could be expected to increase the incomes of rice farmers during the dry season and to increase total production of rice and sugarcane and real revenue from rice during both seasons.

236
Taylor, D.C. (1981)
The Economics of Malaysian Paddy Production and Irrigation. Bangkok, Thailand: Agricultural Development Council.

237
Tnavaraj, S.H. (1973)
The Necessity of Terminal Facilities for Water Management at the Farm Level. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 20 pp.

The older irrigation schemes in Malaysia were designed primarily to prevent crop failure by ensuring delivery of water to as large an area as possible. In recent years, irrigation design has been adapted for multiple cropping without corresponding on-farm facilities. Thus field level problems such as an extended (40 days) presaturation period of rice plants, uneven topography between drains, and inadequate in-field water transport emerged. Benefits to be derived from developing terminal facilities are examined in this paper, such as the division of fields into manageable rotation units, flexibility of crop diversification, and provision for adequate drainage.

238
Tneppachoncherin, P. (1974)
Irrigated Agriculture in the Third Development Plan in the Northern Region. In Irrigated Agriculture in Northern Thailand. Agricultural Development Council National Seminar Report No. 15 (mimeographed).

239
Unson, D.C.D. (1978)
Social Development and the Communal Irrigation System in Laur, Nueva Ecija. Quezon City: Institute of Philippine Culture, 216 pp.

The National Irrigation Administration (NIA) of the Philippines sponsored a socioeconomic survey of project beneficiaries in the Laur, Nueva Ecija Province small-scale irrigation system. Participant observations supported data analysis. Recommendations for improvement of project performance are also included in the report. Tables accompany text.

240
Van Aart, R., and H.L.M. van der Hoff (1981)
Small-Scale Pump Irrigation in Aceh Utara, Indonesia. In Annual Report. Wageningen, Holland: International Institute for Land Reclamation and Improvement. (See also reference 189.)

241
Wickham, G.Y. (1975)
Farmer Attitudes towards Irrigation and Farmer Potential For Cooperation. In Water Management in Philippine Irrigation Systems: Research and Operations, 219-34. Los Banos, Philipppines: International Rice Research Institute.

Results of the socioeconomic surveys conducted in five gravity systems of the National Irrigation Administration in Nueva Ecija, Bulacan, and Laguna provinces, Philippines, are presented in this paper. The first part of the survey dealt with farmers' attitudes towards irrigation. The findings show that attitudes are related to the farmer's location in the system. For example, farms located in the first half of the canal system (head-end) had less conflicts over irrigation than those in the second half. The second part of the survey examined farmer potential for cooperation. Farmers in areas with highly inadequate water supplies had greater potential for cooperation. The last part, farmer relations with NIA, showed respondents preferring to have ditchtenders involved in farming.

242
Wickham, G., and T. Wickham (1974)
An Evaluation of Two Alternatives of Water Sharing Among Farmers. Los Banos, Philippines: International Rice Research Institute.

The Philippines' National Irrigation Administration (NIA) conducted in 1975 a study of rotational irrigation in comparison with a controlled form of continuous irrigation in the Upper Pampanga River Project (UPRP) in Nueva Ecija province. The study was completed in two stages: farmer participation and technical criteria such as yield, water use efficiency, and cost. This report outlines some of the study results and includes maps of the six pilot areas and daily discharge rates from various stations in the pilot sites.

243
Wickham, T.H., and A. Valera (1978)
Practices and Accountability for Better Water Management. In Irrigation Policy and Management in Southeast Asia, 62-75. Los Banos, Philippines: International Rice Research Institute.

Field experiments in selected irrigation systems ranging in size from 3,600 to 75,000 hectares were conducted over a six-year period by the National Irrigation Administration (NIA), the University of the Philippines at Los Banos (UPLB), and the International Rice Research Institute (IRRI). Physical factors that were found to have a low effect on improvement of irrigation performance were farm ditch density, distance of fields from the turnout, and rotation of water

supply at the farm. Factors that had a significant effect on performance were location of field along a distribution channel and rotation of water supply along laterals and sublaterals.

D. NORTHEAST ASIA

244
Chang, K.T., T.Y. Tsai, and S.T. Hsu (1961)
Operation and Maintenance of Irrigation in Taiwan. Proceedings Far East Regional Irrigation Seminar, 360-68, Taipei, Taiwan.

245
Chung-Yue, F. (1979)
Water resources activities in Taiwan, 1968-1978. Industry of Free China 52(1):10-34.

In the decade 1968-78, the growth of the industries and urban areas of Taiwan continued. The following situations affected water resource activities: (1) there was no serious natural disaster (in several years, typhoons and floods caused much damage that were quickly rehabilitated); (2) the Government gave increasing attention to social and welfare factors in its development goals and strategy; (3) labor wages and land prices rose faster than the overall price level; and (4) with relatively high labor wages and high cost of other inputs, farm income was further affected by low price of principal products. Sections of the paper deal with hydrology, 1968-78; a summary of major activities; water management; flood control; expansion of public water supply; irrigation management; improvement of drainage; hydroelectric power development; water pollution control; reclamation of tidal polder; watershed protection and soil conservation; financing the water resources activities; and current issues and recommendations.

246
Degushi, Katsumi (1976)
Country Report of Japan. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 59-65.

A total of 3.27 million hectares or 58 percent of arable land is planted to wet rice in Japan as of 1970. The acreage planted to rice and the percent of labor force engaged in

agriculture, however, have slowly decreased since 1950. For example, in 1965, a total of 12 milion people were directly engaged in agriculture, but by 1970, it decreased to 6.24 million (representing only 12 percent of the total working population in Japan). Consequently, cultivation technologies have shifted toward labor-saving methods such as the use of direct sowing rather than transplanting. With respect to water management, the labor-saving method of using piped water for irrigation is being adopted in addition to its conservation, water quality, and minimal water loss benefits. Serious problems related to piping include the large capital costs of construction, clogging with debris, and lack of adaptability to changes in water requirements at the field. A "pipe-network-rotation" is being introduced to augment partially water supply through a return flow of drained water.

247
Eyre, J.D. (1955)
Water controls in a Japanese irrigation system. Geographical Review (New York) 45:197-216.

248
Food and Agriculture Organization (1978)
TCP irrigation rehabilitation project in the Republic of Korea. IRC Newsletter 27(1):35.

249
Gallin, B. (1966)
Hsin Hsing: A Chinese Village in Change. Berkeley: University of California Press, 79-87, 181-86.

250
Greer, Charles (1979)
Water Management in the Yellow River Basin of China. Austin and London: University of Texas Press.

The author confines his study to the Yellow River Basin and attempts to make an integrated review of China's water management strategies by focusing on the shifting relationship between the capital-intensive approach of building large multipurpose dams and the historical methods of labor mobilization for the construction of more locally oriented flood prevention levees, detention reservoirs, and irrigation canals. He also traces water use and management experience through the dynasties and discusses how the encounter with western technologies has led to basinwide solutions, including the proposal to transfer water from the Yangtze.

251
Japan, Aichi Irrigation Public Corporation (1978)
Aichi Irrigation Project. Nagoya, Japan: Aichi Irrigation Public Corporation, 25 pp.

The Aichi Irrigation Project of Japan supplies irrigation water to approximately 23,700 hectares of arable lands in the southern portion of the Chita Peninsula. A rockfill dam in the upper reaches of the Kiso River conveys water at a maximum discharge of 30 m^3/s. At Kaneyama, a 112-km main canal and branch canals totaling 1,000 km delivers water to farmers who plant rice, barley, and wheat as main crops. Secondary crops include vegetables, fruits, and feed crops.

252
Japanese National Committee, International Commission on Irrigation and Drainage (1978)
Development of the Irrigation and Drainage Technique in Japan During the Recent 30 Years. Proceedings International Commission on Irrigation and Drainage Second Regional Afro-Asian Conference, 25-39, Manila, Philippines.

253
Joint Commission on Rural Reconstruction (1960)
Rotational Irrigation Development in Taiwan. Taipei: Irrigation Engineering Division.

254
Ko, Nai-Cheng (1972)
A Case Study of On-Farm Irrigation and the Off-Farm System of Water Delivery in the Chianan Irrigation Association, Taiwan. Paper presented to Seminar on Management of Irrigation Systems at the Farm Level. Ithaca, New York: Cornell University and Agricultural Development Council.

255
Korea (Republic), Ministry of Agriculture and Fishery (1973)
Pyongtaek-Kumgang Irrigation Project Review of On-Farm Development Works (Land Consolidation). Seoul, Korea: Kumgang Pyongtaek Project Department.

256
Lee, C.Y., and K.M. Lee (1973)
An Economic Study of Irrigation Water Supply and Crop Pattern in Mar-Chia Area, Taiwan. Taichung, Taiwan: Resource Institute of Agricultural Economics, National Chung Hsing University.

257
Lee, S.C., C.Y. Lee, Y.J. Yang, and K.M. Lee (1967)
A Study of the Situation of Water Shortage in the Cultivation of Rice in Tou-Liu Irrigated Area. Taichung, Taiwan: Research Institute of Agricultural Economics, Chung Hsing National University, 125 pp.

258
Lee, S.C., C.Y. Lee, and Y. Yang (1968)
Agricultural Economic Evaluation For Choshui River Basin Development Project. Taipei, Taiwan: Research Institute of Agricultural Economics, Taiwan Provincial Chung Hsing University, 118 pp.

259
Lin, M. (1974)
Red Flag Canal. Peking, China: Foreign Languages Press. 61 pp.

260
Miao, C.T., ed. (1959)
Taiwan Irrigation Works in Progress. Taipei, Taiwan: Joint Council Irrigation Association, 110 pp.

261
Nagata, K. (1965)
Changes in the customary irrigation system of present-day Japanese rural communities. Tochiseidoshigaku (Tokyo, Japan) 7(3):34-51 (in Japanese with English summary).

262
Pasternak, B. (1968)
Social consequences of equalizing irrigation access. Human Organization 27:332-43.

263
Pasternak, B. (1972a)
Kinship and Community in Two Chinese Villages. Stanford, California: Stanford University Press.

264
Pasternak, B. (1972b)
The Sociology of Irrigation: Two Taiwanese Villges. In Economic Organization in Chinese Society, ed. W.E. Wilmott, 193-213. Stanford, California: Stanford University Press.

265
Saburo, K. (1963)
The Aichi irrigation project (Japan). Japan Quarterly (Tokyo) 10:372-84.

266
Steinberg, D.I., R.B. Morrow, I. Palmer, and K. Dong-Il (1980)
Korean Irrigation. USAID Project Impact Evaluation Report No. 12.

The irrigation project evaluated was designed to help South Korea become self-sufficient in rice and barley and to raise farm income. Fifty-five irrigation works including pumping systems, drainage, reservoir construction, and land reclamation were completed. All were small (and in many instances nearly complete) elements of a larger system. Rice self-sufficiency was achieved by 1975, soon after the project began. Barley production declined due to a high rice support price and a growing demand for wheat in urban areas. Farm incomes increased; however, because farm incomes are directly related to farm size, the project affected beneficiaries unequally. The project's success is attributed to the high degree of engineering and administrative competence demonstrated by the government of Korea, the effective delivery of extension services and agricultural inputs, and the high support price for rice.

267
Tamaki, A. (1979)
Development of Local Culture and Irrigation System of the Azusa Basin. Tokyo, Japan: The United Nations University.

The area studied is the alluvial area of the Asuza River in the Matsumoto Basin (also known as Nakanobudaira), Nakano Prefecture of Japan. Agricultural practice and features of its development and change in this area have regional characteristics that differ from those of other farming areas. Among these features, however, is much that reflects the overall character of agricultural modernization in Japan. The report makes an objective analysis of agricultural development in this area and also draws some general conclusions about the significance of irrigation systems and their modernization in Japanese agriculture.

268
United Nations Economic and Social Commission for Asia and the Pacific (1962)
A Case Study of the Comprenensive Development of the Kitakami River Basin. Flood Control Series No. 20. Bangkok, Thailand: UN-ESCAP.

A detailed analysis of the water resources development program for the Kitakami River Basin in Japan is made by comparing problems of water control within the basin with the experiences of Tennessee in the United States and Damodar in India.

269
Vandermeer, C. (1968)
Changing water control in a Taiwanese rice-field irrigation system. Annals Association American Geographers (Lancaster) 58:720-47.

270
Vandermeer, C. (1971)
Water thievery in a rice irrigation system in Taiwan. Annals Association American Geographers (Lancaster) 61:156-79.

271
Wang, Sung-Hsing, and R. Apthorpe (1974)
Rice Farming in Taiwan: Three-Village Studies. Taipei, Taiwan: Institute of Ethnology, Academia Sinica.

272
Yukawa, Kiyomitsu (1976)
Distribution System of Irrigation Water in Japan. Paper presented to Symposium on Water Management for Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 225-30.

Three stages of agricultural development affected greatly the development of approaches for water management in Japan. The first stage, pre-World War II regulation of land and water utilization, was concerned with the training of farmers and engineers for land improvement through construction of agriculture, mainly irrigation. The Irrigation Association Regulation of 1889, the Arable Land Readjustment Law of 1899, and the Land Improvement Law of 1949, were promulgated to accelerate irrigation development. In the postwar period (second stage), land reclamation for extending potential arable land was given priority to meet emergency food requirements. Massive dam construction projects were carried out in the new irrigable lands. The third stage of irrigation development coincided with the rapid industrialization of Japan where severe labor shortages forced the mechanization of agriculture. Land consolidation was then an urgent need, followed by the construction of deeper drainage ditches, and pipeline irrigation systems. As of 1975, modern, pipeline systems were installed in 20 percent of total paddy fields, expanding at a rate of 2 percent per year. Primary land consolidation projects covered 25 percent of total arable area.

V. ENVIRONMENTAL QUALITY AND NATURAL SYSTEMS ASPECTS OF WATER RESOURCES MANAGEMENT

Water and related land resources, and plants and animals that live in a specific area, are interconnected by an intricate web of relationships that form the environment in which organisms exist. These interdependent biological and physical components make up what biologists call an ecosystem. The ecosystem concept, applied in the integration of bibliographic entries in this section, emphasizes the functional relationship among organisms, and between organisms and their physical environment. These functional relationships are exemplified by the food chains through which energy flows in the ecosystem. Thus, an understanding of the flow of energy and the cycling of materials in the ecosystem is essential to our perception of environmental and natural systems effects of water resources management.

Direct threats to human health are the more obvious aspects of environmental deterioration, and these threats are commonly grouped under the term "pollution." Less obvious threats are the indirect effects of human activities upon which complex environmental systems are dependent. Because the problems of environmental deterioration are exceedingly complex, we have chosen to categorize the bibliographic entries into the human activities causing the change and the types of natural systems affected by human activities.

Interaction of Human Activities and Natural Systems

Table 6 provides a classification of bibliographic entries by type of natural systems modification. As the classification shows, the results of human activities in the environment are as varied as the activities themselves. For example, when grasslands are converted to permanent cultivation, a simple ecosystem is replaced by an unstable one. Human attempts to stabilize such systems artificially (e.g., through soil conservation methods and fertilization), can lead to further destabilization and bring about changes elsewhere (e.g., pollution of water downstream). Some of these relationships are discussed in terms of two human activities that often cause severe damage to the environment--deforestation practices and urban growth.

Forest Conversion Practices

Widespread logging of forests can create extreme changes that effectively modify the forest ecosystem. With the removal of forest cover and shade, the soil is directly exposed to the elements and tends to erode faster. Loss of topsoil reduces the water-retaining capacity of an area, causes siltation and sedimentation of streams and reservoirs, and leads to other adverse

Table 6. Environmental and Natural Systems Effects of Water Resources Projects in Asia by Human Activities and Natural Systems

Human Activity	Type of Natural Systems		
	Water Resources	Related Land Resources	Total Ecosystem
Urban areas and industry	Industrial waste water pollution: 320, 423, 432, 434 Industrial reclamation: 333, 357 Flooding in urban areas: 360, 427	Environmental effects of logging and construction activities: 277, 366 Industrial reclamation: 436	Flooding in urban areas--397, 431 Water pollution and deforestation due to industrial activity: 328, 448
Agriculture and forestry	Flood control: 347, 364, 371, 374, 399, 405, 451 Water losses and runoff: 312, 373, 402, 410, 420, 444 Water diversion and storage problems: 346, 352 Water quality: 400, 404, 447 Water scarcity: 292, 308, 409 Drainage problems: 358, 370, 401, 429, 445	Reforestation and erosion control: 280, 334, 337, 349, 356, 426, 437, 442, 443 Watershed management: 279, 298, 302, 303, 304, 305, 311, 313, 314, 326, 330, 331, 336, 338, 344, 362, 367, 368, 389, 406 Swidden and upland cultivation: 281, 331, 365, 403, 424, 452	Sedimentation and mass transfer: 293, 307, 375, 435 Water logging and salinity: 278, 283, 294, 301, 321, 323, 345, 388 Soil erosion: 363, 379, 392 Flooding: 393 Land use and vegetative control: 378, 438, 446 Water losses: 381, 391, 421
Domestic use	Water quality: 275, 327, 343, 372, 395, 417 Drainage and sewage: 354 Saltwater intrusion: 355, 382	Water quality in uplands: 340 Effects of erosion on water quality: 407	Water pollution: 286, 411 Sanitation: 361 Flooding: 396
Combined activities	Flooding: 287, 351, 380, 384, 386, 394, 425, 449 Seepage and water logging: 290, 348, 353, 414, 416 Water quality: 310, 369, 390, 408, 439 Sedimentation: 317, 319, 385, 412	Watershed management: 276, 282, 288, 289, 291, 295, 296, 297, 299, 318, 329, 342, 359, 376 Erosion and sedimentation: 315, 322, 335, 337, 377, 398, 433, 440, 453, 454 Deforestation and road building effects: 341, 350, 383, 428, 455, 456	Conservation technologies: 273, 274, 309, 324, 415, 419, 450 Flood control and reclamation: 256, 300, 430 Runoff: 316, 325, 441 Desertification: 284, 418, 422 Water logging and salinity: 306, 322 Sedimentation: 413

consequences for man. Frequency and intensity of flooding along many of Asia's rivers are aggravated by indiscriminate human activities in watersheds, like extensive agroforestation.

Short-term swidden activities and deforestation practices, in general, change the water cycle by reducing the volume of transpiration of water from plant surfaces. If such practices are extensive, they may modify the weather in the immediate lowlands, usually making it more arid and subject to greater extremes of temperature (Cooper and Jolly 1969). If reforestation is not carried out, the deforested areas may be invaded by pioneer weedy plants that have less desirable characteristics for human use than the forest that was removed.

Historically, heavy deforestation activities have been associated with large increases of desert and wasteland. The great Thar Desert of Western India is a classic example of this relationship. Some 2,000 years ago, what is now the center of this desert was a jungle. As forest clearing and overgrazing proceeded, the rate of increased desertification increased to about five miles per decade around its perimeter, so that now the desert comprises about 60,000 mi^2 (Ehrlich and Ehrlich 1970).

Urban Growth and Water Pollution

Urban settlements are viewed as a "climax" stage of human succession, similar in characteristics to the later stages of forest development (Smith 1974). As urban expansion occurs, various environmental and natural systems alterations develop, often leading to eventual destruction of the original landscape.

One of the more serious side effects of industrial and urban growth is water pollution, often with the danger of contamination of domestic water supplies. In rapidly growing urban areas in developing countries, it is difficult to provide adequate supplies of safe drinking water to the population. Often much of the population must rely on polluted surface and groundwaters for their supply.

Industries and agriculture pour into surface and groundwater systems an imposing array of contaminants: lead, detergents, sulfuric acid, hydrofluoric acid, phenols, ethers, benzenes, ammonia, and many other chemicals, herbicides, and nitrates. Pollution is thus spread, not just in streams, rivers, and lakes, but also in groundwater where purification is almost impossible. And, with the spread of water pollution goes the threat of epidemics and dysentery, and poisoning by exotic chemicals (Fischer 1976).

Water pollution from sewage provides one of the most common examples of external diseconomies of scale from population growth. Low density populations living along a large river may avail themselves of the natural purification capacity of the stream. But

as population densities increase, the assimilative capacity of the river becomes overstrained, and sewage treatment must be provided if the stream is to be suitable for human use. Thus, the greater the human population of a watershed, the higher will be the per capita costs of handling water pollution.

Organization of Reference Materials

The bibliographic entries are classified by type of natural systems--water, land, and total ecosystem--although most of the literature deals with comparatively cohesive hydrologic and physical units, such as the watershed or river basin. The UN-ECAFE proceedings (285, 286, 287) and the Asian and Pacific Development Institute report (274) adopt the river basin as a single planning unit for environmental programs. This is because over three-quarters of the world's land surface has been estimated as potential areas for river basin development (United Nations 1970).

Water-based environmental effects occur mainly in rivers and streams since these are the major agents of siltation and sediment transport and deposition. At the same time that man has benefited by cultivating soils conditioned by streamflow, societies often have been constrained by processes of basin erosion, salinization, and flooding. These effects are discussed in the works of Daniel and Kulasingham (356), Heider and Hong (364), Leigh and Low (380), and Tsuchiya (449), which use the river basin as a single unit of analysis in their evaluation of flood control and sedimentation.

The other environmental side-effect that has gained importance over the past years is desertification or the gradual replacement of primary forest vegetation and jungle. The 1982 U.N Conference on Desertification (Tolba 284) gathered empirical evidence worldwide on the extent and nature of the problem. Spooner's work (283) in Pakistan and the Middle East, the Academia Sinica (418) and Chinese Academy of Sciences (422) studies on China provide evidence in Asia. The latter citation (422) elaborates on conservation measures to control desertification such as the combined planting of trees, shrubs, and grasses, and the use of the "grass kulun" to block wind and sand erosion.

The environmental effects of road building often are overlooked. The studies of Singh (341) and Ambasht and Misra (350) for India, Linden (383) for Indonesia, Imamura (428) and Yoshida (455) for Japan, and Zhu (456) for China provide sufficient information to encourage policymakers to be more sensitive to the environmental side effects of construction along mountain slopes and of easily erodible soils.

Finally, a significant number of studies have been completed on the effects of waterlogging and salinity. A serious data gap, in the form of an absence of international soil classification standards and soil maps (El-Swaify et. al., 278, and the UN-ECAFE report, 286), has hampered the investigation of the spread of

salinization on a regional scale. Nevertheless, several case studies on the national and regional levels provide significant insights on the impact of salinization to production. Among the important studies are Bokhari (294), Spooner (283), and Johnson (306) for Pakistan; Mohite and Shingte (321), Namba (322), and Narayana and Tyagi (323) for India; and Minami (388) for Thailand.

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Cooper, D.F., and William C. Jolly. 1969. Ecological Effects of Weather Modification. Ann Arbor, Michigan: University of Michigan School of Natural Resources.

Ehrlich, Paul R., and Anne H. Ehrlich. 1970. Population, Resources, Environment: Issues in Human Ecology. San Francisco: W.H. Freeman and Company.

Fischer, Claude. 1976. The Urban Experience. New York: Harcourt Brace Jovanovich.

Smith, J.M. 1974. Models in Ecology. Cambridge, U.K: Cambridge University Press.

United Nations. 1970. Integrated River Basin Development. New York: United Nations.

A. GENERAL

273
American Society of Agronomy and Soil Science Society of America (1982)
Soil Erosion and Conservation in the Tropics: Proceedings, Annual Meetings, Fort Collins, Colorado, Special Pub. No. 43. Madison, WI: ASA-SSSA.

This is the result of the symposium on "Soil Erosion and Conservation in the Tropics." Eight papers deal with the erosion problem, its components, and impacts and related experiences in conservation planning and implementation in the tropics.

274
Asian and Pacific Development Institute (1979)
An Empirical Overview of Environment and Development: Asia and the Pacific. An Overview Paper presented at the Regional Seminar on Alternative Patterns of Development and Life-Styles in Asia and the Pacific, Bangkok, Thailand, August 1979.

The paper is divided into four parts. Part I deals with population, the structure of production, and the associated phenomena of inequality, poverty, and unemployment. Part II is devoted to an examination of the profile of the productive resources in relation to the development process and development practices of countries focusing on environmental depredations such as desertification, soil erosion, deforestation, and problems connected with water, fisheries, and energy. Part III provides cases of environmental pollution and includes a selective description of the effects of urbanization on health. Part IV is concerned with likely trends in development and environment of the countries of Asia and the Pacific, in some cases ranging up to the year 2000.

275
Barrow, C.J. (1980)
River Impoundments in Developing Countries: An Appraisal of Undesirable Human Consequences. Paper presented at the Development Studies Association Annual Conference. Swansea, England: Centre for Development Studies, University College of Swansea.

276
Briones, Nick D. (1982)
Erosion, Sedimentation, and Watershed Management in Selected Asian Countries. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 82 pp.

A review of major watershed management programs related to erosion control and forest watershed conservation is presented in this paper for China, India, Philippines, Indonesia, Thailand, Malaysia, Pakistan, Bangladesh, Nepal, and Sri Lanka. Specific examples of effective watershed and forest management programs for the Philippines, China, India, Indonesia, and Thailand are also discussed. China's integrated village forestry program and the taungya (a method of afforesting publicly owned land by using shifting cultivators who are paid partly or wholly by being given free use of the land) cultivation system of the Philippines are used as examples of forest conservation techniques that can be replicated in other Asian countries.

277
Dillaka, T.A., III, D.B. Beasley, and L.F. Huggins (1982) Using ANSWERS model to estimate sediment yields on construction sites. Journal of Soil and Water Conservation (March-April):117-20.

ANSWERS (Aerial Nonpoint Source Watershed Environment Response Simulation), a model used primarily to assess the impacts of alternative management schemes on agricultural lands, was selected for a study of solution to runoff and erosion problems associated with construction activities. Several management alternatives using both conventional and unconventional runoff and sediment control practices were evaluated. Some typical construction practices that left the soil in an exposed disturbed state resulted in sediment yields exceeding those under the area's original row-crop configuration. Other practices, such as seeding exposed areas and graveling road beds and exposing as little soil as possible, resulted in much smaller soil losses. Such structural measures as using sediment basins and diversions produced variable sediment yields.

278
El-Swaify, S.A., et al. (1982) Salinization Problems in Asia and the Pacific. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 15 pp.

The FAO/UNESCO Soil Map of the World shows the extent of salinity inflicted areas in the world, exceeding 1 million hectares in 12 countries, 3 million hectares in 10 countries, 10 million hectares in 6 countries, and 20 million hectares in India, Iran, China, and Australia. There is no comparable data, however, for potentially afflicted areas where existing problem soils reveal that little differences in degree of salinization can be found with respect to inflicted areas. Studies of salinity problems in Pakistan, India, Bangladesh,

Thailand, China, and Hawaii emphasize the need for protective approaches such as the continuous monitoring of soils and irrigation water quality to detect early indications of salinization. A table, containing scope of salinity in extensively afflicted areas in the South, Southeast, North, and Central Asia region, provides good background information on the extent of salinization in the region.

279

Gil, N. (1979)
Watershed Development with Special Reference to Soil and Water Conservation. FAO Soils Bulletin No. 44.

The publication is divided into four parts. Part I deals with basic concepts and methodology of watershed development, namely agroecological zones and their influence on present and potential land-use surveys and assessment, socioeconomic inquiry, land evaluation and land-use suitability, crop groups, and soil conservation requirements in agroecological zones. Part II deals with mechanical and biological works for watershed development, mainly concerned with soil and water conservation, land consolidation, water resources development and water management. Part III consists of appendices of several data sets. Part IV considers the preparation of the development plan and organization.

280

Kunkle, S.H., and A.J. Dye (1979)
Effects of Forest Clearing on Soils and Sedimentation. Paper presented to the Conference on Agricultural Hydrology and Watershed Management in the Tropics, Ibadan, Nigeria.

The paper reviews the causes of increased erosion and sedimentation, the effects of old and new logging methods, and the long-term vs. short-term swidden cycles. The impacts of land clearing for grazing, conversion of forest to agriculture, and building roads are also discussed. Solutions include correct planning for construction, forest conversion, and tree planting (with examples of successful agroforestry projects).

281

Langford, K.J., and P.J. O'Shaughnessy (1977)
Some effects of forest change on water values. Australian Forestry 40(3):192-298.

Water quality degradation can result from the removal of forest cover, soil disturbance, and the application of fertilizer, insecticides, and herbicides. Some large-scale alterations, such as wildfire, can cause regional changes in water yield and peak flow, while small-scale alterations can

build up over time to cause similar changes. The development of forest management strategies to control streamflow volumes may be possible for specific forest types.

282
Perino, J.M. (1979)
Rehabilitation of a denuded watershed through the introduction of Kakawati (Gliricidia sepium). Sylvatrop 4(2):49-67.

283
Spooner, Brian (1979)
Environmental Problems and the Organization of Development in the Arid Lands of Southwest Asia. Paper presented at the U.N. Environment Programme Regional Seminar on Alternative Patterns of Development and Lifestyles in Asia and the Pacific, Bangkok, Thailand.

The report serves as a convenient background material for evaluating environmental (particularly waterlogging and salinity effects) problems with special reference to Pakistan. The first section provides an overview of the water resource environment--supply of total capacity and structures for water diversion. Simple solutions adopted by farmers to counteract salinity are discussed in Section III. These include shifting to salt-tolerant and high-yielding crops and delaying the sowing process by planting a single crop, thereby spreading water more thinly over saline lands.

284
Tolba, Mostafa Kamal (1982)
The UN conference on desertification: A review. Mazingira 6(1):14-23.

285
United Nations Economic Commission for Asia and the Far East (1963)
Proceedings of the Regional Symposium on Flood Control, Reclamation, Utilization, and Development of Deltaic Areas. Bangkok: UN-ECAFE Bureau of Technical Assistance Operations, 224 pp.

The symposium was organized to exchange information and experience in the UN-ECAFE region regarding the development of deltaic areas. Part I discusses the planning approaches used. Part II describes current programs for protection works, drainage, and irrigation. Part III outlines guidelines and criteria for flood protection, drainage, and irrigation.

286
United Nations Economic Commission for Asia and the Far East (1972)
Proceedings of the Tenth Session of the Regional Conference on Water Resources Development in Asia and the Far East. Water Resources Series No. 44, 216 pp. Bangkok: UN-ECAFE.

An application of the global strategy of the U.N. Development Decade was made by relating water resources programs to anticipated food requirements in the UN-ECAFE region. The use of modern scientific management techniques in the operation and maintenance of water resources projects was discussed. Technical measures and socioeconomic considerations for abatement of water pollution were also evaluated.

287
United Nations Economic and Social Commission for Asia and the Pacific (1978)
Damages caused by tropical cyclones, floods and droughts in individual countries or areas in ESCAP Region. Water Resources Journal (June):32-57.

288
Williams, J.A., and L.S. Hamilton (1982)
Watershed Forest Influences in the Tropics and Subtropics: A Selected, Annotated Bibliography. Honolulu, Hawaii: East-West Center, Environment and Policy Institute.

B. SOUTH ASIA

289
Aleem, A. (1979)
A review of watershed management works carried out in Pakistan till June 1978. The Pakistan Journal of Forestry 29(1):53-60.

The article discusses some technical solutions to the problem of rehabilitation of depleted watersheds of Pakistan. It traces the history of watershed management in the country and lists the five primary government agencies involved in the rehabilitation of watersheds.

290
Bahdrapur, T.G., and T. Seshagiri Rao (1981)
The effect of seepage and waterlogging on the development of saline and sodic soils in Tungabhadra project area of Karnata. Journal of the Indian Society of Soil Science 27(4):408-13.

291
Bajracharya, Kishar Man (1976)
Conservation and Development of Water and Energy Resources: Some Aspects in the National Forestry Plan. Paper presented at Symposium on Water and Energy Resources Development, Kathmandu, Nepal.

The author who is with the Nepal Forest Service reports on the status of the forestry development program, focusing on supplemental uses of forests: timber, fuelwood, fodder and grass, wildlife, soil protection, water conservation, and recreation. Of interest to water management is the discussion on the conservation of water resources as an integral component of the "forest ecosystem preservation plan." For example, since 80 percent of total precipitation in Nepal occurs during a four-month rainy season, it is important to maintain forest cover with a deep underground root system that can protect downstream basin areas. Forests in the hillsides and in the Bhabar tract areas of Nepal also serve as recharge zones for artesian water supplies for the lower fertile valleys and the Terai areas.

292
Banerji, S., and V.B. Lal (1977)
New technologies for desert area water problems. Indian Journal of Power and River Valley Development 27(6-7):177-80.

The authors analyze the various implications of water scarcity on farm-level production, specifically on varying degrees of water use efficiency between upstream and downstream users. The desert areas of Rajasthan, India, provide the basis for observations of alternative technologies for augmenting water supplies such as storing rainwater over the desert tract.

293
Biksshamaiah, G., and B. Subramanian (1980)
Chemical sediment mass transfer in the Godavari River Basin in India. Journal of Hydrology 46(3-4):331-42.

Mass transfer (sedimentation) in the Godavari River is predominantly monsoonal since 95 percent of the total load is transported in the wet season. The annual denudation varies from one part of the basin to the other, but the basin as a whole is being eroded at a high rate because 85 percent of the basin is covered by intensive human activity. The annual mass transfer of the river is about 10 percent of the Himalayan drainage system.

294
Bokhari, S.M.H. (1980)
Case study on waterlogging and salinity problems in Pakistan. Water Supply and Management 4(3):171-92.

The effects of irrigation on approximately 3 million acres of agricultural land are considered. The hydraulic structures involved--2 large dams, 20 smaller diversion dams, 20 barrages, over 90,000 farm outlets, and 40,000 meters of conveyance channels--are analyzed in terms of their efficiency in increasing land productivity and in the delivery of irrigation water. The Salinity Control and Reclamation Program is evaluated with respect to its ability to counteract problems of salinity and waterlogging through large-scale development of groundwater projects. Related projects involving the Indus Basin are also discussed.

295
Chaturvedi, Abinash Chandra (1980)
Watershed Management in U.P. Paper presented to Seminar on Mass Mobilization and People's Participation in Implementation of Watershed Management Programme. New Delhi, India: Central Board of Irrigation and Power, 71-79.

One hundred teams of ten persons each were employed in the Ramganga River Catchment, Uttar Pradesh, India, for vegetative control along mountain slopes over a three-year period. The upper reaches of the watershed area were found to remain relatively stable under severe treatment. In addition to this program, two other centrally-sponsored projects were initiated. These were the Soil and Water Conservation of catchments of river valley projects and the Matatila and Drought Prone Area Programme. The main goal of these programs is to divide topography. From this, 450 soil conservation units were organized.

296
Chowdry, K.R. (1980)
Strategy for People's Action in Implementation of Watershed Management Programme (A Case Study of Anantapur District). Paper presented to Seminar on Strategy of Mass Mobilization and People's Participation in Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 57-64.

An economic evaluation of the Drought Prone Areas Programme of India for major watersheds is presented in this paper. The projects evaluated are the soil conservation, dry farming, afforestation, minor irrigation, dairy development, and sheep farming schemes. The study results reveal that low adoption rates of conservation techniques can be attributed to the nonparticipation of farmers in the planning phase. In the

Anantapur District, India, training centers for dryland research were set up to enable farmers to participate actively in the preparation of action programs.

297
Devitt, J.G. (1970)
Forest Management: Trisguli Watershed Project Report No. 2. Kathmandu Nepal: HMG/UNDP/FAO, 28 pp.

298
Dhillon, G.S., and T.C. Paul (1980)
People's Participation in Watershed Management: How Essential and How to Mobilize? Paper presented to Seminar of Strategy for Mass Mobilization and People's Management Programme. New Delhi, India: Central Board of Irrigation and Power, 35-55.

Reforestation and soil conservation, especially in watersheds of rivers on which multipurpose reservoir projects are located, have been emphasized in the Second Five-Year Development Plan of India. In the plan, a total of 986 km^2, including the Bhakra Nangal Project and three other minor watersheds, were treated. In the Fourth Five-Year Plan, the number of watershed projects increased from 14 to 22 and included the Beas Project, with a combined area of 2,590 km^2. The United States and Chinese soil conservation models are also discussed as examples of possible people's participation approaches.

299
Ganguly, S.S. (1980)
Watershed Management--A Weapon to Fight Reservoir Sedimentation. Paper presented to Seminar on Strategy for Mass Mobilization and People's Participation in Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 65-69.

Dam construction for water storage has been an important program for agricultural development in India, starting with the Mettur Reservoir in Tamil Nadu and the Krishna-Rajasagar Reservoir in Karnataka. Twenty-six other storage reservoirs have since been built with a total storage capacity of 120 million acre-feet. However, sedimentation has become a serious problem unless active watershed management programs are initiated. A table is presented showing sediment load data for selected reservoirs by annual rate of silting (hectare-meters/100 km^2).

300
Ghosh, R.C., and B.K. Subba Rao (1979)
Forests and floods (rainfall interception, runoff, soil moisture, watersheds). Indian Forester 105(4):249-59.

301
Gupta, G.P. (1980)
Soil and water conservation in the Catchment of River Valley projects--status report. Indian Journal of Soil Conservation 8(1):1-7.

A special scheme of soil conservation in the catchment areas of river valley projects under a centrally sponsored program was started during India's Third Five-Year Plan for 13 river valley projects (subsequently extended to 31 projects). An area of 1.34 million hectares was treated in 1978-79 and during the Fifth Five-Year Plan the thrust was on treating small watersheds (2,000-4,000 hectares).

302
Hanif, M. (1979)
Observations on Missa comparative watershed study. The Pakistan Journal of Forestry 29(4):209-47.

To study the effectiveness of erosion control practices in the catchment areas of the Kanshi river, two watersheds--Missa Experimental and Missa Control (81 hectares each, and more or less identical in morphometric characteristics)--were selected. The capacity of the experimental watershed to reduce runoff and sediment decreased during the four-year period, 1973-77, due to the siltation of check dams and the destruction of vegetation.

303
Hanumantha Rao, T. (1979)
Integrated Watershed Management for Rural Development in Drought Prone Areas of India. Vol. 3, Papers--World Congress on Water Resources, 1426-35.

304
Indian National Committee for IHP (1981)
Watershed Management in India: Hydcom Report 1. New Delhi: Council of Scientific and Industrial Research.

This monograph assessed the dimensions of watershed management problems and solutions in India by states and by river valley catchment areas.

305
Jayaraman, T.K. (1980)
Strategy for Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. Paper presented to Seminar on Strategy of Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 25-34.

A discussion of people's participation programs for the Mahi Sukhsar II watershed management project in Panchamahal, Gujarat State, India, is contained in this paper. The project, started in 1975, conducted a detailed socioeconomic survey and solicited the aid of farmers in construction of terraces, farm ponds, field channels, and irrigation tanks. In addition, a program for pasture land development and afforestation was started through support services like credit and input supplies. Tribal development plans were also drawn up by the Committee of Direction for Tribal Area Sub-Plan Programme (TASP), which later took charge of extension activities in the project.

306
Johnson, B.L.C. (1979)
Pakistan. London: Heinemann.

Chapter V focuses on the development of water resources in the five major rivers of Pakistan--the Punjab, Jhelum, Chenab, Ravi, and Beas and Sutlej. A brief discussion of the history of the water development program is presented, including a review of the Indus Waters Treaty (1960). In the last section, a summary of water-related environmental problems is provided. These include (1) high waterlogging and salinity rates, (2) alteration of natural landscape by settlement and urban infrastructure, and (3) flooding due to the high density of population along river beds.

307
Johnson, S.H., III, W.D. Kemper, and M.K. Lowdermilk (1979)
Improving irrigation water management in the Indus Basin. Water Resources Bulletin 15(2):473-95.

In Pakistan, over half of the water delivered from the canal system to watercourses managed by farmers is not made available to the farmers' crops. Most of this water loss is due to infiltration into the banks of the watercourses. Various methods of watercourse improvement have been evaluated, including concrete and masonry linings and simple earthen improvements of the ditches with concrete control structures, junctions, and turnouts. Considering the low cost of labor in Pakistan, the earthen improvements with concrete structures appear to be the best investment. Farm water

management improvement programs have been implemented in most of the provinces. Included in the program are discussions of watercourse improvement, land leveling, and irrigation techniques to optimize production.

308
Jones, Garth N., and Raymond L. Anderson (1972)
The problem of under-irrigation in West Pakistan: Research studies and needs. Journal of Rural Development and Administration 9(2):1-42.

The authors discuss waterlogging and salinity by showing the agronomic relationship between crop responses and various levels of water deficiency. For example, at 1-4 cubic feet per second, under-irrigation leads to soil salinity and the water management design is geared towards determination of the amount of water needed to flush out the salts.

309
Joshi, M.D. (1976)
Conservation of Nepal's Water Resources. Paper presented at Symposium on Water and Energy Resources Development. United Nations Development Programme and Center for Economic Development and Administration.

The first part of the paper outlines the major problems related to water resources conservation--flooding, erosion and sedimentation, land degradation, pollution. Four programs are proposed in the next section: (1) identification and priority ranking of major problems, (2) Comprehensive Watershed Development of up to 1,000 km^2 area, (3) development of subwatershed of 10 to 100 km^2 (Surkhet, Pakhara, Bagmati-Kathmandu, Lothar, and Biring areas), and (4) river bank protection projects undertaken at the village level. The Appendix outlines the policy and principles for soil and water conservation in Nepal (Royal Decree of 8 August 1974).

310
Kannan, K.P. (1979)
Socio-Economic and Ecological Consequences of Water Control Projects: The Case of Kuttanad in Kerala (India). Working Paper No. 84. Centre for Development Studies, India.

The environmental and natural system effects of a water control and road-building project in the Kerala region of India are examined in this report. The environmental effects on the physical, biological, and human subsystems from the water control program of the Kuttanand are: (1) reduction in quality and quantity of fish populations, (2) spread of aquatic weeds (e.g., the Afical payal), and (3) conflict between rice farmers and some 20,000 families of fishermen.

These effects were not seriously considered in the planning and evaluation of such public projects, especially in the waterlogged region of the Kerala.

311
Kapon, Krishnan Narain (1980)
Watersheds Management Programme. Paper presented to Seminar on Strategy for Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 89-100.

Watershed management for the Himalayas (affecting India, Nepal, and Bhutan) has concentrated on the alleviation of the following problems: (1) extraction of boulders on the river bed disturbing the regime of the river upstream, (2) overgrazing on hill slopes leading to excessive erosion, (3) rapid burning of forests, contributing to heavy siltation of river beds, and (4) jhum cultivation or swidden farming, heightening the rate of soil erosion. "Channeling" the river was proposed to stabilize the damage caused by siltation. Other conservation measures were adopted, such as vegetative control, land alteration in impervious soils, maintenance of soil cover, and storage of rainwater.

312
Khrishna, J.H. (1982)
A parametric model to estimate runoff from small agricultural watersheds in the semi-arid tropics (India). Journal of Hydrology 55(1/4):43-51.

313
Kislali, A., and C. Sevin (1977)
Seminar on Watershed Management. Peshawar, Pakistan.

314
Malhotra, G.P. (1978)
Parametric Approach to Runoff Estimation for Small Rural Watersheds. Vol. 2, Proceedings of the Symposium on Hydrology of Rivers With Small and Medium Catchments, 36-41. New Delhi, India.

315
Malla, Krishna B. (1976)
Impact of Environmental Deterioration on Water Resources Quality. Paper presented at Symposium on Water and Energy Resources Development. Kathmandu, Nepal: United Nations Development Programme and Center for Economic Development and Administration.

Of the total land area of Nepal, over 70 percent is composed of hills and mountains (115,000 km^2) that are weak and unstable geological formations easily prone to erosion (due to steep topography, soil type, land use, and intensity of rainfall). Sediment load in the Karnali basin is about 75 million m^3, equivalent to 1.7 mm layer of topsoil. The paper concludes that, given the magnitude of the erosion problem, new programs for watershed development and soil conservation must be undertaken.

316
Mana, H.S., et al. (1980)
An estimation of runoff from some small rocky catchments of western Rajasthan and its utilization potential for crops. Indian Journal of Soil Conservation 8(1):38-43.

A large part of western Rajasthan is covered with rocky and semirocky areas. A study was conducted to estimate the runoff from rocky catchments using rainfall data for the years 1965-73. The results show the availability of as much as 1,545 mm, 131 mm, and 218 mm of runoff water during surplus, normal, and deficit rainfall years, respectively. The possibilities of its utilization for supplemental irrigation or basal irrigation for crop growth during different types of rainfall years are also discussed.

317
McKeogh, E.J. (1981)
Sedimentation control in Indian reservoirs. Water Power and Dam Construction 33(10):41-43.

Efficient sediment removal systems in operation in India and Nepal are described. These systems are extremely efficient in removing up to 90 percent of sediment load. The complete system at Himachal Pradesh can remove a complete range of sediment sizes. The settling/flushing tank arrangement at Trisuli can also exclude coarse and medium sediment and is best suited to hilly regions where there is ample head from the tank to the parent river.

318
Megahan, W.F., and A.M. Chima (1981)
Watershed management in Pakistan: Past, present, and future. Journal of Forestry 78(4):217-19.

Past and present land use has seriously impaired the hydrologic function of most upland areas in Pakistan. Damages from flooding, erosion, sedimentation, and loss of productivity have created a crisis situation that cannot be ignored. Remedial measures have been taken but much more needs to be done.

319
Mohan Rao, J.S.R. (1981)
Reservoir-Operation Practices During Floods. Paper presented at Seminar on Operation of Reservoirs and Maintenance and Safety of Dams, Vadodara, India.

320
Mohan Rao, J.S.R. (1982)
Regulation of River Water Conservation for Optimal Utilization. Paper presented at the All India Seminar on Environmental Engineering, Pollution Control, and Water Conservation, Institute of Engineers, Bihar State Centre, Patna, India.

321
Mohite, A.V., and A.K. Shingte (1981)
Evaluation of high-salt-water dilution schedule for reclamation of saline-sodic soils. Journal of the Indian Society of Soil Science 29(1):55-60.

322
Namba, S. (1981)
Influences of Some Factors Upon Soil Losses from Large Mountainous Watersheds. Karachi, Pakistan: Saad Publications.

323
Narayana, V.V.D., and N.K. Tyagi (1981)
Irrigation practices for reclaimed alkali soils (India). Journal of the American Society of Civil Engineers 107:400-406.

324
Negi, S.S. (1982)
Causes and effects of the deteriorating Himalayan environment: A preliminary report. The Journal of Environmental Sciences 25(2):47-50.

The article summarizes the causes and effects of deterioration of the Himalayan environment in India. The relationships among various causative factors such as degraded forests, massive construction projects, landslides, shifting cultivation, and quarrying are discussed.

325
Niwas, S.R., R.A. Rastogi, and S. Ram (1979)
Analysis of Runoff Hydrographs of Flat Small Watersheds in Nainital Tarai (India). Vol. 6, Papers from the World Congress on Water Resources, 2568-75.

326
Pal, Pijush Kanti (1980)
Dhanai Watershed Development Project of Howrah River Catchment of Tripura. Paper presented to Seminar on Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 127-40.

The Dhanai Watershed is located some 20 km east of Agartala, capital of Tripura state, India. It covers an area of 5,000 hectares, the bulk of which is the Baramura hill range, one of six hill ranges in Tripura. Shifting cultivation is practiced in the upper catchment of Dhanai overlooking the Howrah River Basin. A soil survey was conducted as an aid in planning the development of cropping patterns for each gradient level (e.g., 0-5 percent and 5-15 percent slope levels). For example, guava, litchi, mango, sapota, roseberry, lime, lemon, jackfruit, and pineapple can be planted in the 15 percent slope areas.

327
Pant, M.C., et al. (1981)
Aspects of water pollution in Lake Naim Tal, U.P., India. Environmental Conservation 8(2):113-18.

328
Parikh, J.K. (1977)
Environmental Problems of India and Their Possible Trends in the Future. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Environmental problems resulting from increased industrial and agricultural activity in India are discussed. The report concentrates on problems related to water pollution and deforestation.

329
Patri, S., S. Chandra, and B.K. Subba Rao (1980)
Rainfall--Runoff regression models for small mountainous watershed (India). Van Vigyan 18(3/4):49-55.

330
Purushottam, J. (1980)
Implementation of Watersheds Management Programme: Principles and General Issues Involved. Paper presented to Seminar on Strategy for Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 121-26.

Constraints to effective watershed management in India are (1) the overexploitation of forests, resulting in the shortage of fuelwood, (2) overgrazing and the consequent denudation of forests accompanied by high consumption of fertilizers away from the forests and low nutrient consumption in areas near the forest, and (3) sedimentation of reservoirs (e.g., Bhakra Dam siltation rate of 8 hectare-meters per 100 km^2 per year). A program of forestry and livestock development and farmer training is proposed.

331
Rao, V. Raganatha (1980)
Role of Watershed Management for the Rural Development in India. Paper presented to Seminar on Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 127-133.

For purposes of watershed planning, India is divided into six water resources regions: (1) Indus drainage, (2) Ganges drainage, (3) all drainage flowing into Bay of Bengal (Mahanadi, Godavari, Krishna, Pennar, Cauvery, and others), (4) all drainage flowing into the Arabian Sea (Narmada, Tapti, etc.), and (5) ephemeral drainage of the desert regions of western Rajasthan. These regions are further divided into 35 river basins, 112 catchments, 500 subcatchments, and 3,237 watersheds covering an area of 325.5 million hectares. The watersheds are classified into four area sizes to facilitate the ranking of projects and to distribute government resources.

332
Rogers, Peter (1977a)
Environmental Consequences of Development Projects. A Prepared Case Study of the Kosi Project. Division of Applied Sciences, Harvard University (mimeographed).

333
Rogers, Peter (1977b)
The Long Term Stability of the Indus Basin System: Can Pakistan Survive a Salt Death? Center for Population Studies, Harvard University (mimeographed).

334
Sastary, G., and P.N. Bhatt (1980)
Performance of gully control structures in outer Himalayas of Doon Valley. Indian Journal of Soil Conservation 8(2):146-56.

Gully control structures have been constructed in the Himalayas. Most of the structures have not functioned

satisfactorily mainly due to nonprovision of basic components such as spillway, head wall extension, and apron, in addition to improper selection of sites. It appears that peak rates of runoff for these watersheds have also not been taken into consideration for their design. Hydrologic and engineering design details are proposed in the paper.

335
Seckler, David, and Deep Joshi (1982)
Sukhomajri: Water management in India. The Bulletin of the Atomic Scientists 38(3):26-30.

An evaluation of the 1975 Central Soil and Water Conservation Research and Training Institute/Ford Foundation funded project in Sukhomajri, Honjara, India, is discussed. A brief description of the program with respect to the controlled use of grazing in the watershed to prevent excessive erosion and sedimentation of irrigation structures provides the general background for analysis of the natural systems context under which a delicate equilibrium is established between the village population and surrounding natural resources. Forthcoming projects that will serve to maintain this balance include a geophysical survey, dam construction (also tubewell and field leveling), water management and conservation measures, extension, and evaluation and monitoring of both grazing and crop cultivation activities.

336
Shah, S.L. (1981)
The Dynamics of a Changing Agriculture in a Micro-Watershed in the Kumaon Hills of Uttar Pradesh (India). In The Himalayas--Aspects of Change. New Delhi: India International Centre.

337
Shakya, Kehab Man (1976)
Water Resources Management for Control of Flood, Torrents and Top Soil Erosion in Nepal. Paper presented at Symposium on Water and Energy Resources Management, Kathmandu, Nepal.

Shakya reports on activities of the Department of Soil and Water Conservation in Nepal, focusing primarily on the effects of flood, torrents, and soil erosion on the management of water resources. The fundamental problem related to soil conservation has been the lack of integration of good water management practices and sound agricultural patterns, specifically the crop and cultivation cycles, terrace management, and control of deforestation. The latter problem appears to be the most serious: in the last 20 years, 6.4 million hectares of forest lands were converted into agriculture, with forest areas disappearing at a rate of 2

percent per year. This is compounded by heavy grazing and uncontrolled wood extraction for fuelwood and timber. With respect to soil erosion, desertification of wide tracts of land (terai rivers and the Kosi in Bihar)--about 10 percent in the Okhaldhunga, Sallyan, Sarlahi, Maholtari--has occurred at an alarming rate due to heavy siltation.

338
Sharma, A.C., and B.R. Garg (1981)
Kandi watershed and area development project of the Punjab State: An ex-ante appraisal of the forestry component. Indian Journal of Agricultural Economics 33(4):223-30.

The article proposes that the forestry component can be a viable subproject (within watersheds) that can provide employment and contribute toward the establishment of a paper mill in the area, besides increasing the productivity of its land resources.

339
Sharma, A.K., and V. Kumar (1978)
Land capability and land use planning of Danpo and Adbora watersheds in Kumaon Hills of Uttar Pradesh. Patnagar Journal of Research 391:69-74.

340
Shimkhada, D. (1972)
Need for environmental quality in Kathmandu. Rising Nepal 1:1-15.

341
Singh, A.J. (1979)
Environment and development. Development and Cooperation 1:12-15.

Environmental dangers from deforestation, roadbuilding, more intensive forms of agriculture, increased use of pesticides and other chemicals are discussed with examples from Afghanistan, Pakistan, and India.

342
Sivanappan, R.K., M. Koteswaran, and A. Alfred Newman Bright (1980)
Land and Water Use Planning of Watersheds: A Case Study. Paper presented to Seminar on Strategy for Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programme. New Delhi, India: Central Board of Irrigation and Power, 81-88.

The Lower Bhavani River in Bangalore, India, was divided, for planning purposes, into 126 watersheds, of which 26 are considered priority areas for development by the State Agricultural Department under the River Valley Project Scheme. One watershed, the Pogalur, occupies an area of about 2,500 hectares and the Pogalur subwatershed II (1,338 hectares) is the area of this case study. The entire subwatershed lies in an average elevation of 387.4 m above sea level and the terrain varies from 1 to 6 percent slope. A classification of present land use is presented in Table 1 showing the dominance of dryland crops. For irrigated lands, rice and sugarcane are the major crops planted. In the last section, proposed structural measures and their costs are outlined (Table 2) by type of conservation technology.

343
Tariq, M.N., et al. (1978)
Rural Water Quality Surveillance. Report No. 035-01-78. Pakistan: University of Engineering and Technology.

Hand pumps used for drinking water by the majority of India's population have been found defective. Of the 262 water samples suggested, only 58 were acceptable based on World Health Organization (WHO) international standards. Causes for the low water quality levels are the (1) absence of cement platforms for the pumps, (2) inadequate drainage outlets around the pump, enabling contaminated water to re-enter the supply, (3) existence of pipe leakages, and (4) existence of sources of contamination close to the pump source vicinity (such as livestock ponds and standing rainwater). The report recommends stricter hand pump water quality surveillance to reduce contamination.

344
Trehan, N.C., and I.D. Mirchandani (1980)
Special Study of Watershed Management and the Type of Motivation Needed for Mass Mobilization and People's Participation in Sirmour District. Paper presented to Seminar on Strategy for Mass Mobilization and People's Participation in the Implementation of Watersheds Management Programmes. New Delhi, India: Central Board of Irrigation and Power, 12 pp.

The World Bank financed a pilot watershed development project in Himachal Pradesh, India, in October 1979. The total area of the watershed is 628 km^2 covering 324 villages with a population of 50,835 inhabitants. The entire area is hilly, with altitudes ranging between 700 m to 3,650 m in the subtropical zone. A "people's participation" program was introduced by mobilizing local labor for the construction of terraces and drains and the building of small harvesting structures (e.g., irrigation ponds). Compensation was in the

form of land amortization exemptions (called Abiana charges) for four to five years.

345
United Nations (1977)
Case Study of Desertification: Mona Reclamation Experimental Project. Nairobi, Kenya: U.N. Conference on Desertification, 123 pp.

A case study of the effects of waterlogging and soil salinization on food production in the Mona Reclamation Experimental Project in Pakistan has shown that applied research on a continuous basis is necessary in evaluating irrigation water use efficiency at the field level. This paper presents the experience of such continuous field-level monitoring. The general finding is that pilot (or test) sites need to be set up for investigation of on-farm water management practices prior to large-scale project development.

C. SOUTHEAST ASIA

346
Ackermann, N.L., et al. (1971)
Stage Development of the Sam Lac Pumping Station. Hydraulic Model Investigation, Research Report No.7. Bangkok: Asian Institute of Technology.

A hydraulic model investigation for the Sam Lac pumping station in Thailand is made to plan effectively for diversion of approximately 7 m^3 per second of water from the Chao Phya River. The water eventually will be treated and used for augmenting drinking water supplies in Bangkok. Structural modifications of the proposed intake structure are also given.

347
Ackermann, N.L., et al. (1975)
Bicol River Basin Flood Control Investigation. Research Report No. 48. Bangkok: Asian Institute of Technology.

A flood control simulation model, which uses as inputs hydrological and water level information, and astronomical and meteorological tides data for the Bicol River Basin area in the Philippines, was estimated using 31 locations along the Bicol and Sipocot rivers and tabulated for the 13- and 50-year storms. Water levels in the adjacent San Miguel Bay and Ragay Gulf were also measured. Various basin modifications to reduce the effects of flooding were recommended.

348
Ackermann, N.L., T. Tingsanchali, and V.A. Sahagun (1975)
Salinity Intrusion and Flood Control Investigation for Bicol River Basin. Research Report No. 51. Bangkok, Thailand: Asian Institute of Technology.

A combination of flood control measures and irrigation withdrawal rates of design storms for 13- and 50-year return periods is analyzed for surface water in the Bicol and Sipocot rivers, Bicol River Basin, Philippines. The effects of flood control on salinity intrusion into the rivers are also studied. A proposed flood relief project for long-term drainage in tne upper reaches of the Bicol River is evaluated.

349
Agpaoa, A., et al. (1975)
Manual of Reforestation and Erosion Control for the Philippines. Eschbar, Germany: German Agency for Technical Cooperation.

A guide for erosion control, especially for foresters, is presented with detailed technical information for the establishment, maintenance, and protection of forest plantations.

350
Ambasnt, R.S., and K.N. Misra (1980)
Conservation Studies of a Hilly Grassland. In Proceedings of the Fifth International Symposium of Tropical Ecology, ed. J.I. Furtado, Kuala Lumpur, Malaysia.

Three sloping plots of differing ecological stature were studied to analyze the effectiveness of each grass area against monsoon rain and runoff-induced erosion.

351
Asian Institute of Technology (1977)
Hydrodynamic Model of the Chao Phya River System. Bangkok, Thailand: Asian Institute of Technology.

An investigation was conducted by AIT to develop mathematical models that can be used to describe the hydrodynamic conditions in the Chao Phya River System. This study was intended to provide tools for the water resources engineers and planners to investigate the past, present, or future events of flow in the rivers of the Chao Phya River Basin. The hydrological, meteorological, and astronomical factors were considered as the inputs to the mathematical models when the computations were made.

352
Baconguis, S.R. (1980)
Water balance, water use and maximum water storage of a dipterocarp forest watershed in San Lorenzo, Norzagaray, Bulacan. Sylvatrop 5(2):73-98.

353
Banconguis, S.R., and C.S. Rondilla (1979)
Infiltration studies on giant Ipil-Ipil (Leucaena leucocephala) plantation sites at the Buhisan Watershed (with and without agricultural crop inter-planting, surface runoff). Sylvatrop 4(1):23-29.

354
Bonatan-Dura, F.M. (1981)
Appropriate Drainage and Sewerage Systems for a Section of Cebu and Mandaue: A Research Report. Cebu City, Philippines: San Carlos Publications, 79 pp.

A study was made to evaluate the existing drainage systems in the cities of Cebu and Mandaue in the Philippines. The drainage facilities in these two cities were found inadequate in preventing flooding in certain sections during periods of heavy rainfall. Also, water quality was below acceptable public health and sanitation standards. A combined public sewerage system for domestic water and storm runoff and a separate system for industrial waste water collection and treatment were proposed.

355
Caldwell, J.M. (1973)
A Preliminary Study to Develop Salinity Barrier Concepts for the Bicol Estuary, Luzon Island, Philippines. Manila, Philippines: U.S. Agency for International Development, 26 pp.

The report presents a plan to build a barrier preventing salt water from San Miguel Bay from entering the Bicol estuary and lower reaches of the Bicol and Sipocot rivers in Camarines Sur, Philippines. The factors involved in the design of the salinity barrier in the lower Bicon Basin and the requirements for dike and drainage construction are presented. Cost estimates for each design proposal are included.

356
Daniel, J.G., and A. Kulasingham (1974)
Problems arising from large scale forest clearing for agricultural use--the Malaysia experience. Malaysian Forestry 37:152-60.

Discussion on the conversion of forests in river catchments for agricultural development that led to hydrological problems, soil erosion, and other environmental problems in Malaysia is presented. Control and management of these consequences are also discussed.

357
Eelart, L.J. van den (1982)
Problems in reclaiming and managing tidal lands of Sumatra and Kalimantan, Indonesia. International Institute for Land Reclamation and Improvement (Wageningen) 31:272-90.

358
Federation of Malaya (1961)
Drainage and Irrigation Department Manual. Kuala Lumpur: Federation of Malaya.

359
Food and Agriculture Organization (1980)
Demonstration and Training in Forest Range and Watershed Management: Philippines. Rome: FAO/UNDP.

360
Fricke, T.J., and K.V. Lewis (1976)
Flood Estimation for Urban Areas in Peninsular Malaysia. Hydrological Procedure No. 16. Kuala Lumpur: Ministry of Agriculture, Rural Development, Drainage and Irrigation Department.

A flood estimation procedure using the Rational Method of flood estimation as a guideline was developed for use in urban areas in Malaysia. The modified Rational Method (1) measures peak discharges, (2) produces a hydrograph corresponding to the peak discharge, (3) utilizes input data from topographic and land use maps, and (4) estimates flood occurrences using simple calculations. Some important parameters and a relatively simple coefficient, when added to the standard Rational Method, give the effects of detention storage. This report contains the procedure used in estimation and a discussion of the limitations of the procedure.

361
Gearheart, R.A. (1981)
Rural Sanitation and Manpower Development Project in Indonesia: Appropriate Technology and Information Dissemination. Arlington, Virginia: Water and Sanitation for Health Project Coordination and Information Center, Camp Dresser and McKee International, Inc.

The Rural Sanitation and Manpower Development Project of Indonesia is a four-year plan that aims to provide (1) laboratory equipment, (2) library facilities, (3) appropriate technology, (4) field training, (5) communications, (6) information systems, and (7) faculty development. Nine sanitary schools have been completed. Courses offered are discussed. The course description and content for water pollution control and water related health problems are based on United Nations standards.

362
German Foundation for Developing Countries (1968)
Forest, Forest Range, and Watershed Management in the Philippines. Paper presented to Seminar on Planning of Forestry and Forest Industries in Tropical Regions, circa 1968, FAO and UNDP.

A project for the development and rehabilitation of forest lands in the Philippines was conducted in 1968 by the German Foundation for Developing Countries. The project components described in this report include the following: (1) forest area description, (2) industrial management, (3) shifting cultivation, (4) problems of forest management, (5) grazing, (7) proper land uses, and (8) specific investment policy guidelines. The appendix contains an exhaustive listing of commercial trees in the Philippines.

363
Hatch, T. (1980)
Preliminary Results of Soil Erosion and Conservation Trials Under Pepper (Piper nigrum) in Sarawak, Malaysia. In Soil Conservation Problems and Prospects, ed. R.P.C. Morgan, 255-62. Chichester: Wiley.

364
Heider, T.D., and Chew Hai Hong (1974)
Magnitude and Frequency of Floods in Peninsular Malaysia. Hydrological Procedure No. 4, 54 pp. Kuala Lumpur: Ministry of Agriculture and Fisheries, Drainage and Irrigation Division.

The method used in Malaysia for estimating floods for ungauged locations is presented in this report. A description of the regional flood frequency curve and mean annual flood-catchment relationship is examined using regional data.

365
Heiler, Terrance (1975)
Prospects and Planning for Upland Crop Irrigation in Peninsular Malaysia. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 154-83.

Recognition of the diversity and complexity of upland environments requires a detailed investigation of what the author calls TCA or "time to cover the area." A model for TCA was devised using rainfall, potential evapotranspiration, moisture-holding capacity of the soil, and root depth of the crop, then correlated with recurrence of moisture stress. For Malaysia, the minimum tolerable level of 50 percent depletion of water held between field capacity and permanent wilting point was estimated. Possible irrigation methods include (1) hand-shift automatic sprinkler, (2) manually controlled graded furrows, and (3) semiautomatic border system.

366
Hock, P.D. (1981)
The suspended and dissolved sediment load of three small drainage basins in peninsular Malaysia. The Malaysian Forester 44(4):438-52.

367
Interim Committee for the Co-ordination of Investigations of the Lower Mekong Basin (1979a)
Environmental Management and Water Resource Development in the Nam Pong Basin of Northeastern Thailand. Report of the Nam Pong Environmental Management Research Project.

This document summarizes the findings of the second phase of the Nam Pong Environmental Management Research Project executed by the Mekong Secretariat during 1977-79 in collaboration with scientists from various Thai institutions. Financial support for this project was provided by the Ford Foundation. The objectives of this project featured initial identification and measurement of environmental and sociocultural effects arising since the commencement in 1964 of the construction and operation of the Nam Pong water resource development project.

368
Interim Committee for the Co-ordination of Investigations of the Lower Mekong Basin (1979b)
Nam Pong Environmental Management Research Project: Land Use. Working Document No. 3.

The purpose of this study is to investigate land-use development in the Lower Mekong Basin, including existing and potential agricultural land-use patterns and changes, land

morphology due to erosion, seasonal drawdown areas and their utilization, plant canopies, and plant biomass of the upstream area. A gradual increase in urban built-up land, agricultural land, and water resources, which will result in complete destruction of forests by year 2045, is predicted.

369
Interim Committee for the Co-ordination of Investigations of the Lower Mekong Basin (1979c)
Nam Pong Environmental Management Research Project: Water Quality--Physical and Chemical Aspect of the Reservoir. Working Document No. 11.

The purpose of this study is to investigate the quality of water in its regime relating to the environmental factors. The Ubolratana reservoir is relatively shallow. It receives about 2 million tons of sediment annually. Main characteristics of the reservoir water varied only slightly from season to season. The concentration of physical and chemical constituents was generally low.

370
Japan International Cooperation Agency (1977)
Hydrological Data Book for the Pampanga River Basin, Philippines: Major Floods During 1960-1974. Tokyo: Japan International Cooperation Agency, 287 pp.

The past six major floods in the Pampanga River Basin of the Philippines are assessed in this report. It is divided into two parts: (1) a descriptive account of flood characteristics, and (2) a comparative analysis of flood occurrence based on weather records, rainfall, gauge height, peak time, discharge, flood damage, and flood forecasting.

371
Jaraswathana, D., and S. Pinkayan (1974)
Practices of Design Flood Frequency for Small Watersheds in Thailand. Vol. 2, Design of Water Resources Projects with Inadequate Data: Proceedings of the Madrid Symposium, International Association of Hydrological Sciences Publication No. 108.

The purpose of this paper is to present the general practices of hydrologic analysis in Thailand, particularly on design flood frequency in small watersheds. The method, which is the common practice for assessing design floods, is based on the concept of the rational formula, the unit distribution graph, and the design storm obtained by the conventional procedures of frequency analysis. It concludes that the new concepts and statistical analyses, which are more reliable, are needed for the design of small water resources projects in Thailand.

372
Jindarojana, J. (1979)
The Socio-Economic Evaluation of Small Reservoir Projects, Water Quality. Working Document. Khon Kaen University, Thailand.

The objective of this study is to investigate the seasonal conditions of rural water sources in terms of water quality, emphasizing the comparison between the group of villages having ponds or small reservoirs with adequate supply in all seasons and the group of villages having inadequate water resources during the dry season.

373
Kampen, J. (1970).
Water Losses and Water Balance Studies in Lowland Rice Irrigation. Unpublished Ph.D. dissertation, Cornell University, Ithaca, New York.

374
Kang, N. (1979)
Development of Operating Rule Curve for Flood Control of the Pa Mong Project. Vol. 1, Proceedings International Conference Water Resources Engineering, 107-17. Bangkok Thailand: Asian Institute of Technology.

375
Kedah, H. (1970)
Protecting the Water Catchment Areas of Muda Irrigation Scheme: A Corollary to Project 14 (Estimate Proposal for Protecting the Catchment). Alor Star, Malaysia (mimeographed).

376
Kunkle, S.H. (1978)
Forestry Support for Agriculture Through Watershed Management, Windbreaks, and Other Conservation Acts. In Proceedings of the 8th World Forestry Congress, Jakarta: Indonesia.

Forestry management can aid farmers in preventing ongoing reduction in agricultural production due to loss of soil and reduced water supplies. Also discussed are deforestation and downstream effects, trees as soil protectors, forestry to improve agriculture in windy zones, agricultural development, and forestry conservation.

377
Kwi, S.N. (1980)
Soil Erosion and Conservation in Peninsular Malaysia: A Monograph. Kuala Lumpur, Malaysia: Rubber Research Institute of Malaysia.

378
Land Use Study Project, University of London (1978)
Land Use and Socio-Economic Changes Under the Impact of Irrigation in the Lam Pao Project in Thailand. London, England: University of London, School of Oriental and African Studies.

379
Leigh, C.H. (1978)
Slope hydrology and denudation in the Pasoh Forest Reserve, surface wash: Experimental techniques and some preliminary results. Malaysian Nature Journal 30(2):179-97.

A significant relationship was found between waterflow/sediment transport and thickness of litter cover (thick cover, less waterflow) with no significant relation between soil texture and runoff.

380
Leigh, C.H., and K.S. Low (1980)
The flood hazard in peninsular Malaysia: Government policies and action. Pacific Viewpoint 19(1):47-64.

In Peninsular Malaysia particular attention has been devoted to the improvement of flood forecasting, warning, and evacuation procedures. A major flood control system is to be implemented by the Klang Valley, where the cost of the project is justified by the highly capitalized nature of development within the basin. The adoption of more appropriate land-use planning policies and land-management practices has also been constrained by several factors. Recent proposals suggest that the federal government is conscious of the need for an integrated approach to development and environmental management, but the successful implementation of such policies may continue to be inhibited by a lack of appropriate action at the state and district levels.

381
Lim, Cheong Chup (1976)
Some Aspects of Farm Water Management in Malaysia. Paper presented to Symposium on Water Management in Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 263-72.

The majority of wet-rice cultivation in Malaysia occurs in the coastal plains where topographic conditions are suitable for flooding of large tracts of land. In noncoastal areas, rice is grown on the alluvial floor of lowland valleys below a 30-meter contour. Irrigation facilities were set up to conform to the 120-mm water depth estimated to bring soil moisture to full saturation. In the absence of land consolidation, canal design has followed the existing topography and boundaries of farmlots. Quarternary canals are located on ridges or levees, while drains are placed in depressions and aligned along common boundaries.

382
Limpadanai, D., and P. Brahmanonda (1978)
Salinity Intrusion into Lake Songkla, a Lagoonal Lake of Southern Thailand. Vol. 20, Part 2, Proceedings: 20th Congress, International Vereinigung fur Theoreoreticshce und Angewandte Limnologie, 1111-15, Copenhagen, Denmark.

Seasonal salinity fluctuations in lagoonal Lake Songkla, southern Thailand, are caused by a month of heavy rainfall (up to 800 mm) toward the end of each year, which coincides with salinity levels as low as zero parts per thousand (ppt), and tidal flow into the lake's southern inlet, resulting in maximum salinity levels of 32 ppt. Salinity in the southern basin has increased since 1967 from a maximum of 20 ppt to the current 32 ppt maximum, due primarily to dredging of the outlet channel. Dredging removed 2.1 million m^3 of silt in 1967 and 0.5 million m^3 in 1972. Water resources development in the western part of the watershed, including paddy field irrigation, is not a major contributor to increased salinity. Effects of salinity increase on aquatic organisms tolerated certain amount of salinity change.

383
Linden, P. van der (1978)
A reconstruction of the quarternary landscape development of the Serayu River Basin (Central Java). The Indonesian Journal of Geography 8(36):1-16.

384
Malaysia, Ministry of Agriculture (1976a)
Design Flood Hydrograph Estimation for Rural Catchments in Peninsular Malaysia. Hydrological Procedure No. 11. Kuala Lumpur: Ministry of Agriculture, Drainage and Irrigation Division.

A procedure for estimating design flood hydrographs for ungauged rural catchments in Peninsular Malaysia was developed using an analysis of design storm, rainfall-runoff relationships, and triangular hydrograph measurements for 12

ungauged catchments. The limitations of the procedure are also discussed.

385
Malaysia, Ministry of Agriculture (1976b)
Magnitude and Frequency of Low Flows in Peninsular Malaysia. Hydrological Procedure No. 12. Kuala Lumpur: Ministry of Agriculture, Drainage and Irrigation Department.

In determining water supply availability, the low flow characteristics of rivers must be estimated. Three elements are important in the measurement: magnitude, duration, and frequency of low flows. This procedure was estimated for some ungauged rivers in Peninsular Malaysia, but in most cases, there are few or no streamflow data available to estimate low flows.

386
Malaysia, Ministry of Agriculture and Fisheries (1974)
Rational Method of Flood Estimation for Rural Catchments in Peninsular Malaysia. Hydrological Procedure No. 5. Kuala Lumpur: Ministry of Agriculture and Fisheries.

The use of the Rational Method of Flood Estimation is widely accepted throughout the world. The method is particularly relevant when applied as a statistical link between the frequency distributions of the design rainfall and the design flood. This study presents the results of the application of the method for rural areas in Peninsular Malaysia. Catchment areas of up to 40 mi^2 are used. Limitations of the method are also discussed.

387
Mendoza, V.B. (1978)
Watershed problems in the upper Pampanga River Basin. Canopy 4(10):11-12.

388
Minami, Isao (1966)
Salinity problems of the Chao Phya River. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: The Center for Southeast Asian Studies, Kyoto University.

The problem of salinity intrusion in the Lower Mekong Basin and the Chao Phya delta is discussed in this paper with respect to the major causes and some preventive measures. The causes of salinity intrusion cited are (1) large decrease in discharge in the dry season, causing increased water intake upstream, (2) changes in topography caused by decreases in

water retaining capacity of the upper basin, (3) saline damage caused by land development, and (4) inadequate preventive measures. Some of the preventive measures proposed are (1) constructing embankments to prevent intrusion of seawater, (2) building back-tide gates where rivers flow into the sea, (3) increasing river discharge in the dry season, and (4) constructing estuary dams. Schematic diagrams of delta cross-section and streamflow discharge, and salinity distribution estimates are included in the report.

389

Mines, N.H., and M.Y. Golour (1971)
Demonstration and Training in Forest, Forest Range, and Watershed Management in the Philippines. Rome: Food and Agriculture Organization and United Nations Development Programme, 91 pp.

The Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNDP) organized a watershed management project in the uplands of Central and Northern Luzon in the Philippines from 1966 to 1970. This report summarizes the project's findings. Problems identified were heavy flooding, low streamflow, and high sediment loads of rivers. Land misuses such as slope cultivation, fire, clearing of protection forest, improper road construction, and logging practices were also described.

390

Nelson, M.L., et al. (1970)
Report on the Potential Growth of Aquatic Plants of the Lower Mekong River Basin, Laos/Thailand. USAID, Corps of Engineers.

391

Park, Kee Seung (1975)
Design Criteria and Layout of Farm Irrigation and Drainage Ditches in Paddy Cultivation. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 140-51.

Using field experiments conducted in the Chianan Irrigation Association, Taiwan, the author suggested the possible relationship between density of irrigation channels and ditches and effective water management. With respect to drainage design, the author argues that sufficient attention should be given to tonnage, allowable submergence levels, and stages of crop growth. Formulae for the estimation of runoff in paddy fields are also presented as a guide for design of distribution channels and drainage systems.

392
Pemberton, E.L. (1975)
Erosion at Santo Tomas Diversion Damsite and Sediment Problems at Diversion Structures in the Philippines. Denver, Colorado: U.S. Department of the Interior, Bureau of Reclamation, 44 pp.

An analysis of erosion problems in the Santo Tomas Diversion Dam and sedimentation in the Agno, Bonga, and Marbel River diversion dams in the Philippines is presented in this report. Some solutions include the shift to a more desirable dam location for Santo Tomas, construction of settling basins in Agno, use of undersluice techniques in Bonga, and the building of fabricated steel guide vanes in Marbel.

393
Philippines (Republic), Bicol River Basin Development Program (1978)
Integrated Development Area IV-A (Naga-Calabanga Project). Camarines Sur, Philippines: Bicol River Basin Development Program.

The Naga-Calabanga Project of the Bicol River Basin Development Program (BRBDP) in Camarines Sur Province, Philippines, provides irrigation, drainage, salinity control, and flood protection to agricultural lands in the basin area. A total investment of $30.2 million is planned over a seven-year period, the major component being infrastructure improvements.

394
Philippines (Republic), Department of Public Works, Transportation, and Communications (1978)
Pampanga Delta/Candaba Swamp Area Development Project. Quezon City: Department of Public Works, Transportation, and Communications and Tahal Consulting Engineers, Israel, 123 pp.

The devastating floods in the Pampanga Delta and Candaba Swamp areas in 1972 prompted the Philippine government to conduct a basin-wide study on flood control projects. This two-volume report presents the results of the feasibility studies and includes details on the type of infrastructure needed for development of surface and groundwater resources. The regional impact of flood control in the basin and the environmental effects of uncontrolled flooding are also considered.

395
Philippines (Republic), Local Water Utilities Administration (1980)
Project Report for the Interim Improvement of Kabankalan Water District. Quezon City: Local Water Utilities Administration, 45 pp.

The Interim Demonstration Program (IDP) of the Local Water Utilities Administration (LWUA) is designed to improve the quality of existing water services on the provincial level. The Kabankalan Water District in Negros Occidental Province, Philippines, has been selected as a pilot site for the IDP. This report contains the survey results of existing water resources in the province, population and service area consumption projections, financial analysis, and proposed water rates.

396
Philippines (Republic), Department of Public Works, Transportation, and Communications (1978)
Metro Manila Flood Control and Drainage Program: Status and Accomplishments, 1972-1977. Manila: Department of Public Works, Transportation, and Communications, 56 pp.

This report contains a summary of various projects implemented under the Flood Control Program of the Department of Public Works, Transportation, and Communications of the Philippine government for the first five years of the program (1972-77). The major ongoing projects are categorized into pumping stations, drainage mains/outfalls, estero dredging, and banks and drainage laterals improvement projects. Proposals for the next five years (1978-82) are also outlined.

397
Philippines (Republic), National Hydraulic Research Center (1978)
Napindan Hydraulic Control Structure: Hydraulic Model Studies. Quezon City: National Hydraulic Research Center Report No. 26.

In the Philippines, the Napindan control structure prevents the Pasig River in Metro Manila from polluting nearby Laguna Lake during low lake stages and reduces the lake's elevation to enable its optimum capacity to store excess water during the rainy months. This paper contains the results of scouring and deposition estimates near the control structure and an investigation of flow regime around the structure. Recommendations regarding the alignment of river walls and sheet piles are made.

398
Philippines (Republic), National Irrigation Administration (1976) Ecological Programme on the Control of Sedimentation in Rivers and Canals in Existing Irrigation Systems. Quezon City: National Irrigation Administration.

A study to investigate methods for controlling sedimentation of existing rivers and irrigation canals in the Philippines was made by the National Irrigation Administration (NIA) using selected service areas of the Agno River irrigation system in Pangasinan Province, Philippines, as pilot sites. Results of sediment load analyses from water samples, sediment control measures, bed material and soil analysis, and irrigation water classifications are summarized in this report. Recommendations to minimize the impact of sedimentation on water yield and water quality in the Agno River are provided.

399
Philippines (Republic), National Power Corporation (1975) Chico II and IV Hydroelectric Projects. Hydrology Report No. 2. Manila: National Power Corporation and Lahmeyer International GMBH, Germany.

Flood frequency curves were derived from the Chico River at Chico II (Sadanga) and Chico IV (Luguagan) dam sites in the Cagayan River Basin in the Philippines. These curves were used in determining optimal magnitudes and frequencies of design floods for the spillways and diversion works.

400
Pinkayan, S., and V.A. Sahagun (1973) Hydrologic Study of the Thung Ma Hiu Project. Research Report No. 42. Bangkok: Asian Institute of Technology.

A study of the hydrology, drainage, and flood control improvement of the Thung Ma Hiu Irrigation Project in Pibulmangsaban District, Ubon Rajathani, northeast Thailand, was made. The hydrologic study included a survey of existing water resources in the project, development of mathematical models to synthesize streamflows in the Huai Thewads catchment area, and prediction of design floods for return periods of 5 to 100 years. Irrigation for the dry season taking into account different levels of irrigation water demand was estimated with respect to volume of floodwater to be drained and period of drainage.

401
Pohjakas, K. (1975) Water Management: The Key to Improving Irrigated Agriculture. Paper presented to National Seminar on Water Management at the Farm Level, Kedah, Malaysia, 77-84.

Both policymakers and researchers have given little attention to problems associated with drainage. Double cropping has created serious drainage problems resulting in lower yields. Also, irrigation development for upland crops must also be studied by regional stations, and local rainfall patterns and soil composition data must be gathered before irrigation systems are designed for the upland region.

402

Pushparajah, E. (1979)

Proceedings of the Symposium on Water in Malaysian Agriculture. Kuala Lumpur, Malaysia: Malaysian Society of Soil Science.

The seventeen papers in this publication cover the following topics:

1. soil water relations, erosion, water management, and water conservation; and
2. the water relations of cow peas, oil palm, rice, rubber, pineapple, and durian.

403

Rouysungnern, S. (1979)

The Role of Para-Rubber Plantation on Soil and Water Conservation. Research Section, Watershed Management Division, Royal Thai Forest Department.

Hevia brasiliensis (para-rubber) is shown as effective in minimizing erosion based on an experiment in Southern Thailand (at slopes of 30-35 percent).

404

Ruangdej, Srivardhana (1979)

Environmental Assessment. Report No. 4. A Report Prepared for USAID/Thailand. Thai University Research Association.

The paper evaluated the environmental trends and assessments from some of the existing literature. At the existing rapidly depleting rate, some resources such as forests and clean water will not be available, even for consumption purposes in the future. Water pollution has received the most attention because of its specific nature that made the research effort manageable and meaningful.

405

Scott, W.J., F.M. Riberny, and T.J. Fricke (1976)

Hydrology of Flood Mitigation Measures in the Pahang River Basin, Malaysia. In Hydrology Symposium, 73-77. Preprints of Papers. Sydney, Australia: The Institution of Engineers.

The hydrological investigations associated with a large river basin study are described. Establishment and operation of rainfall, streamflow, and water level stations were carried out. Analysis of existing and collected data provided inputs to the assessment of flood mitigation works, both for river regulation and land-use strategies. Catchment modeling on annual, monthly, and daily bases was carried out using various techniques. Floodplain mapping to a scale of 1:10,000 was completed over a 3,000 km^2 area.

406
Sears, T.W. (1968)
A Few Definitions and Considerations for Watershed Management Planning. Paper presented at Conference on Ambuklao and Binga Watersheds, Baguio City, Philippines.

An operational definition of the term "critical watershed" is made by applying the concept to the Ambuklao and Binga watersheds condition in northern Luzon, Philippines. The importance of dense vegetative cover in maintaining a proper balance of land and water resources in the Ambuklao-Binga watersheds is discussed.

407
Sims, B.D., and M.L. Bonita (1976)
Watershed Management and Development: Their Application to Agricultural Water Supply. Los Banos, Philippines: University of the Philippines at Los Banos, College of Forestry.

Results of case studies of selected watersheds in the Philippines are discussed in this paper. Part I deals with the potential for increasing water yield as observed in the Laguna province areas. In Part II, problems related to soil erosion, range management, timber harvesting, and road construction are examined.

408
Soerjani, N. (1980)
Recent Trends in Aquatic Weed Management in Indonesia. In Proceedings of the 7th Conference of the Asia-Pacific Weed Science Society, Supplementary Volume, 39-46, Sydney, Australia.

Indonesia has 1 million hectares of natural lakes, while the present 50,000 hectares of man-made lakes will increase to 500,000 hectares in the future. In most lakes the expansion of aquatic weeds is the most serious problem interfering with the proper management of water resources. Therefore, there is a need to develop appropriate aquatic weed control based on proper water resources management and considering the

socioeconomic and cultural factors at the locality of the problem. In newly-built man-made lakes, preventive measures have been the most effective method in avoiding aquatic weed expansion. In infested waters, critical populations of aquatic weeds have to be controlled efficiently through mechanical (mainly manual) or chemical means. Moderate populations can be managed through proper utilization of the plant mass (e.g., as soil additives, animal feeds, material for handicraft, and mushroom culture). Other uses--for example, bio-gas production and pulp material, and a bio-purifier of polluted water--are still under investigation. A demonstration campaign, as a model for developing unified aquatic-weed-management programs, was conducted in Central Java near Rawa Pening Lake in May 1979. Evaluation of the campaign is briefly discussed.

409
Soo, Tee Thean (1975)
Water Problems in Agricultural Production in Peninsular Malaysia. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 17-25.

The largely uneven rainfall distribution throughout Peninsular Malaysia has resulted in two major water problems: (1) excessive water and flooding in the west coast lowland areas, and (2) insufficient water in the upland areas of the east coast. The possibility of developing irrigation for areas with brine soils is discussed, but since this type of soil has a low water holding capacity and low nutrient status, very little prospects for food crop agriculture can be expected.

410
Srivardhana, Ruangdej (1982)
No Easy Management: Irrigation Development in the Chao Phya Basin, Thailand. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 31 pp.

The major water resource management problems in the Chao Phya Basin in Thailand that have emerged in the 30 years of operation of the program are discussed. The basin, approximately 177,500 km^2, equivalent to 35 percent of Thailand's total area, generates 31,470 million kilowatt-hours of electricity. Serious environmental problems, however, threaten the operation of the reservoir as forest cutting activities in the Ping Watershed above the Bhumiphol Dam had accelerated. Irrigation water quality has also been affected by chemical residues and salinization. Some solutions include the recognition of nonphysical factors in the planning and implementing of future programs, and controlling of water use through effective water pricing policies.

411
Suwarnarat, K. (1970).
Pollution Study of the Chao Phya River A.D. 1969-1970. Bangkok, Thailand: Ministry of Public Health.

The objectives of this study were to determine the present condition of the river. Through a detailed examination of the various sources of pollution, the second objective is to be able to propose immediate interim measures to improve conditions or at least prevent further deterioration, pending the construction of the main Bangkok Sewerage Scheme.

412
Thimakorn, P., et al. (1978)
Navigation Channel Improvement for the Development of Pak Phanong Harbour, Nakhoin Si Thammarat, Thailand. Research Report No. 72, 65 pp. Bangkok, Thailand: Ministry of Communications, Harbour Department, and Asian Institute of Technology.

The sedimentation problem in the Pak Phanong estuary was investigated from an analysis of sediment transport in the river. It was estimated that sediment yield from the estuary is 1.2 times that of sediment supply from the upper basin due to additional side flows.

413
Toebes, C., and Goh Kiam Seng (1975)
Notes on Some Hydrological Effects of Land Use Changes in Peninsular Malaysia. Publication No. 4. Kuala Lumpur: Ministry of Agriculture and Rural Development, Drainage and Irrigation Department.

Major land-use changes, especially deforestation, afforestation, forest operations, and urbanization, are evaluated with respect to their effects on water yield. For example, water yield increases after deforestation and decreases upon afforestation. Peak water flows and flood volume increase with deforestation and urbanization.

414
Ueda, M. (1980)
A manual for protection of agricultural coastal lands (erosion) in Malaysia (design and construction of sea dikes. Japan Agricultural Research Quarterly 14(3):150-56.

415
Upland Hydroecology Research Program (1978)
Results and Policy Implications (1976-1978). College, Laguna: University of the Philippines at Los Banos.

The report discusses the research programs undertaken by the University of Philippines at Los Banos, College of Forestry, in grassland areas as bases for policy recommendations. Diversified vegetation covers are recommended. Also discussed are agroforestry, farming attitudes and practices, and land-use policy.

416
Wang, J.K., et al. (1970)
Bicol River Basin Water Allocation. Honolulu: Department of Agricultural Engineering, University of Hawaii.

This report forms part of a USAID-funded evaluation project on the Bicol River Basin in the Philippines. Technical analysis of rainfall, streamflow, and lower basin salinity are presented with respect to their implications to crop diversification, rice production, and fisheries.

417
World Health Organization (1978)
Comprehensive Water Quality Management Program: Laguna de Bay, Vols. 1 to 3. Geneva: World Health Organization and United Nations Development Programme.

The three-volume report on the largest freshwater lake in Southeast Asia, Laguna de Bay in the Philippines, contains background information, survey results, and conclusions on a study of water quality management and development. The study uses periodic water quality monitoring and limnological investigations to assess the beneficial water uses as well as the pollution loading of the bay. Recommendations related to irrigation return flows, water quality standards, lake oil pollution, domestic water supply, growth of water hyacinths, high multiplication of algae, and fisheries development are proposed in relation to a general environmental assessment of the bay.

D. NORTHEAST ASIA

418
Academia Sinica (1978)
Desert transformation in China. Scientia Sinica 21(2):251-78.

Various degrees of desertification are found in China due mainly to the numerous bioclimatic zones. Accordingly, several management approaches have been developed and applied to localized areas. Shelterbelts of trees and grasses have

been applied in sandstorm areas to anchor the sand and protect natural vegetation, and pastures in the more humid zones are carefully protected from overgrazing by nomadic animals. Desert areas with more abundant water and land resources have been chosen for construction of major engineering works such as reservoirs, canals, and irrigation and drainage systems.

419
Chan, C.C. (1981a)
Conservation Measures on the Cultivated Slopelands of Taiwan. Extension Bulletin. ASPAC Food and Fertilizer Technology Center, Taipei, Taiwan.

420
Chan, C.C. (1981b)
Evaluation of Soil Loss Factors on Cultivated Slopeland of Taiwan. Technical Bulletin. ASPAC Food and Fertilizer Technology Center, Taipei, Taiwan.

421
Changming, Liu, and Wang Guangte (1980)
The estimation of small watershed peak flows in China. Water Resources Research 16(5):881-86.

A watershed management model based on the analysis of data measured from a number of small experimental watersheds and various physical geographic factors is formulated for predicting the flood peak discharge resulting from storm rainfall. This method is now widely used for railway design works in the northwest and for hydraulic engineering design in certain regions in China with fairly good results.

422
Chinese Academy of Sciences (1977)
Combating Desertification in China. Nairobi, Kenya: U.N. Conference on Desertification, 50 pp.

A description of the distribution and characteristics of deserts in China and the various measures used in controlling desertification are examined in this paper. Some of the control measures discussed are (1) the sand-blocked forest and farmland protective forest network, (2) combined use of trees, shrubs, and grasses for soil protection, (3) "contain-sand-cultivate-grass" approaches for vegetative protection, (4) use of "grass kulun" to block wind and sand and to encourage pasture, (5) engineering measures and vegetation-building, and (6) construction of new oases through proper water and soil utilization practices.

423
Chou, C.H., et al. (1979).
Impacts of water pollution on crop growth in Taiwan: The Hsinchu and Taoyuan areas. Botanical Bulletin of Academia Sinica 20(2):123-44.

The effect of industrial waste water from seven factories in the Hsinchu and Taoyuan areas was studied during 1977 using pot trials with lettuce, rice, and Italian rye grass plants, the sensitivities of which diminished in that order. Toxicity of the waste water was higher in the day than it was in the evening. Most of the water samples significantly retarded vegetative and reproductive growth of rice and led to decrease in panicle number, ripening rate, test weight, and grain yield. The major detrimental factors were electrical conductivity, pH, suspended solids, Cl, SO_4, NH_4, Na, and the heavy metals Cu, Zn, and Cr, the respective concentrations of which were significantly correlated with phytotoxicity. The concentration of these elements was often above the limits laid down for irrigation water on agricultural land.

424
Fang, Z.S., et al. (1981)
Terraces in the Loess Plateau of China. In Soil Conservation Problems and Prospects: Proceedings of Conservation 80, ed. R.P.C. Morgan, 482-513. The International Conference on Soil Conservation, National College of Agricultural Engineering, Silsoe, Bedford, U.K. Chichester: Wiley.

425
Fujimoto, S., and S. Takasu (1979)
Historical Development of Large Capacity Outlets for Flood Control in Japan. Vol. 3, Transactions 13th International Congress on Large Dams, 417-38. New Delhi, India.

426
Hosoyamada, K. (1981)
Studies on the Estimation of Erosive Soil Loss. I. Soil Erosion by Rainfall at Bare Sloping Field Composed of Kuroboku Soil (Japan). In Transactions of the Japanese Society of Irrigation, Drainage and Reclamation 91:8-14.

427
Howard, P.M. (1981)
Impressions of soil and water conservation in China. Journal of Soil and Water Conservation 36(3):22-24.

Until watershed erosion is controlled, the use of reservoirs for reducing flood peaks and trapping sediment will be limited. Mechanical parts are rapidly worn by the high

sediment content of the water. Several critical sites along the Yellow River have been targeted for major erosion control programs. Revegetation has aided erosion areas that were destroyed by the rapid harvesting of the forests.

428
Imamura, N. (1980)
Land Improvement Investment and Agricultural Enterprises in Japan--as Seen in the Azusa River Basin. Tokyo, Japan: The United Nations University.

429
International Affairs Commission of the Japanese Society of Irrigation, Drainage and Reclamation Engineering (1972)
Irrigation and Drainage in Japan. Tokyo, Japan: Japanese Society Irrigation Drainage Reclamation Engineers.

430
Japan, Ministry of Construction (1972)
Organization and Function of the Ministry of Construction and Rivers in Japan. Tokyo, Japan: River Bureau, Ministry of Construction, 65 pp.

Development of rivers and flood control are studied with respect to developing land conservation measures, flood forecasting, and flood control systems. A government institutional structure for flood control is proposed.

431
Japan, Ministry of Construction (1977)
Comprehensive Flood Prevention Measures in an Urban River. Tokyo, Japan: Ministry of Construction, River Bureau, 16 pp.

Urbanization in Japan has rapidly progressed, generating serious flood problems in river basins. Flood prevention measures discussed in this report are (1) maintenance of water-holding capacities of river basins, (2) identification of flood-prone areas, (3) formulation of long-term flood control plans, and (4) introduction of flood warning and evacuation systems. These measures are applied in six river basins. However, only the Tsurumi River Basin flood control plan is discussed in detail in this report.

432
Japan, Ministry of International Trade and Industry (1977)
The Industrial Water Service of Japan. Technical Paper No. 177. Tokyo, Japan: Ministry of International Trade and Industry and U.N. Water Conference.

A plan to lessen dependence on groundwater supplies for use by Japanese industries has been developed, leading to a marked decrease in the groundwater subsidence problem, especially in the urban areas. The financial and management aspects of providing water service for industries are also discussed.

433
Jian, D.Q., L.D. Qi, and J.H. Tan (1981)
Soil Erosion and Conservation in the Wuding River Valley, China. In Soil Erosion and Prospects: Proceedings of Conservation 80, ed. R.P.C. Morgan, 461-79. The International Conference on Soil Conservation, National College of Agricultural Engineering, Silsoe, Bedford, UK. Chichester: Wiley.

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Kadomura, H. (1980)
Erosion by human activities in Japan. GeoJournal 4(2):133-44.

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Kira, H., and K. Ohta (1979)
On the empirical prediction of sediment deposition in reservoirs. Transactions Japanese Society Irrigation Drainage Reclamation Engineers 79:17-22.

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Kodaira, T., and R. Hamada (1980)
Vegetation of reclaimed land. I. Differentiation of plant community and survey of microrelief (Tokyo Bay in Chiba Prefecture). Japanese Journal of Ecology 30(4):323-31.

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Kung, S.Y., and T.C. Chiang (1979)
Soil erosion and its control in small watersheds of the Loess Plateau (Yellow River, China). Scientia Sinica 22(11):1302-13.

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Lee, C. (1967)
Some aspects of land utilization in Korea with reference to irrigation projects. Koreana Quarterly (Seoul) 8(3):44-62.

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McGarry, M.G., and J. Stainforth, eds. (1978)
Compost, Fertilizer, and Biogas Production From Human and Farm Wastes in the People's Republic of China. Peking, China: The People's Hygiene Publisher and International Development Research Center, 94 pp.

The collection of papers discusses the design, construction, maintenance, and operation of local Chinese technologies in producing from human and farm wastes liquid fertilizer, compost, and methane gas. The process of controlling waste water pollution in the recycling process is interesting, in particular, its low dependence on capital inputs.

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Moroto, K., and S. Watanabe (1979)
Runoff in a small watershed. Journal of the Japanese Forestry Society 61(8):302-4.

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Nagahori, K., and N. Haccho (1981)
Studies on the Characteristics of Water Adsorption and Their Effects on Physical Properties of Soil and Sea Land Reclamation Area (Kojima, Nakaumi, and Ariake Polders). Scientific Reports of the Faculty of Agriculture, Okayama University, 57:41-52.

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Ogawa, S., N. Ebisu, and K. Mizutani (1980)
A study of the runoff mechanism in the mountainous watershed (in Ehime University Forest, Flood and Erosion Control). Bulletin of the Ehime University Forest 17:93-99.

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Robinson, A.R. (1981)
Erosion and sediment control in China's Yellow River Basin. Journal of Soil and Water Conservation 36(3):125-27.

Terracing and vegetative coverings are used in China to reduce erosion in loess areas. Check dams or gully plugs help to contain runoff sediment in gullies. Diverted flows laden with sediment are used for irrigation. Warping--a process of improving sandy soil--is practiced to increase farmland acreage.

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Satoh, M. (1978)
Analysis of Operation Rules and Procedures for Flood Control at Multipurpose Reservoirs in Japan--Release in Advance of Flood at Multipurpose Reservoirs (I). Transactions Japanese Society Irrigation Drainage Reclamation Engineers 76:45-53.

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Shibuya, K. (1980)
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Sing, L.M. (1981)
A brief introduction to the Linbian-Lili River Bed Development Project (land reclamation, sugar cane). Taiwan Sugar 28(6):198-201.

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Sun, P.C. (1969)
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448
Tsuchida, A., and T. Murota (1979)
The scarred face of Japan. Ecologist 9(7):221-26.

Broad trends in Japanese agricultural systems are described: the Tokugawa era and the Meiji restoration with their major ecological effects. Postwar dam building, the devastation of arable lands, and the coming of cheap Middle Eastern oil brought about great changes that culminated in the Gentan policy of 1970, whereby subsidies were paid to farmers who gave up growing rice. The growing opposition to the industrialization and consequent pollution of land and water resources is shown in numerous organized movements. In 1971, the Organic Farming Association of Japan was established.

449
Tsuchiya, A. (1977)
Flood Risk Mapping. Tokyo, Japan: Ministry of Construction, Public Works, and Research Institute.

Aside from the conventional flood control measures using flood protection structures, nonstructural informational sources such as flood risk maps, zoning ordinances, subdivision regulation, and building codes can be used effectively for

flood control purposes. This paper discusses the use of the flood risk map and flood plain management approach. The different types of maps and methods of estimation of flood-prone areas are discussed.

450
Vermeer, E.B. (1977)
Water Conservancy and Irrigation in China. The Hague, Netherlands: Leiden University Press.

The author covers widely divergent issues concerning water management--namely, the scales and methods of labor mobilization (including personnel training) and capital allocation, the extent of natural calamities and relief programs, construction standards for anti-flood projects, irrigation and salinization. National, provincial, and local data from China are used when available.

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Watanabe, K., and T. Oshima (1981)
An investigation of river flood and sloped farm land damages in Saga Prefecture (shore reclamation). Agricultural Bulletin of Saga University 51:79-98.

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Williams, J.F. (1981)
Agricultural Use of Slopelands in Taiwan. Boulder, Colorado: Westview Press.

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Woo, B.M. (1982)
Soil erosion control in South Korea. Journal of Soil and Water Conservation 37(3):149-50.

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Yabashi, S., et al. (1978)
Soil erosion in Namioka east side upland--Study on slope erosion (II). Transactions Japanese Society Irrigation Drainage Reclamation Engineers 76:31-37.

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Yoshida, H. (1981)
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456
Zhu Zhir Song (1981)
China's Great Green Wall. American Forests 87(5):58-59.

The shelterbelt on the southern coast of China is made up mainly of Casuarina, and it is successful in resisting typhoons, warding off sandstorms, stabilizing the sand dunes, and fighting against drought as well as supplying timber and fuel. Established in 1954, the shelterbelt now has a total length of 3,000 kilometers and an area of 1 million hectares.

VI. SURVEY, PLANNING, AND IMPLEMENTATION METHODOLOGIES

The subject matter of water resources management, encompassing engineering, natural science, economic and other social science issues, increasingly has been the focus of interdisciplinary research (459, 464, 465, 466, 469, 470). While this convergence of research interests has produced comprehensive studies on the utilization of water resources and detailed explanations of human or social responses to specific environmental problems, it has also led to the development and use of a wide variety of research methodologies that may have contributed to problems of communication and exchange of ideas.

Classification Scheme and Definitions

In this chapter the different research methodologies are grouped under seven major headings. The methodologies use quantification techniques in varying levels, and some methods are closely associated with a single discipline--for example, benefit-cost analysis with economics--while other methods such as systems analysis and multiple-objective evaluation approaches are less restrictive in disciplinary orientation. Methods used in case studies--such as the various types of survey research methodologies and the use of ethnographic techniques in anthropology--are not reviewed in this chapter but are covered in Chapter IV.

Systems Analysis

General systems analysis, broadly defined, is a method of applying a body of theories that deal with interrelationships in the empirical world. The theories are developed with applicability to more than one discipline (Bertalanffy 1968).

There are two broad types of systems studies. A closed system is one that is bounded for heuristic reasons and is treated as if it were unaffected by forces outside the system. Most of the engineering studies, for example, confine analysis to a well-defined hydrologic system, especially in the small-scale irrigation systems where very little watershed-forest influences are recognized (see entries 476, 548, 550, 569, 619, 623, 627, 632).

Although using a closed systems approach is well suited for some experimental types of studies, which allow scientists to deal more effectively with complex data, most systems are viewed as open to outside forces. Thus an open system requires recurring inputs from the outside to maintain the system and may also generate outputs that leave the system. The interconnectedness of components in an open system helps to preserve the system.

Through cybernetics (Miller 1975), or through those processes that maintain control and adaptability by information feedback (Moran 1979), information flows about factors outside of the system may lead to feedback loops that do not return the system to equilibrium but instead promote changes within the system itself. This makes the approach ideal for responding to one of the challenges facing researchers in water resources management: how to deal with the occurrence of change especially in the process of human use of water and related land resources.

A description of the open systems approach is found in Biswas (458), Chaturvedi (460), and Rogers (471). The application of the approach in engineering is presented in Attanato (457), Early (461), and Gopalakrishnayya (462). In the social sciences, refer to Carruthers and Mountstephens (459), Ingersoll (463), Levine (466), Lenton (464, 465), Mathur (470), Lowdermilk, Early, and Freeman (467), and the pioneering work of Maass, et al. (468). The use of the systems technique that incorporates related land resources (watershed) is made by Maheswaran (469), Sheik (473) and, to some extent, Rogers (471), whose main concern is flood control.

Benefit-Cost Analysis

An economic evaluation of water resources projects is usually made with respect to (1) the provision of resources requiring efficient organization of production and equitable distribution and (2) the study of environmental effects in relation to technology and productivity. For example, while providing irrigation water from a reservoir to increase food production is beneficial from an economic point of view, there is now the additional challenge of maintaining a balanced relationship between technology and the environment (e.g., economic consequences of sedimentation and removal of natural vegetation, and the pollution effects from discharge of toxic chemicals damaging wildlife, fish, domestic animals, and humans).

Benefits from technology of water resources use (such as dams and feeder canals) arise principally as savings in the use of resources, or as surplus in the form of larger output levels (Schmid 1967). In principle, benefit and cost calculations of water resources projects seem straightforward--i.e., estimates are made of the total resource cost before construction of the water system or, alternatively, estimates of output prior to water delivery are compared with output after the introduction of improved water use (whether in irrigation, hydroelectric power, or domestic supply).

This type of benefit-cost calculation (or BCA) is used by the Bangladesh Institute of Development Studies (474), Bhatia (476), Bhatia and Mehta (478), Dhawan (484), Haque (487), Pal (494), Rogers and Hurst (499), and Singhal (502) in the evaluation of tubewell and groundwater irrigaton projects. The application to gravity canal systems is found in Easter (485) for a village irrigation system in

India, Huelgas and Torres (488), Johnson (490), Prasad (496), Rada and Lee (497), Sharma (501), Sinha and Bhatia (503), Taylor (510), and Trung (513) for large-scale, multipurpose water projects.

Benefit-cost analysis also has been used in devising a water fee schedule: Basu, Gopinath, and Karady (475), Rada and Lee (497), Small (506), and Tagarino and Torres (507). In some cases the results of benefit-cost analysis are used as policy instruments, as in the allocation of funds and in the setting of priorities for development. The studies of Bottomley (480), James (489), Kikuchi (492), Major (493), and Slade (504) are a few examples.

Benefit-cost anlaysis also is used in evaluating domestic water supply projects: Garcia-Yangas (486) and the Philippines Local Water Utilities Administration study (495). Alternative uses of water, such as hydroelectric power, navigation, domestic use, and recreation, are evaluated in Basu, Gopinath, and Karady (475), Bhatia (476), Bokhari (479), Selverajan and Subramanian (500), the Taiwan Provincial Water Conservancy Bureau (508), and Trung (513).

Social and environmental side effects are considered in Conlin (482), Kandiah (491), and Shinha and Bhatia (503). The studies of Rogers (498) and Thamoldaran, Bide, and Heady (512) elaborate on a method for quantifying serious environmental (including health) consequences of river basin development.

Optimization Models

Several types of optimization models are used to determine the most efficient mix of resources to achieve desired goals, given a set of system constraints. Linear programming is the most popular method used, and a good description of the method is found in Prabowo's (521) application to the Solo River Basin in Indonesia.

Another optimization model is goal programming, where alternative water uses are evaluated by examining their relative contribution to a number of societal goals. The papers of Hakanglu (518) for the Indus Basin and Prasad (522) for the Ganges Basin in India illustrate this approach. The works of Early (515, 516) for Pakistan and Singhal (524) for India give detailed descriptions of how computer programs can quantify multiple sets of data. Computer programming also is used in determining optimal cropping patterns such as the model used by Singh and Rahim (523) for the watershed area in Uttar Pradesh, India.

Optimization models also are used in determining resource distribution, especially of capital and labor as shown in the works of Gavan and Rogers (517), the Malaysia Ministry of Agriculture (519), and the Philippines National Power Corporation (520). The papers of Chaturvedi and Rogers (514) and Vedula (525) concentrate on the large-scale river basins in identifying an optimal pattern of resource use. Prasad's (522) application to the Ganges Basin in

India focuses on structural methods for transferring water to drought-prone areas, thereby reducing flood occurrence in the Ganges.

Simulation Models

The use of modeling for open systems aids in identifying data gaps and in formulating relationships that need to be investigated. Given the limited time available in most research projects, modeling can be helpful in monitoring the gradual accumulation of data and in classifying these data toward some meaningful research output.

Simulation, at the intermediate stage of research, allows the testing of the model's accuracy using empirical data. It has been one of the most useful techniques, since dynamic interactions between system components are reproduced. Thus, a technique for studying problems, by following a system's changes over time, becomes feasible by simply incorporating data into such computer-simulation programs as Dynamo or Analog Simulation.

The simulation model, as applied to economic evaluation of projects using both economic and noneconomic data, is used in Lee and Hsu (528); Lee, Lee, and Yang (530); Lee, Yang and Shyu (529); and the Taiwan, Provincial Water Conservancy studies (539 to 541). The following studies provide examples of measurement approaches used in large-scale river basin projects: Narayanmurthy and Revelle (531), Rao (534), and Rogers and Smith (535).

Differences in soil fertility and relative distance to the water source have been evaluated using a simulation model: Gomez (527), Pacheco, et al. (532), and Rondinelli (536). Water deficits and scarcities are analyzed with respect to their impact on yield and other factors. The papers of Chaturvedi and Srivastava (526), Rao (534), and Rydzewski and Nairizi (537) are the more important examples of such studies done in India.

Simulation also has been used to analyze, systematically, climatic variations with respect to crop-yield response and water availability. For example, the climatic water balance study of Rao (533) has been used extensively in India. Sumayao (538) used this technique in a study in the Philippines.

Technical Feasibility Studies

It is important to review periodically the requirements of various uses of water within the system, especially in reservoir projects. Irrigation water requirements, for example, are highly seasonal with a maximum during the dry season and little or no demand during the wet season. Unless the command area is expanded, the average annual demand for irrigation water will be constant

when irrigation storage is used effectively as insurance against drought.

Hydroelectric power demand has a marked seasonal variation depending on the area serviced. Since power production does not include consumptive use of water, it is more compatible with other uses. For example, water released from storage for use as irrigation downstream may be passed through a turbine to produce hydroelectric power.

Domestic water supply needs are fairly constant throughout the year. Maintenance of an adequate reserve to avoid water shortage during the drought is necessary. Sanitary precautions, however, may preclude the use of reservoirs for recreational purposes.

Reservoir control methods for irrigation, hydroelectric power, and domestic uses are analyzed in the reports of the Malaysia Ministry of Agriculture (549) and the Philippines Ministry of Public Works and Highways (560) and National Hydraulic Center (561, 562), and the study of Notodihardjo, Amster, Putuhena, and Wardoyo (550) for Indonesia. Water requirements for specific uses are evaluated in the following studies: (1) for hydroelectric power generation--Philippines National Hydraulic Center (562) and National Power Corporation (564, 565) reports; (2) domestic water supply--Gunawardana (546), Johnson (547), and the series of studies on the Philippines (552 to 560); and (3) navigation--Ackermann (542). Irrigation water delivery from reservoirs is discussed in the Philippine government reports (560, 561, 563, 565).

Groundwater development is explored in Arumugam (543), Curtin (544), Kanazawa (548), the Philippines Department of Public Works, Transportation, and Communications (551), Tingsanchali et al. (570), and Wagner (572). Alternative technologies for groundwater improvement are presented in Sivanappan and Kumari (569) and Watt and Collett (573), the latter providing technical drawings and specifications of chain and washer pumps used in China.

Farm level water used for various types of cropping patterns are evaluated in De Wolf (545) and Kanazawa (548). The United Nations Report (571) uses a combined technical and organizational approach to development of the Laguna Lake in the Philippines.

Multiobjective and Multiattribute Models

A variant of the optimization models and simulation techniques is the use of multiobjective or multiattribute programming. A description of the methodology, as applied to water resources project planning, is found in Cohon and Marks (574), Hiames, Hall, and Freedman (575), Rao (584), and Rogers, Rao, and Ramasheshan (588).

The basic approach of separating a water project's set of objectives from the attributes of each project component is

followed in the approach used by Livingstone and Hazelwood (578), where risk is evaluated in terms of fulfillment of a set of objectives. Levine's (577) discussion provides a perspective on the methodology by showing that engineering aspects requiring critical management inputs need to be incorporated in the planning and design stages. The Japan International Cooperation Agency (576), provides an example of the application of the approach in Ilocos Norte, Philippines. The other applied studies are Moore (579) in Sri Lanka, Ogata (580) in Japan, the Philippines National Irrigation Administration study (581), Ritchie (586) for Thailand, Prabowo (583) for Indonesia, and Potts, Knight, and Sternberg (582) where various objectives and alternative plans for local manufacture of hand pumps in the Philippines are evaluated.

Evaluation (Ex-post) Approaches

The materials in this category are subdivided into (1) the social and economic impact of water resources development, (2) performance or efficiency of the project in delivering desired water use levels, (3) the effectiveness of national water resources development programs, and (4) usefulness of action research projects.

The social and economic impact studies deal with the effects of water resources development programs on the regional economy. Macroeconomic implications of water resources development in terms of contribution to the economy and in increasing agricultural income are presented in Arulpragasam (589), the Bangladesh Agricultural University (591), Division of Agricultural Economics, Indian Agricultural Research Institute (594), Fujioka (595), Fukuda (596), Gittinger (597), Husein (598), Indonesia Ministry of Public Works and Electric Power (599), Saito (607), Soelistyo (608), and Wu (610). On the local level, water resources project effects are evaluated in the Philippines National Water Resources Council report (606), Tomosugi (609), and Yang (611).

The benefits from tubewell or underground water projects are quantified in Megino and Sta. Iglesia (603) and Murshed and Hossein (605). Social benefits are incorporated in the studies of Assen (590), Burke (593), Japan Cultural Science Society (600), Motooka (604), and Tomosugi (609).

Technical, hydraulic engineering performance of water resources infrastructure are reviewed in the Dutch National Committee (620), Ienaga (626), Jayaraman (628), Kanchanaphol (629), Lim (631, 632), Mukerji (635), Pai and Hukkeri (637), Palosoot and Van Dis (638), Philippines National Irrigation Administration (640), Sakamoto (641), Selvalingam and Phonopraphan (642), Shimura (643), Small (646), Spencer (647), Tamaki (649), Tsuchimochi, Ezaki, and Yashima (651), and Yukawa (658).

Crop-water relationships are evaluated at the farm level in the studies of Aglibut (612), Colorado State University (616), Cowley,

McClennan and Swatotirurk (618), Gerards (621), Goonasekere (622), Goonasekere and Wickham (623), Hsu (624), Huang (625), India Central Board of Irrigation and Power (627), Kumar (630), Lim (632), Sakamoto (641), Skogerboe, Reuss, and Kemper (645), Skogerboe, Kemper and Reuss (644), and the papers compiled by UN-ESCAP (652). Minor irrigation systems, including groundwater irrigation, are evaluated in the following: Alam (613), Bari (615), Patel, et al. (639), and Van Aart (653).

Terminal facilities and water distribution systems at the tertiary level are examined in Lim (631), Omar (636), Wickham (655), and Yukawa (658). Control of extraneous forces such as climate is studied in De Vera (619) and Malaysia Ministry of Agriculture (633).

Several national water resources management programs are reviewed. A few examples are the CARE Agricultural Program in Bangladesh (Bhuiyan, 662), the Thana Irrigation Program (Patten and Khan, 668), and the Command Area Development Programme (CAD) of India (Wade, 672). The U.N. Study Tour in China (671) contains a listing of some of China's major water resources projects.

Action Research

The term "action research" was first used by Kurt Lewin to depict the close correspondence between researchers and clients in seeking solutions to problems of local organizations (Bottrall 676). Recipients of water resources projects are viewed as active participants in an ongoing research project. Bottrall (676) proposes that four steps are important in the plan formulation/reformulation and plan evaluation/feedback cycle. These are (1) proper diagnosis of system elements and problems, (2) action planning, including remedial action, (3) action taking or acceptance by clients of the plan, and (4) evaluation through joint discussion and review with clients.

An experimental or on-site type of approach is presented in Angeles (674), Bhuiyan (675), and Wickham and Reyes (687) for the Philippines; Tamil Nadu Agricultural University (678); Palanisami and Thornton (682), and Sivanappan and Palanisami (685) for India; and Kemper et al. (680) and Reuss (684) for Pakistan. Field research tools, one using farmer participation, is the "paddy map" proposed by Early and Bagadion (679), and the other, using the applied agronomic data-gathering method developed by Van (686), offer promising approaches to action-research.

Broader issues related to the widespread adoption of action research programs are discussed in Chambers and Lenton (677) and Lenton (681).

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A. GENERAL SYSTEMS ANALYSIS

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Biswas, Asit K. (1981)
Systems analysis applied to water management in developing countries. Environmental Conservation 8(2):107-12.

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Carruthers, I.D., and N. Mountstephens (1980)
Integration of Socioeconomic and Engineering Perspectives in Irrigation Design. International Commission on Irrigation and Drainage, Tenth Congress, R. 29, Q. 33. Chankyaspuri, New Delhi, India: Internal Commission on Irrigation and Drainage.

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Chaturvedhi, M.C. (1974)
Ganges Basin Integrated System Studies: Water Resources Development. Harvard University (mimeographed).

461
Early, Alan C. (1981)
Irrigation System Management Diagnosis and Improvement Methodologies Developed in the Philippines. Paper presented at the International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

Problems concerning irrigation system management were surveyed in terms of three "weaknesses" in the planning of irrigation projects: (1) goals were too high and time frames unrealistic, (2) inappropriate designs were applied in terms of the physical and institutional environment, and (3) management methods were often insensitive to the local culture. Part II details the diagnostic analysis work done at the International Rice Research Institute (IRRI) where the management "weaknesses" were evaluated. Two case studies--the Penaranda and Lower Rural Talavera Irrigation System (LTRIS) in Central Luzon, Philippines--were discussed to illustrate the use of the approach.

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Gopalakrishnayya, K. (1979)
An integrated approach to command area development programme. Indian Journal of Public Administration 25(1):74-85.

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Ingersoll, J. (1968)
Mekong River Basin development: Anthropology in a new setting. Anthropological Quarterly 41:127-67.

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Lenton, Roberto L. (1980)
Water Resources Management: Some Thoughts on Interdisciplinary Research. IHD Endowment Lecture. New Delhi, India: Ford Foundation.

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Lenton, Roberto L. (1982)
Ford Foundation Programs in Water Resources Management in Asia. Paper presented at Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center.

The paper provides an excellent description of Ford Foundation water management projects in Asia. Section 1 gives an overview of the problems and potentials of water resources development in Asia--emphasizing action research, training, and information exchange rather than the design, construction, and rehabilitation of irrigation systems. The last section describes the approach to water resources management as defined by two sets of problems: (1) the need to improve productivity and equity in large-scale irrigation systems and (2) to fulfil the requirement for better organizational structures for small-scale irrigation systems.

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Levine, G. (1982)
Perspectives on integrating findings from research on irrigation systems in Southeast Asia. ADC Teaching and Research Forum 26:9-24.

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Lowdermilk, Max K., Alan C. Early, and David M. Freeman (1978)
Farm Irrigation Constraints and Farmers' Responses: Comprehensive Field Survey in Pakistan. Vol. 1, Water Management Technical Report No. 48-60. Fort Collins: Colorado State University.

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Maass, Arthur, et al. (1962)
Design of Water Resource Systems. Cambridge: Harvard University Press.

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Maheswaran, A. (1979)
Integrated Approaches to Water Resources Management in Rural Areas in the ESCAP Region. Paper presented at the United Nations Economic and Social Commission for Asia and the Pacific Regional Seminar on Alternative Patterns of Development and Lifestyles in Asia and Pacific.

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Mathur, P.D. (1980)
Social Science Research in the Rajasthan Canal Command Area: A Trend Report. India: Department of Political Science, University of Rajasthan.

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Rogers, Peter (1968)
A Systems Analysis of the Lower Ganges-Brahmaputra Basin. Proceedings of the International Symposium on Floods and Their Computation, Pub. No. 85. International Association of Scientific Hydrology.

The study approaches the problem of flooding from the Lower Ganges and Brahmaputra river systems in East Pakistan in terms of a systems framework. Flood control is evaluated by combining structural and nonstructural variables and by identifying complementary uses such as hydropower, year-round navigation, saline intrusion control and conjunctive use of surface and groundwater. These complementarities exist alongside the various uses of the river while controlling for flooding--an approach which conventional analysis cannot adequately cover due to the large number of variables and alternatives included in the problem.

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Schramm, Gunter (1980)
Integrated river basin planning in a holistic universe. Natural Resources Journal 20(4):787-806.

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Sheik, M.I. (1980)
Integrated Research in Forestry Resources (Pakistan). Washington, D.C.: USDA Forest Service.

B. BENEFIT-COST ANALYSIS

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Bangladesh Institute of Development Studies (1980)
An Evaluation Study of Deep Tubewells Under IDA Credit in North West Bangladesh. An Interim Report. Adamjee Court, Motijheel Commercial Area, Dacca 2, Bangladesh.

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Basu, D.N., C. Gopinath, and G. Karady (1976)
Evaluation of Alternate Allocation Principles for Irrigation Development. Center for Population Studies, Harvard University.

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Bhatia, Ramesh (1979)
Energy Alternatives for Irrigation Pumping: Some Results for Small Farms in North Bihar. Paper presented at International Seminar on Energy, Hyderabad, India.

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Bhatia, Ramesh (1980)
Economics of Energy Alternatives for Irrigation Pumping: Some Results for Eastern India. Department of City and Regional Planning, Harvard University.

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Bhatia, Ramesh, and Mura Mehta (1975)
Tubewell irrigation: An analysis of some technical alternatives. Economic and Political Weekly, Bombay.

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Bokhari, S.M.H. (1975)
Ex-Post Evaluation of River Basin Developments in Pakistan. Paper presented at UNDP Interregional Seminar in River Basin and Interbasin Development, Budapest, Hungary, 26 pp.

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Bottomley, A. (1982)
The economics of irrigated river basin development. Agricultural Administration 9(3):221-28.

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Bruce, C.M.F., and Y.H. Kimaro (1978)
An Economic and Social Analysis of the Chao Phya Irrigation Improvement Project II. World Bank Staff Working Paper No. 299. Washington, D.C.: International Bank For Reconstruction and Development.

This paper reports on the application of the economic and social cost-benefit methodology of Little-Mirless and Squire van der Tak. The application (to the Chao Phya Irrigation Improvement Project II in Thailand) is one of a number of case studies designed to test the feasibility and practicability of carrying out social as well as economic cost-benefit analysis. Sensitivity of the net present value and internal rate of return to variations in both national and project-specific parameters are included in the analysis. The sensitivity analysis used APAS (Agricultural Project Analysis System)--a computerized data processing system designed to be used in the processing of agroeconomic data for all kinds of project work. The conclusions of the analysis point out that there are time-consuming aspects to preparing the data for inclusion in the methodology and that the latter is difficult to master but that its application did bring to light facets of the project that might not otherwise have surfaced and the whole process was less time-consuming than might be expected.

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Conlin, Sean (1981)
Irrigation in Nepal: Questioning the Benefits. Katnmandu, Nepal: Land Resources Development Centre.

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Das, Kumar B. (1979)
Cost-benefit analysis of minor irrigation projects: A theoretical formulation. The Asian Economic Review 21 (1-3):62-66.

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Dhawan, B.D. (1975)
Economics of groundwater utilization: Traditional vs. modern techniques. Economic and Political Weekly, Bombay.

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Easter, K. William (1972)
Improving village irrigation systems: An example from India. Land Economics 53:56-66.

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Garcia-Yangas, R. (1976)
The Social Soundness of Improving the Water Supply System in Five Provincial Cities: A Final Report. Quezon City: Ateneo de Manila University, Institute of Philippine Culture.

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Haque, Fazlul Md. (1973)
An Economic Analysis of Shallow Tubewell Irrigation in Bogra, Bangladesh. Mymensingh, Bangladesh: Bangladesh Agricultural University, Bureau of Economic Research.

This research forms part of a series of studies on water resources financed by the U.S. Agency for International Development (USAID) in 1969. The survey was conducted in Bogor district, Bangladesh, using 24 irrigated and 22 nonirrigated sample farms. Average landsize was 20.86 acres for irrigated lands and 6.14 acres for drylands. Potato is planted in irrigated farms closest to the district town due to marketing advantages. Crop frequency or multiple cropping was also 10 percent higher on irrigated farms. For lands using the new varieties, rice yields were much higher for irrigated lands and returns to water use greater than potato cultivated farms.

488
Huelgas, R.R., and R.D. Torres (1979)
Preliminary Analysis of Selected Gravity Irrigation Systems in the Philippines. In Irrigation Policy and Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham, 151-54. Bangkok, Thailand: Agricultural Development Council.

An economic evaluation of seven diversion-type irrigation systems (2,400 ha to 9,000 ha) was conducted in 1974 to compare the performance of the irrigation system as initially projected. Only two-thirds of total command area was irrigated in the wet season and cropping intensity was 1.54, equivalent to a doubling of effective cropped area. Total costs for operation exceeded projected costs: over 15 percent for construction expenses and over 55 percent for maintenance. Net income for farmer-beneficiaries was US$147 per hectare per year (twice the level estimated at the start of the project).

489
James, L.D. (1978)
Economics of Water Development in Less Developed Countries. Vol. 7, Water Development, Supply, and Management. New York: Pergamon Press.

This paper forms part of the Water Development, Supply, and Management (Vol. 7) series. It examines the major components of water resources project planning with respect to meeting specified project objectives, technical feasibility and efficiency measures, and overall project design. Evidences, mostly from the Indian subcontinent region, are cited as case studies for recommended economic feasibility (testing) models. In Part II of the study, techniques developed from U.S. water resources projects are evaluated in terms of their relevance to the developing country context. In addition, the paper identifies evaluation tools that can be applicable to water projects for countries at different stages of economic development.

490
Johnson, Sam H., III (1979)
Economic Possibilities of Small Reservoirs for Irrigation: Northeast Thailand. Bangkok, Thailand: Ford Foundation.

491
Kandiah, A. (1978)
Some technical and social problems in the irrigation projects of Sri Lanka. Agricultural Mechanization in Asia 9(4):49-53.

One of the major setbacks in increasing agricultural production is poor water management at the farm level. To solve this problem, benefits from irrigation projects must be centered on farmers' fields, attention should be given to on-farm irrigation design, and incentives and economic benefits should be planned along with the introduction of new water management practices.

492
Kikuchi, Masao (1979)
Irrigation Rice Technology in Agricultural Development: A Comparative History of Taiwan, Korea, and the Philippines. Unpublished Ph.D. dissertation, University of Hokkaido, Japan.

Benefit-cost analyses for Taiwan, Korea, and the Philippines are used to test the hypothesis that as land resources for cultivation become scarce, agricultural technology plays a critical role in determining relative costs of producing an additional unit of output through land expansion. Relative profitability is used as a determinant for inducing irrigation investments. The results show that heavy investments in irrigation were induced in Taiwan and Korea during the 1920s. The share of public funds in total irrigation investments was high for these two countries. For the three countries, the growing difference in the marginal cost of increasing agricultural output between land expansion and irrigation emerged as the factor for inducement of irrigation

infrastructure investments due to the exhaustion of relatively less costly sites for irrigation.

493
Major, D.C. (1969)
Benefit cost ratios for projects in multiple objective investment programs. Water Resources Research 5(6):1174-78.

494
Pal, S.P. (1979)
Economic Evaluation of State Tubewell Irrigation in Bihar, India. Harvard University (mimeographed).

495
Philippines (Republic), Local Water Utilities Administration (1980)
Project Report for the Interim Improvement of Aparri Water District. Quezon City: Local Water Utilities Administration, 43 pp.

An improvement program for the Aparri Water District in Cagayan Province, Philippines, is described in this report. An economic benefit-cost analysis (BCA) is used in comparing alternative water supply projects, and a justification for expenditure of government funds is made with respect to the water district's ability to repay the loan.

496
Prasad, P.H. (1972)
Economic Benefits in the Kosi Command Area. Patna, India: ANS Institute of Social Studies.

497
Rada, E.L., and T.H. Lee (1963)
Irrigation Investment in Taiwan: An Economic Analysis of Feasibility, Priority and Repayability Criteria. Economic Digest, Series No. 15, 159 pp. Taipei, Taiwan: Joint Commission on Rural Reconstruction (United States and China).

498
Rogers, Peter (1966)
A Preliminary Study of the Feasibility of Basinwide Planning for the Lower Ganges-Brahmaputra Rivers. Harvard University (mimeographed).

499
Rogers, Peter, and Christopher Hurst (1980)
Engines for Development III: The Case of the Self-Energized Irrigation Pump. Center for Population Studies, Harvard University (mimeographed).

500
Selverajan, S., and S.R. Subramanian (1981)
Economic impacts of resource use optimisation and water augmentation in farms of Parambikulam Aliyar Project region. Indian Journal of Agricultural Economics 36(1):89-100.

501
Sharma, R.K. (1978)
The Economic Impact of Irrigation Projects: A Preliminary Study of Gandak Canal in East U.P., India. Harvard University (mimeographed).

502
Singhal, Mahendra K. (1980)
Techno-Economic Alternative for Irrigation Pumping: Some Cases in U.P. India. Department of City and Regional Planning, Harvard University.

503
Sinha, Basawan, and Ramesh Bhatia (1982)
Economic Appraisal of Irrigation Projects in India: A Case Study in Social Benefit Cost Analysis. New Delhi, India: Agricole Publishing Academy.

504
Slade, R.H. (1975)
Some Aspects of Investment Appraisal Related to Irrigation and Small Farm Projects. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 198-207.

Benefit-cost analysis of the MUDA scheme for estimating indirect economic impact of the project in the region is made following a methodology that takes risk and uncertainty into account during project appraisal. This is done through computer simulation, probability distributions of input variables, and repeated random sampling. The result is a probability distribution of the internal rate of return for the project.

505
Small, L.E. (1972)
An economic evaluation of water control in the northern region of the Greater Chao Phya Project of Thailand. Bangkok Bank Monthly Review 13:397-407.

506
Small, L.E. (1982)
Investment decisions for the development and utilization of irrigation resources in Southeast Asia. ADC Teaching and Research Forum 26:1-9.

507
Tagarino, R.N., and R.D. Torres (1971)
The Pricing of Irrigation Water: A Case Study of the Philippines' Upper Pampanga River Project. In Irrigation Policy and the Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham, 143-50. Bangkok, Thailand: Agricultural Development Council.

508
Taiwan Provincial Water Conservancy Bureau (1964)
A Study of Price Levels for Benefit-Cost Analysis on Water and Related Land Resources Development Project in Taiwan. Water Economics Study Series No. 3. Taipei, Taiwan.

509
Taylor, Donald C. (1979a)
Economic Analysis to Support Irrigation Investment and Management Decisions. Paper prepared for Workshop on Irrigation Water Management, Los Banos, Philippines (Serdang, Selangor, Malaysia: Malaysian Agricultural University and International Rice Research Institute).

The paper demonstrates the potential for economic analysis to provide useful insights into irrigation, drainage, and flood control investment and management in Asia. The basic approach is to outline the series of current and prospective issues in Asian irrigation development; for example, infrastructural intensification, which are amenable to economic analysis. The nature of economic analysis that might be undertaken to deal with each issue is indicated, and reference is made to illustrative research studies of Asian irrigation. The paper concludes with a suggested agenda of possible research topics for the future.

510
Taylor, D.C. (1979b)
Financing Irrigation Services in the Pekalen Sampean Irrigation Project, East Java, Indonesia. In Irrigation Policy and Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham. Bangkok, Thailand: Agricultural Development Council.

The paper examines various issues in financing irrigation services in the Pekalen Sampean Irrigation Project (PSIP) in east Java, Indonesia. Background on the organization of the PSIP is provided, including a discussion of irrigation benefits to farmers, and the nature and extent of current payments. Operation and maintenance (O&M) costs are calculated, and it is discovered that even though Indonesia has no nominal water tax, farmers are already paying more for irrigation water than what is being spent on O&M in the project. If government, agroindustries, and the food-consuming public also benefit from irrigation water, the possibility of increasing water charges payable by farmers should be approached with caution. The study shows that land and water resources in the PSIP are being used in an efficient manner; any change in the current system of collecting water charges as a component of land development taxes may not produce any gain.

511
Taylor, Donald C., and Kanaengnid Tantigate (1981)
Costs and Performance of Different Types and Locations of Irrigation Schemes in Malaysia. Paper presented to Agricultural Development Council Workshop on Investment Decisions to Further Develop and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

512
Thamoldaran, R., Shashanka Bide, and Earl O. Heady (1982)
An economic analysis of water management systems in Southern Tamil Nadu: Production function and programming approach. Indian Journal of Agricultural Economics 36(1):43-56.

513
Trung, N.Q. (1979)
Economic Analysis of Irrigation Development in Deltaic Regions of Asia: The Case of Central Thailand. In Irrigation Policy and the Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham, 155-64. Bangkok, Thailand: Agricultural Development Council.

The paper is a case study of the Chao Phya Irrigation Project in Central Thailand, which serves a land-locked area of 650,000 ha, almost all of which is planted to rice in the wet

season. Three phases of water management can be identified since the 1950s--the Chainat Dam (1951-57) and major canals and laterals, ditches and dikes, etc., the Bhumipol (1958-64) and the Sirikit (1965-73), and localized land consolidation and development for improving water control at the farm level (1969) to present. Direct economic costs and benefits and internal rates of return are calculated for each phase and all three phases in combination. Results indicate high IRR for Phase III (16.2 percent to 18.4 percent) and B/C ratios of 1.33 to 1.56. Phase I was the least viable project with an IRR of only 6.4 percent and a B/C ratio of 0.59. All three phases combined produced an IRR of 10.1 percent (with actual level of fertilizer application) and a B/C ratio of 0.72.

C. OPTIMIZATION MODELS

514
Chaturvedi, M.C., and P. Rogers (1975)
Large-Scale Water Resources Systems Planning with Reference to Ganges Basin. Vol. 2, Proceedings: Second World Congress, International Water Resources Association, 283-97. New Delhi, India.

515
Early, Alan C. (1978)
A Computer Program for Punjab Evapotranspiration Estimates. Fort Collins: Colorado State University.

516
Early, Alan C., et al. (1980)
Consequences of and Farmers' Reactions to Indus Basin Water Management Constraints. Fort Collins: Colorado State University.

517
Gavan, J.D., and P. Rogers (1975)
Optimal Water Use, Its Impact on Population Reinvestment in the Ganges Basin. Center for Population Studies, Harvard University.

518
Hakanglu, Erol (1980)
An Alternative Approach to the Indus Basin Model: Goal Programming. Harvard University.

519
Malaysia, Ministry of Agriculture (1977)
Water Resources for Irrigation of Upland Crops in South Kelantan. Water Resources Publication No. 8, 41 pp. Kuala Lumpur, Malaysia: Ministry of Agriculture, Drainage and Irrigation Department.

A water resources sector study of the Sg. Rasau-Sg. Yong area in Kelantan state, Malaysia, has been completed for intensive irrigation of 5,500 hectares of upland paddy farming. Study results and some recommendations for alternative cropping systems are presented in this report.

520
Philippines (Republic), National Power Corporation (1976)
Pulangi River Development Study. Vols. 1 and 2. Manila: National Power Corporation and Sofrelec, Paris.

A comprehensive study of the Pulangi River Development Project in Mindanao, Philippines, was conducted to determine power availability, energy production, and economic worth of the project. The study team recommended the construction of the Lumbayao-Maramag subproject for the first phase of the program. Estimates of power demand up to year 2000 were also made by incorporating into a data processing model rate of population growth, program of network development, and unit consumption levels.

521
Prabowo, D. (1978)
Water Development and Farm Production Possibilities in the Solo River Basin of Indonesia: A Linear Programming Analysis. Unpublished Ph.D. dissertation, Washington State University.

An attempt is made to establish the nature of abundance and scarcity of resources in Javanese agriculture and determine resources allocations that maximize returns to farmers and to the River Solo Basin region in central Java. The results indicate that farms with irrigation and controllable water supplies have potential for much higher incomes than do farms that are only partially irrigated. Unirrigated farms have the lowest income of all. Practically free water enhances the fully irrigated farms' earning capacity, and helps them to accumulate capital to adopt more intensive programs and high yielding technology. Disparity is increased because irrigation here tends to be most developed on the farms in areas with the highest levels of natural rainfall and the best land which can produce two crops a year. Furthermore, credit and other inputs are more readily available in the irrigated rice producing areas since programs such as Bimas are oriented to irrigated farms. Farmers in the fully irrigated areas typically receive and apply more irrigation water than they

need for producing crops that will yield maximum income. By reallocations of this water, a larger area actually could be irrigated in an average year. If unirrigated areas with low income could be given an allocation of water, total regional income could be increased. The water resource development in the study area could give priority to the exploitation of groundwater resource wherever feasible and economical.

522
Prasad, Triyugi (1976)
Water Resources Planning for the Water Abundant Regions in the Ganges Basin. Center for Population Studies, Harvard University.

This paper focuses on flood management techniques, specifically the goal programming approach. Structural methods recommended are the following: (1) using storage reservoirs for excess water, (2) groundwater recharge, (3) maintenance of embankments and diversion channels, and (4) channel improvement. Nonstructural techniques include (1) flood plain zoning, (2) flood insurance, and (3) flood forecasting and warning. Goal programming is used to decompose organizational and administrative hierarchies with respect to planning and implementing the structural and nonstructural solutions.

523
Singh, K., and K.M.B. Rahim (1978)
Identification and evaluation of optimal cropping systems for a typical watershed in Uttar Pradesh Hills. Indian Journal of Agricultural Economics 33(4):29-35.

524
Singhal, M.K. (1978)
System Design of Reservoir Storage and Yield. Vol. 3, Hydrology of Rivers with Small and Medium Catchments. New Delhi, India: Indian Central Board of Irrigation and Power.

525
Vedula, S. (1977)
An Outline of Proposed Study on Optimum Utilization of Cauvery Basin Waters. Center for Population Studies, Harvard University (mimeographed).

D. SIMULATION MODELS

526
Chaturvedi, M.C., and V.K. Srivastava (1979)
Induced groundwater recharge in the Ganges Basin. Water Resources Research 15(5):1156-66.

Almost 85 percent of rainfall in the Ganges Basin takes place in the 2- to 3-month rainy season. Surface storage is extremely limited but groundwater recharge appears feasible since sedimentary alluvial formation extends very deep. Three alternative schemes are proposed. One involves pumping heavily along perennial rivers prior to monsoons so as to lower groundwater level and further promote induced groundwater recharge. The second proposes a similar approach along nonperennial rivers. The third involves irrigation during monsoons with groundwater lowered adequately in the nonmonsoon period so that enough induced groundwater recharge takes place to provide adequate supplies for nonmonsoon months. A simulation-optimization model was developed to study the surface flow-groundwater interaction and was applied to study comparative cost effectiveness of the three alternatives. Sensitivity analysis was also carried out. The results indicate that the third scheme is the most attractive.

527
Gomez, G.E.M. (1976)
Crop Diversification as an Aid to Water Management--Some Computer Studies on Mahakanadarawa Irrigation Project, North Central Province, Sri Lanka. Paper presented to Symposium on Water Management in Rice Field. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, 209-24.

The paper presents the results of special studies conducted by the Hydrology Division of the Irrigation Department of Sri Lanka as part of an FAO/IBRD cooperative program for the Mahakandarawa Irrigation Project in north central province of the dry zone of Sri Lanka. The gross irrigable area in the dry zone is 350,000 acres, and the Mahakandarawa ancient reservoir scheme (restored in 1967) is designed to irrigate 2,350 acres in the wet season and 700 acres in the dry season. A suitable cropping pattern for each season was done through simulation analysis, incorporating the rainfall pattern, reservoir yield, soil type, and water requirements for each type of crop. Computer results indicate that with a field efficiency level of 50 percent, water should be extended to irrigate 6,000 acres in the wet season and 4,000 acres in the dry season to maximize reservoir capacity. Subsidiary crops to be planted are onions, chillies, and dahl.

528
Lee, C.Y., and S.T. Hsu (1971)
Agricultural Economic Evaluation for Li-Yu-Tan Reservoir. Taichung, Taiwan: Resource Institute of Agricultural Economics, Chung Hsing National University.

529
Lee, C.Y., Y.J. Yang, and S.T. Shyu (1971)
Agricultural Economic Evaluation for Ming-Teh Reservoir. Taichung, Taiwan: Resource Institute of Agricultural Economics, Chung Hsing National University.

530
Lee, S.C., C.Y. Lee, and Y.J. Yang (1966)
Agricultural Economic Evaluation for Choshui River Basin Development Project. Taichung, Taiwan: Resource Institute of Agricultural Economics, Chung Hsing National University.

531
Narayanmurthy, S.G., and Roger Revelle (1975)
Proposed Development of the Narmuda River for Irrigated Agriculture, Center for Population Studies, Harvard University (mimeographed).

532
Pacheco, E.S., et al. (1978)
Computerized Diversion Control Programs: Upper Pampanga River Project. Report No. 22. Quezon City, Philippines: National Hydraulic Research Center and National Irrigation Administration.

In order to determine the exact amount of water releases at hundreds of diversion points in the Upper Pampanga River Project (UPRP) in the Philippines, a computer program was developed. A description of the 14 computer programs used in processing raw data relating to rainfall, local flows, and conveyance losses is presented in this report. A major output of the program is the irrigation delivery schedule for the zone and lateral levels. The computer listings and output of five of the computer reports are attached to this report.

533
Rao, K.N. (1976)
The Climatic Water Balance of India. New Delhi, India: Controller of Publications.

534
Rao, P.K. (1976)
Studies in Punjab Water Resources System: Bias-Sutlej System. Center for Population Studies, Harvard University.

535
Rogers, P., and D. Smith (1970)
An algorithm for planning irrigation projects. Bulletin of ICID (New Delhi, India):15-30.

A linear programming model is presented to examine the various efficient combinations of irrigation water demand and alternative water supplies subject to various levels of costs and benefits of irrigation water management practices. Irrigation methods such as the tubewell, canal, and surface drainage are compared in terms of allowable cropping patterns, recharge capacities, and availability and fertility of lands. A case study of an east Pakistan irrigation system is used to illustrate the methodology.

536
Rondinelli, D.A. (1980)
Spatial Analysis for Regional Development: A Case Study in the Bicol River Basin of the Philippines. Resource Systems Theory and Methodology Series. Tokyo, Japan: The United Nations University.

The paper describes the spatial analysis for regional development approach used in the Bicol River Project in the Philippines from 1976 to 1978. Of importance to water resources management is Section 4 where a method for identifying land and water resources potentials is presented. In addition, the paper compares the methodology to other case studies in Asia and evaluates the organizational problems in implementing the approach on a wider scale.

537
Rydzewski, J.R., and S. Nairizi (1979)
Irrigation planning based on water deficits. Water Resources Bulletin 15(2):316-25.

The article analyzes the productivity of irrigation water in relation to harvested area and output levels and on-farm production costs. The focus of the investigation is on South Asia where large tracts of agricultural land are systematically underirrigated, such that evaluations of the magnitude and timing of water deficits with respect to yield can be observed. A computer simulation model that assesses benefits and costs with respect to the irrigation design capacity is used to determine the maximum level at which a combination of water and other land-related inputs can be

applied. The results show that deliberate underirrigation of lands could produce economic benefits as long as the timing of water application is matched with specific crop growth activities.

538
Sumayao, C.R. (1973)
Climatonomy of the Mabacan River Watershed. Unpublished M.S. thesis, University of the Philippines, Quezon City.

The immediate and delayed processes of total runoff that are not captured in simulation measurements, to estimate runoff rates in watersheds, are evaluated in this study through the use of Lettau's evapotranspiration climatonomy model. The experiment was conducted in the 46 km^2 Mabacan River Watershed in Calauan, Laguna Province, Philippines. Results indicate the usefulness of the model in predicting climatic trends for average years. For short-period processes, the models remain inappropriate.

539
Taiwan Provincial Water Conservancy Bureau (1965)
Agricultural Economic Evaluation for Tsengwen Reservoir Project. Water Economics Study Series No. 4. Taipei, Taiwan.

540
Taiwan Provincial Water Conservancy Bureau (1971)
Agricultural Economic Evaluation for Pein-Nan Irrigation Project. Water Economics Study Series No. 20. Taipei, Taiwan.

541
Taiwan Provincial Water Conservancy Bureau (1972)
An Economic Evaluation on Integrated Project of Irrigation Drainage and Land Consolidation. Water Economics Study Series No. 19. Taipei, Taiwan.

E. TECHNICAL FEASIBILITY STUDIES

542
Ackermann, N.L. (1970)
Navigation Channel Improvement on the Mekong River at Keng Kabao. Research Report No. 15. Bangkok, Thailand: Asian Institute of Technology.

The feasibility of installing a navigation channel, 30 m wide and 2.2 m deep, and discharging 960 m. per^3 second, is tested for the Mekong River Basin Project at the Keng Kabao rapids, approximately 27 km upstream from Mukdahan, Thailand. Results of the study show that by excavating 4,800 m^3 of material, the desired navigational conditions can be established.

543
Arumugam, S. (1978)
Ground-water studies of the Kala Oya River Basin, stage I. Engineer (Sri Lanka) 6(1):16-19.

544
Curtin, G. (1976)
Practical Methods in Groundwater Development. Paper presented to the Third Symposium on Hydrology. Manila: Philippine National Committee of the International Hydrological Program.

A brief description of some geological methods used in groundwater surveys in the Philippines is presented in this report. The type of surveys discussed relate to resistivity and electric logging and some aspects of groundwater quality investigation. A number of treatment measures are discussed in the last section.

545
De Wolf, J. (1980)
Rice Cultivation and Water Control. Reprint No. 19. Wageningen, Netherlands: International Institute for Land Reclamation and Improvement.

546
Gunawardana, R.A.L.H. (1978)
Hydraulic Engineering in Ancient Sri Lanka: The Cistern Services. In Sevanah Paranavitana Commemorative Volume, ed. L. Premortelleke. Liden: C.J. Brill.

547
Johnson, C.R. (1976)
Standards and Procedures for the Design of Water Supply Systems in Rural Areas of Nepal and Bhutan. United Nations International Children's Emergency Fund, 95 pp.

This booklet contains information on the design problems in the construction of small water systems in the remote hill and mountain regions of Nepal. Special topics such as criteria for design standards and estimates and specifications of infrastructure components are discussed.

548
Kanazawa, N. (1969)
The Rice Farming and Irrigation Pattern--River and Pond *Irrigation*. In Economic Approaches to Japanese Agriculture, 23-31. Tokyo, Japan: Fuji Publishing Company.

549
Malaysia, Ministry of Agriculture (1976)
The Estimation of Storage-Draft Rate Characteristics for Rivers in Peninsular Malaysia. Hydrological Procedure No. 13. Kuala Lumpur, Malaysia: Ministry of Agriculture, Drainage and Irrigation Department.

A simple procedure for deriving storage-draft rate characteristics for gauged and ungauged rivers in Peninsular Malaysia consists of an estimation of storage to sustain a given draft rate and the risk of insufficient storage to meet the draft rate.

550
Notodihardjo, M., R.C. Amster, F. Putuhena, and G. Wardoyo (1976)
Methods and Techniques for Improving Water Requirements Estimates for Agriculture in Indonesia. Surbiton, Surrey, U.K.: Land Resources Development Centre.

The paper considers improvements in some of the methods used in Indonesia to calculate water requirements for the planning, designing, and operating stages of agricultural projects. The major part of the discussion concentrates on water requirements for rice irrigation as well as palawija (non-padi) and sugar crops. The question of estimating water consumption for rainfed rice and palawija cropping is raised because of its significance in future agricultural production. The paper concludes that certain aspects of water requirements calculation need further investigation.

551
Philippines (Republic), Department of Public Works, Transportation, and Communications (1977)
Groundwater Development and Exploitation of the Pampanga River Basin: A Prefeasibility Study. Manila: Department of Public Works, Transportation, and Communication and Tahal Consulting Engineers, Israel, 63 pp.

The Pampanga River Basin in the Philippines has a groundwater basin of continuous elastic aquifer materials. Hydrogeological and hydrological surveys are made to measure aquifer constants, water levels, groundwater flow direction, and chloride content. Recommendations related to water balance, water availability, and distribution are given.

552
Philippines (Republic), Farm Systems Development Corporation (1977) Sta. Cruz Water Impounding Project: Feasibility Report. Report No. 8, 93 pp. Manila: Farm Systems Development Corporation.

A feasibility study of the proposed Sta. Cruz Water Impounding Project in Baliti, Arayat, Pampanga, Philippines, was conducted to explore the possibilities for irrigation, fisheries, and water supply. A reservoir and dam on the Baluga Creek and an irrigation delivery system was proposed. The dam will discharge 30.46 m^3 per second at maximum water surface. Total area affected will be 432 hectares of year-round irrigation.

553
Philippines (Republic), Local Water Utilities Administration (1976a) Water Supply Feasibility Study: Los Banos Water District. Quezon City: Local Water Utilities Administration, 405 pp.

A technical feasibility plan for upgrading and expanding the water supply system in Los Banos, Laguna Province, Philippines, up to year 2000 is contaned in this two-volume report. Volume I includes the recommended plan and methodology memoranda and a complete description of existing facilities and population projections. The technical plans and organizational charts for implementing the program are presented in Volume II.

554
Philippines (Republic), Local Water Utilities Administration (1976b) Water Supply Feasibility Study: Philippine Provincial Urban Areas. Quezon City: Local Water Utilities Administration.

Summaries of water supply feasibility studies for the urban areas of Ozamis, Daet, Butuan, Zamboanga, Cebu, Lucena, Lipa, Tarlac, Cabanatuan, and San Fernando, La Union in the Philippines, are contained in this report. The population affected by these studies is more than 8 percent of the total population. It also contains findings on prefeasibility surveys of 131 communities serviced by 110 waterworks systems.

555
Philippines (Republic), Local Water Utilities Administration (1977a) Immediate Improvement Program: Calamba Water District. Quezon City: Local Water Utilities Administration and Camp Dresser and McKee International, Inc., 37 pp.

The immediate improvement program for the Calamba Water District in Laguna province, Philippines, is designed to provide, within a 2-year period, an increased source, transmission, and distribution system for the growing population of Calamba. This will be done through the construction of a new pumping station and the installation of 8.71 km of pipelines. Technical and economic feasibility study results are also discussed in the report.

556
Philippines (Republic), Local Water Utilities Administration (1977b)
Water Supply Feasibility Study: Bangued Water District. Quezon City: Local Water Utilities Administration, 256 pp.

Results of a feasibility study to upgrade and expand water supply in the Bangued water district, Abra Province, Philippines, are contained in two volumes. The first volume presents a description of the water district's existing facilities, population and water demand projections, and available resources. The second volume contains detailed technical plans and a proposed organizational chart for implementing the project.

557
Philippines (Republic), Local Water Utilities Administration (1979a)
North Cotabato Water District: Water Supply Feasibility Study. Quezon City: Local Water Utilities Administration, 308 pp.

A feasibility study was completed for the improvement and expansion of water supply systems in Kidapawan, Makilala, and Matalam municipalities in the North Cotabato water district of the Philippines. The development plan includes (1) the development of a separate water source for Kidapawan and Makilala that is independent from the Matalam water source by tapping four springs and constructing ground storage and three reservoirs and (2) the expansion of the Matalam system by building two deep wells and two elevated storage tanks.

558
Philippines (Republic), Local Water Utilities Administration (1979b)
Project Report for the Interim Improvement of Tanay Water District. Quezon City: Local Water Utilities Administration, 56 pp.

A summary of engineering and feasibility studies conducted in the Tanay water district of Rizal Province, Philippines, is presented in this report. The results include (1) a survey of the existing water supply system, (2) projections for future

water demand, (3) details of a proposed water supply plan, and (4) financial analysis of future revenues and expenses and a schedule of proposed water rates.

559
Philippines (Republic), Local Water Utilities Administration (1980) Project Report for the Interim Improvement of Villasis Water District. Quezon City: Local Water Utilities Administration, 64 pp.

This report describes the engineering and feasibility studies conducted for the Villasis water district in Pangasinan Province, Philippines. A proposed schedule of water rates based on benefit-cost analysis (BCA) computations is used to evaluate alternative water supply development schemes.

560
Philippines (Republic), Ministry of Public Works and Highways (1982)
Feasibility Report on the Pampanga Delta Development Project. Main Text, Vols. 1 to 3. Quezon City: National Irrigation Administration and Japan International Cooperation Agency, Tokyo.

The flood control program for the Philippines' Pampanga River, affecting the south Candaba Swamp and the downstream region below Sulipan and Calumpit in Luzon, is presented. The proposed infrastructure includes the embankment of levee and the widening and excavating of river channels 40 km long between Candaba and Manila Bay. Irrigation to produce an additional 47,000 tons of rice is also included. Volumes I to III contain detailed plans for each flood control, agriculture, irrigation and drainage, inland fisheries, seawater intrusion, and organizational subprojects.

561
Philippines (Republic), National Hydraulic Research Center (1979) San Roque Multipurpose Project: Hydraulic Model Investigations. Quezon City: National Hydraulic Center and National Power Corporation.

This report describes the hydraulic model used by the National Power Corporation (NPC) in the development of the San Roque Multipurpose Project in Pangasinan Province, Philippines. The project is the third multipurpose reservoir constructed along the Agno River with a design flood capacity of 12,000 m^3 per second. Three alternative spillway structures are considered: (1) chute spillway on the right side of the dam, (2) combination chute spillway and tunnel spillway, and (3) three tunnel spillways on the left side of the dam.

562
Philippines (Republic), National Hydraulic Research Center (1981) Agus No. I Hydroelectric Project: Hydraulic Model Investigations. Quezon City: National Hydraulic Research Center and National Power Corporation.

The results of the hydraulic model studies on the power intake and tailrace channels of Agus No. I Hydroelectric Project in Lanao del Norte Province, Philippines, is presented in this report. The project is 3 km from the mouth of the Agus River where a major water resources potential study was completed by the National Hydraulic Research Center.

563
Philippines (Republic), National Irrigation Administration (1980) Balog-Balog Multipurpose Project Feasibility Study. Quezon City: National Irrigation Administration.

The Balog-Balog Multipurpose Project in Central Luzon, Philippines, is expected to provide year-round irrigation and hydroelectric power. The feasibility study, conducted in two stages, covers the following: (1) a preliminary evaluation and rating of surface and groundwater potential, and (2) a comprehensive assessment of engineering and economic feasibility for alternative schemes. Appendices 1 to 3 contain the results of the hydrological and geological surveys. Appendices 4 to 8 describe the various schemes for irrigation and hydroelectric power development.

564
Philippines (Republic), National Power Corporation (1978) Maramag Hydroelectric Project: Pulangui River Development Interim Report. Vols. 1 to 4. Manila: National Power Corporation and Sofrelec, Paris.

The Maramag Hydroelectric Project is a major component of the Pulangui River Development Program in Bukidnon Province, Philippines. It has an installed capacity of 250 Mw and an energy output of 1,000 BWH. The project design consists of a diversion dam and intake structure to a 9-km long power channel, an intake structure to penstock, and a semioutdoor type powerhouse with three generating units. Volume I gives a general description of the project, specifically plant capacity and output. In Volume II, maps of the main hydraulic structures provide detailed information on the storage, diversion, and powerhouse layout. Volume III describes the construction program for the Lumbayao Dam. Volume IV discusses the geological background of the project.

565
Philippines (Republic), National Power Corporation (1980) Cagayan and Tagoloan River Basin Project Feasibility Study. Manila: National Power Corporation, 364 pp.

The National Power Corporation of the Philippines contracted the services of Electroconsult, Milan, Italy, and Engineering Services Corporation, Manila, to conduct a comprehensive study of the Cagayan and Tagaloan River Basin Project in Mindanao, Philippines. The main report of the consultants is compiled in this document. The three appendices deal with the geology, hydrology, and socioeconomic aspects of the project. Part A of the main report discusses the physical environment of the area and the development potentials of water resources for irrigation and hydroelectric power. Alternative schemes are presented. In Part B, the technical and economic study results are discussed and preferred alternatives for hydroelectric programs are identified using the benefit-cost ratio estimates.

566
Philippines (Republic), National Water Resources Council (1977) Staff Review on the Paranaque Spillway. Quezon City: National Water Resources Council, 87 pp.

A review of technical and economic feasibility studies for the Paranaque Spillway in the Philippines is summarized in this report. The effectiveness of the spillway structure in controlling flooding in the Laguna de Bay shorelands is verified. However, economic analyses show that constructing the Marikina Dam for augmenting Manila's water supply should receive higher priority; thus the implementation of the flood spillway project has been deferred.

567
Philippines (Republic), National Water Resources Council (1978) Cost Allocation and Operational Guidelines for Multipurpose Storage Projects. Quezon City: National Water Resources Council, 50 pp.

The mechanics of reservoir operation of multipurpose projects and the principles and methods involved in the equitable distribution of costs among various project functions are discussed in this paper using the Angat River Multipurpose Project in the Philippines as an example. Guidelines related to reservoir release regulation under certain runoff conditions are analyzed with respect to the maximum reservoir releases allowed. The water release schedule then sets the standards for an impartial and equitable distribution of costs among various water uses served by the project (e.g., hydroelectric power vs. irrigation).

568
Philippines (Republic), National Water Resources Council (1980)
Upper Cagayan River Basin: Framework Plan. Quezon City: National Water Resources Council, 164 pp.

The Upper Cagayan River Basin, in Region II of the Philippines, has a total area of 6,250 km^2 and covers the provinces of Quirino, Nueva Vizcaya, Isabela, and Quezon, with a total population of 359,640. This report contains the plan for the development and utilization of land and water resources for the basin and includes feasibility studies of various types of water resources projects.

569
Sivanappan, R.K., and O. Padma Kumari (1982)
Drip Irrigation. Coimbatore, India: Tamil Nadu Agricultural University.

570
Tingsanchali, T., et al. (1976)
Water Balance Study: Bicol River Basin. Research Report No. 58. Bangkok: Asian Institute of Technology.

A water balance study for the Bicol River Basin in the Philippines was made to determine the fractions of rainfall that are converted to streamflow, evapotranspiration, basin water storage fluctuations, and groundwater recharge. The results were then used as guidelines in pinpointing potential irrigation and domestic water supply areas within the basin. However, it was found that water balance only provided a rough estimate of groundwater recharge. Some recommendations were made to improve hydrological and climatological observations.

571
United Nations (1970)
Feasibility Survey for the Hydraulic Control of the Laguna de Bay Complex and Related Activities. Vols. 1 to 3. New York: United Nations and T. Ingledow and Associates, Limited.

A regional development program for the Laguna de Bay area in the Philippines was designed to assess existing resources and to identify high priority investments for government and the private sector. A summary of engineering, economic feasibility, and socioeconomic evaluation studies is presented in several volumes.

572
Wagner, W.K. (1977)
Groundwater Investigation Programmes for Irrigation in Some Parts of Luzon and Bohol and Panay Islands, Philippines. UN-ESCAP Regional Mineral Resources Development Centre Advisory Services Report HG/12.

A plan for groundwater exploration for use in irrigation for the provinces of Ilocos Sur, Ilocos Norte, and Abra in northwestern Luzon, Bataan, Zambales, and Cavite provinces in Central Luzon, and Bohol and Panay islands in the Philippines is discussed in this report. A program for predevelopment investigations of ground water potential for coastal and fluvial plains and limestone areas is examined.

573
Watt, S., and J. Collett (1976)
Chain and Washer Pumps from the 1958 Peking Agricultural Exhibition. London: Intermediate Technology Publications, Ltd., 49 pp.

Twenty-one types of chain and washer water lifting devices, selected from over a hundred simple pumping devices on display in the 1958 Peking Agricultural Exhibit in the People's Republic of China, are described and evaluated in the report. The devices were chosen on the basis of materials used and technology for driving water (whether powered by hand, foot, animal, wind, or motor). Technical information on the design, construction, and mode of operation is included.

F. MULTIOBJECTIVE AND MULTIATTRIBUTE MODELS

574
Cohon, J.L., and D.H. Marks (1973)
Multiobjective screening models and water resources investments. Water Resources Research 9(4):826-36.

575
Hiames, Y.V., W.A. Hall, and H.T. Freedman (1975)
Multiobjective Optimization in Water Resources Systems. Amsterdam: Elsevier Scientific Publishing Company.

576
Japan International Cooperation Agency (1980)
Overall Plan for Ilocos Norte Irrigation Project in the Philippines. Tokyo: Japan International Cooperation Agency, 125 pp.

The National Economic and Development Authority (NEDA) of the Philippines requested the Japan International Cooperation Agency to conduct a feasibility study and project survey of the Palisiguran River Multipurpose Project, which is a major component of the Ilocos Norte Integrated Rural Development Project. Irrigation improvement for agricultural development is the main thrust of the project plan that was originally conceived by the National Irrigation Administration (NIA). Findings of the Japanese survey team and project proposals for infrastructure improvements in the area are included in this report.

577
Levine, Gilbert (1980)
The Relationship of Design, Operation, and Management. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 51-62. Ithaca, New York: Cornell University Press.

Water requirements, from an engineering point of view, are estimated for crop production based on two physical measurements--the difference between evapotranspiration rate and amount of rainfall. Since water requirement is computed from crop water needs rather than field or farmer requirements, irrigation design often has been lacking especially in the distribution of water. The author suggests that more attention be given to encouraging management "based upon indigenous social relationships." A water use program that differentiates equity from equality of water distribution follows from such an approach.

578
Livingstone, I., and A. Hazelwood (1979)
The analysis of risk in irrigation projects in developing countries. Oxford Bulletin of Economics and Statistics 41(1):21-35.

579
Moore, M. (1980)
Approaches to Improving Water Management on Large-Scale Irrigation Schemes in Sri Lanka. Brighton, England: Institute of Development Studies, University of Sussex.

580
Ogata, H., ed. (1979)
Water Use and Japanese Agriculture. Tokyo, Japan: Tokyo University Press.

The increased conflicts in water use in Japan between water for irrigation and water for urban use, the changes in farming structure such as the expansion of part-time farming, and the decline of rural communities inevitably have altered the traditional systems of irrigation. The present system of water use for irrigation and the changes in water use in rural areas resulting from the changes in rural socioeconomic conditions are discussed. The problems of managing irrigation facilities are analyzed from the viewpoints of technology and legislation, respectively. Finally, present problems of water use, such as coordination of water use for rural and urban purposes, are discussed.

581
Philippines (Republic), National Irrigation Administration (1976)
Second Davao del Norte Irrigation Project: Libuganon and Lasang Schemes Feasibility Report. Quezon City: National Irrigation Administration and Water and Power Development Consultancy Services Limited, India, 107 pp.

A comprehensive water resources development plan for the Davao II water resources area in Mindanao, Philippines, was conducted to increase agricultural production in the area. The four components of the plan are (1) irrigation and drainage, flood control, and water supply, (2) integrated agricultural development, (3) equipment and materials for construction, operation, and maintenance, and (4) engineering and consultancy services.

582
Potts, P.W., R. Knight, and Y.M. Sternberg (1979)
Feasibility of Local Manufacture of the Aid Hand-Operated Water Pump and Other Technology Appropriate for Rural Water Supply Programs in the Philippines. Arlington, Virginia: Water and Sanitation for Health Project, WASH, Camp Dresser and McKee International, Incorporated, 25 pp.

This report contains the findings of a three-man team to the Philippines to investigate the possibility of using the Aid hand-operated pump for use in the rural water supply program. The Aid program includes the installation of a pump, faucet, meter, and screen. The surveys of available resources in the Philippines show that manufacturing capabilities of machine shops to produce the Aid hand pump, plastic screen, water faucet, and water meters are diverse and vary from region to region.

583
Prabowo, D. (1978)
Allocation of farm resources in the Solo River Basin. Bulletin of Indonesian Economic Studies 14(1).

584
Rao, P.S. (1976)
Multi-Objective Analysis of Project Water Resource System. Unpublished Ph.D. dissertation, IIT, Kampur, India.

585
Rege, N.D. (1978)
Management Studies in Water Resources. Bombay, India: Agricultural Refinance and Development Corporation.

586
Ritchie, J.C., et al. (1980)
Water Management in Central Thailand. Bangkok, Thailand: Acres International Ltd.

587
Rogers, P., and M.C. Chaturvedi (1975)
Ganges Basin Studies. Multipurpose Basinwide Model. Planning Division of Water and Other Natural Resources: First Year Progress Report. Cambridge, Mass.: Center for Population Studies, Harvard University.

588
Rogers, P., P.S. Rao, and S. Ramasheshan (1976)
Multiobjective Analysis for Planning and Operation of Water Resource Systems: Some Examples from India. Center for Population Studies, Harvard University.

The authors apply the multiobjective decision-modeling approach by separating "attribute space" from "objective space" in two case studies--Bhakra Reservoir Project and the Ganges Basin Project. Alternative solutions are proposed in evaluating trade-offs more systematically. For example, cropping patterns for rotating winter and monsoon crops are used such that a small decrease in irrigation use can lead to substantial increases in water for hydropower.

G. EVALUATION (EX-POST) APPROACHES

G.1. SOCIAL AND ECONOMIC IMPACT

589
Arulpragasam, L.C. (1972)
Socioeconomic incentives for agricultural development under irrigation schemes. FAO Irrigation Drainage Paper 12:293-301.

590
Assen, J.H. (1970)
Socioeconomic Survey in the Pioneer Irrigation Project Area of Prek Thnot. Bangkok, Thailand: ECAFE, Committee for Coordination of Investigations of the Lower Mekong Basin.

591
Bangladesh Agricultural University (1975)
An Economic Analysis of Small Scale Irrigation Systems in Bangladesh. Mymensingh, Bangladesh: Bureau of Agricultural Economics, Statistics, and Sociology Research, Bangladesh Agricultural University.

592
Basu, D.N., and S.B. Mukerjee (1963)
Evaluation of Damodar Canals (1959-1960): A Study of the Benefits of Irrigation in the Damodar Region. London: Asia Publishing House.

The Damodar Valley Project was organized in April 1946 by the government of India with the assistance of W.L. Voorduin, senior engineer of the Tennessee Valley Authority (TVA). The project has a command area of 3,770 mi^2 over four districts of West Bengal, India. The Damodar River runs through a course 336 miles in length, and its river basin is 9,240 mi^2 located in five districts of Bihar and four districts of West Bengal. Two major canals, Damodar and Eden, convey water from the source to the fields, irrigating over 186,000 acres of agricultural lands. Four multipurpose dams at Tilaiya, Konar, Maithan, and Panchet Hill release stored water for irrigation throughout each cropping season. Water discharge is regulated by a system of headworks consisting of a barrage across the river and regulators over the main canals at both sides of canal embankments. A total of 1,550 miles of canals comprise the entire conveyance structure--140 miles of main canals, 98 miles of branch canals, 952 miles of distributaries, and 260 miles of drainage channels. This study is one of five major research projects sponsored by the Research Programme Committee of the Indian Planning Commission.

593
Burke, J.T. (1962)
A Study of Existing Social Conditions in the Eight Townships of the Shihmen Reservoir Area Including a Brief Analysis of the Impact of Irrigation and Benchmarks for Measuring Special Change. Joint Commission on Rural Reconstruction (United States-China), Economic Digest, Series 14, 114 pp.

594
Division of Agricultural Economics, Indian Agricultural Research Institute (1980)
Studies in Economics of Irrigation. Research Bulletin No. 32. New Delhi, India: Indian Agricultural Research Institute.

595
Fujioka, Y., ed. (1966)
Water Resource Utilization in Southeast Asia. Kyoto, Japan: Kyoto University, Center for Southeast Asian Studies.

596
Fukuda, H. (1973)
The Development of Japanese Irrigated Agriculture. In (Report) Regional Workshop on Irrigation Water Management, Philippines, Thailand and Indonesia, 199-210. Manila, Philippines.

597
Gittinger, J.P., ed. (1973)
Appraisal of Yong San Gang Irrigation Project--Stage I, Korea. Agricultural Projects: Case Studies and Work Exercises, 359-463. Washington, D.C.: World Bank.

598
Husein, Z. (1978)
Economic Impact of Developing Sederhana (Simple) Irrigation in Indonesia. Unpublished M.S. thesis, University of the Philippines at Los Banos, Laguna, Philippines.

599
Indonesia, Ministry of Public Works and Electric Power (1975)
Social and Non-Economic Aspects of Water Resources Development in Indonesia. Paper presented at the UN-ESCAP Symposium on Social and Non-Economic Factors in Water Resources Development, Bangkok, Thailand.

This paper provides an overview of the Indonesian government's water resources development program and elaborates on the problems encountered in the implementation of water resources

projects. An analysis of the noneconomic aspects of development of the Jratunseluan Basin Development Program in Central Java and the Tuntang-Serang Agricultural Development Plan is also discussed.

600
Japan Cultural Science Society (1970)
Brief Report of the Research on Social Implications of the Comprehensive Development Programme Along the Kitakami River. Tokyo: Japanese National Committee for UNESCO.

601
Japan Government and FAO (1973)
Seminar on Water Management and Control for Agriculture. Proceedings. Tokyo, Japan: Japan Government and FAO.

The book contains 15 Asian country reports and discussions and 13 other technical papers about irrigation. The purpose of the seminar was to bring together experts in agricultural water development and management in the Asia and the Far East region to identify policies, technical methods, and institutional aspects that would encourage the participating governments to formulate and implement water development and management projects in the most effective way and to provide the participants with first-hand knowledge and information on the subject through study tours. During the course of the seminar, it was recognized that irrigation and drainage are integral parts of agriculture and neither their technical aspects nor their impact on production can be discussed independently of the development of agriculture as a whole and that the integration of engineering and agricultural activities should be focused on the farmer's field. The seminar also highlighted the importance of water management as the basic requirement for increasing land and labor productivities and that proper use and management of land and water resources are a basic necessity for the improvement of socioeconomic conditions in much of the developing world. It was strongly felt that the wise use and careful conservation of land and water resources should be as important to developing countries as pollution and environmental problems are to developed countries. (Proceedings summary)

602
Lim, Cheong Chup (1975)
Irrigation Development and Water Management in Peninsular Malaysia. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia.

The existing irrigation development program in Malaysia is geared toward increasing rice production, but the incomes of farmers still remain comparatively low. Steps to increase

farm incomes include the modernization of rice farming, changing tenure status, and providing adequate water for crop growth. Past irrigation projects were developed merely to supplement rainfall and so new irrigation projects must include designs that would accommodate changing cropping patterns and future land-use schemes.

603
Megino, R.P., and J.C. Sta. Iglesia (1963)
Pump irrigation costs and practices in four northwestern towns of Laguna. The Philippine Agriculturist 40(6/7):357-80.

604
Motooka, Takeshi (1966)
Political, Economic and Social Factors on the Development of Water Resources in Southeast Asia. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto University, Japan: Center for Southeast Asian Studies.

605
Murshed, S., and M. Hossain (1976)
An Economic Appraisal of Deep Tubewell Irrigation in an Area of Bangladesh. Mymensingh, Bangladesh: Department of Agricultural Economics, Bangladesh Agricultural University.

606
Philippines (Republic), National Water Resources Council (1980)
Chico River Basin: Framework Plan. Quezon City: National Water Resources Council, 193 pp.

The Chico River Basin in Cagayan Valley, Philippines, with a total area of 5,247 km^2, is evaluated with respect to its resources potential, land conservation, capacity for domestic water supply, irrigation, power, and flood control potential. The capacity estimates are used as bases for conclusions and recommendations as embodied in the framework plan.

607
Saito, H. (1970)
An economic study of the role of irrigation in farm modernization in Japan. Bulletin National Institute Agricultural Science, Ser. H 41:1-26. Tokyo, Japan: Farm Management Land Utilization.

608
Soelistyo (1975)
Creating Employment Opportunities in the Rural Areas of East Java. Unpublished Ph.D. dissertation, University of Colorado.

The author found that 74 percent of the increased yield was due to irrigation and only 19 percent was due to the new rice technology. Irrigation alone increased labor absorption of about 27 percent while the cultivation of the new high yielding seed varieties alone increased the labor requirement by 7 percent.

609
Tomosugi, T. (1966)
Historical Development of Irrigation and Drainage in the Chao Phya Delta. In Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: Center for Southeast Asian Studies, Kyoto University.

610
Wu, W. Chia Hung (1976)
An Economic Study of the Irrigation Management System Between Off-farm Service and On-farm Service in Taiwan. Paper presented for Seminar on Irrigation Policy and the Management of Irrigation Systems in Southeast Asia, Los Banos, Philippines.

611
Yang, Y.J. (1981)
An analysis of paddy rice production and irrigation water in the Tsen Wen reservoir irrigation areas. Journal of Agricultural Economics (Taiwan) 30:31-52.

G.2. PERFORMANCE OR EFFICIENCY

612
Aglibut, A.P. (1965)
Essential consideration for improving irrigation practices. Sugarland (Phils.) 11(1):20-23.

613
Alam, M. (1974)
Capacity Utilization of Low-lift Pump Irrigation in Bangladesh. Research Series Report No. 17. Dacca, Bangladesh: Bangladesh Institute of Development Economics.

614
Alton, C.T. (1977)
The Economics of Dry Season Irrigation in Northeast Thailand. Unpublished Ph.D. dissertation, University of Kentucky.

615
Bari, F. (1975)
Causes and Effects of Late Operations of Pumps and Tubewells in Comilla Kotwali Thana, 1973-1974. Comilla, Bangladesh: Bangladesh Academy for Rural Development.

616
Colorado State University (1980)
Development Process for Improving Irrigation Water Management on Farms. Water Management Technical Reports Nos. 65 A-D. Fort Collins, Colorado: Water Management Research Project, Engineering Research Center.

617
Cowley, J.E., and D. Jaraswathana (1978)
Results of the Preliminary Phase of the Chao Phya and Mekong River Basin Study in Thailand. Vol. 2, Proceedings International Conference Water Resources Engineering, 727-48. Bangkok, Thailand: Asian Institute of Technology.

618
Cowley, J.E., B.I. McClennan, and Chutchawal Swatotirurk (1980)
A Water Operations System for the Chao Phya Basin, Thailand. Niagara Falls, Canada: Acres International Ltd. and Bangkok, Thailand: Royal Irrigation Department.

619
De Vera, M.R. (1976)
Analysis of Probable Effective Rainfall for Lowland Rice Production in the Philippines. UPLB-PCARR Project 76 Terminal Report. Los Banos, Philippines: PCARR.

This report contains the results of a year-long study to determine the effective rainfall for the growing season for various transplanting dates within selected stations of the Philippines and to compare this with the least amount of irrigation as computed by the National Irrigation Administration (NIA). The results show that the rainfall distribution, effective rainfall and number of dry days, and amount of irrigation water are the more significant factors affecting yield.

620
Dutch National Committee, ICID (1978)
Operation and Maintenance in the Northern Chao Phya Plain of Thailand. Vol. 6, Trans. 10th Congr. Irrig. Drain., Q. 35 (Part II), 495-507. Athens, Greece.

621
Gerards, Jan L.M.H. (1981)
Defining On-Farm Water Management for Programs Development in Small-Scale Irrigation Systems in Indonesia. Paper presented to the Agricultural Development Council Workshop on Investment Decisions to Further Develop and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

622
Goonasekere, K. (1978)
Field Water Use and Production Efficiency of Selected Crops Grown in the Dry Zone of Sri Lanka. Unpublished M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

623
Goonasekere, K., and T. Wickham (1978)
Some Findings on Field Water Use and the Productive Efficiency of Water for Chillies, Soybeans, and Rice in the Dry Zone of Sri Lanka. Los Banos, Philippines: International Rice Research Institute.

Sri Lanka has embarked on an agricultural production program through land expansion by extending cultivated area to the less developed dry zones. This study presents the results of a study that (1) determined the effects of different types of terrace and drainage designs on yield and water use, (2) evaluated the productive efficiency of water use of rice for upland and lowland field conditions, and (3) investigated the irrigation management requirements of upland crops.

624
Hsu, Y.P. (1970)
Water Management in Paddy Field. Paper presented at the Short Training Course Sponsored by the Asian Pacific Council Food and Fertilizer Tech. Center, Taipei, Taiwan, 42 pp.

625
Huang, Y. (1972)
Some reflections on paddy double-cropping in west Malaysia. Malayan Economic Review (Singapore) 17:119-29.

626
Ienaga, Y. (1971)
Irrigation System and Water Management. In The Mechanism of Asian Development--Agricultural Aspects, ed. S. Ishikawa. Tokyo, Japan: Institute of Developing Economies.

627
India, Central Board of Irrigation and Power (1976)
Design Practice for Unlined Incised Canals. Technical Report No. 7. New Delhi, India: Central Board of Irrigation and Power.

Guidelines for possible use on the national level regarding the design of unlined, incised canals are outlined in this paper. Details concerning longitudinal slope, coefficient of rugosity, maximum and minimum permissible velocities and critical velocity ratio, side slopes, and freeboards are explained. However, transit losses, permissible curvature in canal alignment, and other related measures are not analyzed due to inadequate experimental data.

628
Jayaraman, T.K. (1981)
Water Management Policy in Surface Irrigation Projects. Gujarat, India: Command Area Development Commissioner.

629
Kanchanaphol, L. (1978)
The Srinagarind multipurpose in Thailand. International Water Power and Dam Construction 30(3):46-48.

630
Kumar, P. (1977)
Economics of Water Management: A Study of Field Channels. New Delhi, India: Heritage.

631
Lim, C.C. (1976a)
Irrigation Development and Present Status of Farm Water Management in Malaysia. In Water Management in Rice Field; Proceedings of a Symposium. Kitanakazuma, Japan: Tropical Agriculture Research Center.

The history of irrigation schemes for rice culture in Malaysia, development of water resources for large-scale double cropping and on-farm development, and water management are summarized.

632
Lim, C.C. (1976b)
Some Aspects of Farm Water Management in Malaysia. In Water Management in Rice Field; Proceedings of a Symposium. Kitanakazuma, Japan: Tropical Agriculture Research Center.

Irrigation requirements for paddy rice culture, drainage requirements, development of on-farm facilities, and layout of drainage and canal structure are discussed.

633
Malaysia, Ministry of Agriculture (1976)
Evaporation in Peninsular Malaysia. Kuala Lumpur: Ministry of Agriculture, Drainage and Irrigation Department; and Engineering Export Association, Inc., New Zealand.

A review of the methods in obtaining estimates for evaporation for Peninsular Malaysia based on available climatic and evaporation pan data is made from an analysis of maps showing open water and forest grassland evaporation. Point and spatial variability of various regions in Malaysia are also studied.

634
Merriman, John L. (1980)
Demand Irrigation Schedule: Concrete Pipeline Pilot Projects, Sri Lanka. Mahakanadarawa Tank, Sri Lanka: Mahaweli Development Board.

635
Mukerji, S.P. (1979)
Irrigation management. Bhagirath, The Irrigation and Power Quarterly (India) 26(2):59-60.

636
Omar, Afifuddin Haji (1981)
Terminal System Infrastructure and Management: Policy Issues. Paper presented to Agricultural Development Workshop on Investment Decisions to Further Develop and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

637
Pai, A.A., and S.K. Hukkeri, ed. (1979)
Manual on Irrigation Water Management. New Delhi, India: Department of Agriculture.

638
Palosoot, P., and M. van Dis (1974)
Project and Farm Level Management of R.I.D. Irrigated Systems. In Irrigated Agriculture of Northern Thailand, 72-86. Agricultural Development Council National Seminar Report No. 5.

639
Patel, S.M., et al. (1969)
Management of Lift Irrigation (report on a pilot research project in Gujarat). Ahmedabad, India: Indian Institute of Management.

640
Philippines (Republic), National Irrigation Administration (1975)
Water Management Improvement in the Philippines. Quezon City: National Irrigation Administration and National Science Development Board, 122 pp.

Field tests were conducted in the Agno, Magat, Angat, and Sta. Cruz river irrigation systems in the Philippines to evaluate the effects of water management improvement schemes of the National Irrigation Administration (NIA). Plant-water studies were made regarding the impact on different rates of irrigation, water use efficiency, and conveyance conditions.

641
Sakamoto, I. (1973)
Irrigation management for paddy field from Ishikari River. Journal Japanese Society Irrigation Drainage Reclamation Engineers 41(6):5-12.

642
Selvalingam, S., and S. Phonopraphan (1978)
Operation of Mekong Basin Reservoir System, Thailand. Vol. 2, Water Resources Engineering, 1289-1308. Bangkok, Thailand: Asian Institute of Technology.

643
Shimura, H. (1978)
The Tendency of Increasing the Cost of Water Resources Development Through Constructing a Dam and the Influences on the Irrigation Water. Vol. 2, Trans. 10th Cogr. Irrig. Drain., Q. 33 (Part II), 659-71. Athens, Greece.

644
Skogerboe, G.V., W.D. Kemper, and J.D. Reuss (1980)
Development of improved water management practices in Pakistan. Water Supply Management 4(5-6):299-312.

The report forms part of the Colorado State University Engineering Research Center study for on-farm water management in Pakistan. Started in 1976, the project includes some 1,500 of Pakistan's 80,000 watercourses. Specific suggestions for improving water deliveries to farms are lining and cleaning of channels, land leveling, improving agronomic and water use practices, and upgrading institutional control over water users. In cooperation with the University of Agriculture at Frisalabad, the project reports successful training of supervisors of watercourses, which form part of the technical team that monitors on-farm water use.

645
Skogerboe, G.V., John D. Reuss, and W. Doral Kemper (1980)
Improving Irrigation Water Management on Farms. Water Management Technical Report No. 66. Fort Collins, Colorado: Water Management Research Project.

646
Small, Leslie E. (1981)
Evaluating Improvements in Irrigation Performance. Paper presented to the Agricultural Development Council Seminar on Investment Decisions to Further Develop and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

647
Spencer, Terry (1981)
The Effectiveness of Small-Scale Irrigation in Developing Countries. Unpublished M.S. dissertation, Institute of Irrigation Studies, University of Southampton, England.

648
Suzuki, I. (1972)
Upland Irrigation and Farm Management in Japan. In (Report) Seminar on Water Management and Control for Agriculture, 222-33. Tokyo: Government of Japan and FAO.

649
Tamaki, A. (1971)
Productivity of Paddy Farming and Irrigation Systems in Japan. Nippon no Nogyo No. 76, 100 pp. Tokyo: Nosei Chosa Iinkai.

650
Torres, R.D. (1972)
Potential Benefits and Pricing of Irrigation Water: A Case Study of the Santa Cruz System. Unpublished Ph.D. dissertation, University of Minnesota, St. Paul, Minnesota.

651
Tsuchimochi, M., K. Ezaki, and S. Yashima (1979)
Development of field infrastructure in relation to regional features. Agricultural Engineering Study (Water Management) Under Double Cropping of Paddy in the Muda Area, Malaysia (IV). Bulletin of the National Research Institute of Agricultural Engineering, Japan 18:75-90.

Under present conditions in the Muda area, in which the secondary canal systems are arranged at intervals of about 1 mile, a period of about 40 days is necessary to irrigate the whole area by plot-to-plot irrigation. This causes delays in the cropping schedule in the loss of one crop every two to three years. The construction of tertiary canal systems between the secondary irrigation and drainage canals is therefore proposed using Japanese experience in this field of research.

652
United Nations, Economic and Social Commission for Asia and the Pacific (1979)
Proceedings of the Workshop on Efficient Use and Maintenance of Irrigation Systems at the Farm Level in China. Water Resources Series, ESCAP No. 51.

The workshop on efficient use and maintenance of large-scale reservoir irrigation systems at the farm level was the first regional project organized in China by the UN-ESCAP. This was designed to provide information to technical staff of developing countries on farm level irrigation in China, with particular reference to potential transferability of the Chinese experience to other countries in Asia. The report is organized in three parts. The first part covers the workshop itself. The second part is composed of reports by participants on irrigation projects visited in China and observations on their relevance to developing countries. The third part consists of country papers from Bangladesh, Burma, India, Malaysia, Philippines, Nepal, Sri Lanka, and Thailand.

653
Van Aart, R. (1979)
Report on a Mission to Madhya Pradesh, India, for the Evaluation of a Project on Minor Irrigation. Wageningen, Netherlands: International Institute for Land Reclamation and Improvement.

654
Wade, R., and R. Chambers (1980)
Managing the main system: Canal irrigation's blind spot. Economic and Political Weekly 15(39):107-12.

Irrigation programs in South and Southeast Asia are being made with insufficient attention to a comprehensive diagnosis of the causes of the disappointing performance of publicly operated canal systems. This paper argues that main system operation should be tackled. This involves the design of appropriate management structures. Six issues that obscure the importance of main system management are considered.

655
Wickham, T. (1975a)
A Low Cost Technology for Improved Irrigation in Lowland Rice. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 103-13.

The efficiency of water use at the farm level is estimated for 11 survey areas in the Philippines. The survey results show that water efficiency is higher in the dry season due to a generally lower level of water supply at the field. Also, the lateral movement of water away from the canals is effective only where there is a high density of turnouts and farm ditches to reach even localized high areas.

656
Wickham, T. (1975b)
Some Soil-Plant Water Research Findings Useful to Irrigation Design and Management. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 85-101.

Field experiments conducted in the Philippines regarding the influence of water requirements for rice production and the interaction of water with nitrogen fertilizer were presented. It was reported that depth of flooding up to 15 cm had no significant effect on yield if the soil remained unsaturated for periods less than two to three days. With respect to drought, improved rice varieties experienced yield reduction when water stress occurred during panicle initiation. When water stress is felt in the vegetative stage, yield effects can be compensated by the use of nitrogen fertilizer after the stress period.

657
Wickham, T., and K. Takase (1976)
Some Management Issues in Irrigation Development. Los Banos, Philippines: International Rice Research Institute.

The paper examines various issues affecting the performance of irrigation systems in the Philippines. Suggestions for policy are made with respect to increasing yields over large irrigated areas. Some specific problems identified are the lack of effective extension services to farmers, field technicians, and even planners, and the inefficient delivery of water to the field.

658
Yukawa, K. (1972)
Water Management Distribution Systems in Japan. In (Report) Seminar on Water Management and Control for Agriculture, 129-51. Tokyo: Government of Japan and FAO.

G.3. EFFECTIVENESS OF GOVERNMENT PROJECTS AND PROGRAMS

659
Asian Productivity Organization (1977)
Report of APO Survey on Farm Water Management for Rice Cultivation. In Farm Water Management for Rice Cultivation. Tokyo, Japan: Asian Productivity Organization.

The Asian Productivity Organization (APO) conducted a survey in six Asian countries covering the following levels of irrigation management: national, terminal, and experimental stations. This report focuses primarily on the terminal irrigation units. The geographic division of sample countries in the survey classifies Japan and China as insular with paddies separate from irrigation canals and ditches and having mid-season drainage; Philippines and Indonesia as insular but with distinct wet and dry seasons and with fields dependent on paddy-to-paddy irrigation with partial rotation systems; Thailand as continental with continuous irrigation and no weeding; and Pakistan as nonmonsoon continental with continuous, nonweeding type of irrigation. The study findings try to generalize on certain patterns of water distribution with respect to specific rice cultivation practices. Tables accompany the text.

660
Asian Productivity Organization (1980)
Farm Level Water Management in Selected Asian Countries: Report of a Multi-Country Study Mission. Tokyo, Japan: Asian Productivity Organization.

661
Atthayodhin, C. (1972)
Operation and Maintenance of Irrigation Projects in Thailand. In Seminar on Water Management at the Farm Level, 143-54. Bangkok, Thailand: Royal Irrigation Department.

662
Bhuiyan, Shah Jalaluddin (1980)
CARE Agricultural Production Program in Deep Tubewell Areas of Bangladesh. Dacca, Bangladesh: Deep Tubewell Irrigation and Credit Program.

663
Boonlu, J. (1974)
Existing and Potential Ditch and Dike Programs in Thailand. In Irrigated Agriculture in Northern Thailand, 87-89. Agricultural Development Council National Seminar Report No. 5.

664
Eckert, Jerry, Niel Dimick, and Wayne Clyma (1975)
Water Management Alternatives for Pakistan: A Tentative Appraisal. Water Management Technical Report 43. Fort Collins: Colorado State University.

665
Gandi, P.C. (1980)
Regulated Irrigation Makes Them Time-Conscious. Times of India (October 30).

666
Harriss, J. (1979)
The Use of Documentary and Historical Evidence in Irrigation Studies: The Problems of Developing "Nomothetic Statements." Development Studies Discussion Paper No. 53. United Kingdom: University of East Anglia.

The paper analyzes the role of documentary sources in the formulation of nomothetic statements (generalized) about irrigation institutions and argues that documentary evidence as material for establishing generalizations about irrigation is limited because of inadequacies in controlling quality of inputs. Harriss proposes instead that historically determined structures be evaluated at a level that can yield relevant policy recommendations. The second part contains an excellent review of documentation-based studies: Valencia, Spain (Glick 1971), South Iraq (Fernea 1970, 1965), Mexico, Teotihuacan Valley (Milton et al. 1962), Crucatu Region, Mexico (Hunt and Hunt 1974), and Sri Lanka (Harriss 1974). A brief description

of the Gezira Scheme (Barrett 1977) and the Bhakra Canals, India (Reidinger 1974) is included in the last section.

667
Mohsin, Nadeem (1980)
Water management: Need to solve some basic problems. Economic Times (January 3).

668
Patten, Robert H., and Akhter Hameed Khan (1980)
An irrigation programme for Bangladesh: Parameters for design derived From physical, organizational, and economic realities. Journal of Bangladesh Academy for Rural Development (Comilla) 9:1-2.

669
People's Republic of China, Bureau of Water Conservancy and Electric Power (1977)
Water Resources Management in the People's Republic of China. Translated by J.E. Nickum. People's Republic of China: Bureau of Water Conservancy and Electric Power.

This pamphlet, translated by J.E. Nickum, describes a national model for irrigation management in China. It discusses how the Chinese overcome national adversity and illustrates the problems involved in operating an irrigation district, and how the scheme responds to various problems (such as expansion of supply through new construction, coordination of works, promotion of more efficient water application, land improvement, establishment of adequate water allocation procedures, and development of multiple operations).

670
Seang, Teoh Tiaw (1975)
The Need of Irrigation Extension in Irrigation Projects, With Special Reference to Muda Irrigation Project. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 186-96.

Technical information on the proper use of water management technologies at the field level can be transmitted through an effective irrigation extension program. Extension work in the Muda irrigation project, for example, shows that training of all grades of personnel is geared toward the improvement of demonstration plots. Muda extension work is now concentrated on the development of block irrigation. Committees are formed where farmers can fully participate in the operation and maintenance of terminal facilities. The role of Muda project irrigation inspectors and overseers is also discussed.

671
United Nations Development Programme (1977)
Study Tour on Water Resources Management in China. United Nations Development Programme, Centre for Natural Resources, Energy and Transport, 31 pp.

The United Nations organized the first of a series of study tours to the People's Republic of China (or China) to learn from the Chinese different approaches to water resources management. The following projects were observed: (1) land reclamation schemes, (2) dams and reservoirs, (3) canal, aqueducts, and tunnels, (4) multipurpose river basin development programs, and (5) related land resource projects.

672
Wade, Robert (1980)
On substituting management for water in canal irrigation: A south Indian case. Economic and Political Weekly (Bombay), 15, 52, 27:A147-60.

673
Wen, L.J. (1981)
Improvement of Irrigation Systems and Water Management in Taiwan. Economic Review, Bank of China 204:10-29.

The paper, presented at the Eleventh Congress of the International Commission on Irrigation and Drainage in Paris in September 1981, describes the type of irrigation development in Taiwan, chiefly for rice cultivation. So far, simple and low-cost irrigation projects have been completed. Demand for water is rising with the expansion of industrialization, urbanization, and agricultural modernization, and the acquisition of new water supplies has become increasingly difficult and costly. The paper includes data on water requirements, the determination of system capacity, and management programs for rice irrigation. It also refers to social, economic, and institutional aspects.

G.4. ACTION RESEARCH

674
Angeles, H.L. (1975)
Water Scheduling for Diversion Irrigation Systems. Munoz, Philippines: Central Luzon State University.

Based on farm-level water measurements in the Penaranda River Irrigation System (PENRIS) in Nueva Ecija and the Santa Cruz River Irrigation System in Laguna, Philippines, a methodology for determining weekly estimates of the area to be irrigated by diversion irrigation systems was made. A recommended schedule of planting and water distribution dates was also presented. The schedule was expected to expand area planted and irrigated in the dry season.

675
Bhuiyan, Sadiqul (1981)
Experience in Field Research in Irrigation System Management in the Philippines: Some Methodological Issues. Paper presented at Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

The issue of main system vs. on-farm irrigation management is a methodological concern. Appropriate criteria for evaluating the proper mix of management approaches are evaluated: (1) crop yield indicators, (2) estimates of cropped area, (3) water use efficiency, (4) relative water supply, (5) water adequacy, and (6) water distribution "equity." Comparisons of benefits and costs on a before-after basis serve to evaluate project worth vis-a-vis macroeconomic objectives. In this paper, the author proposes a mixture of independent engineering and hydraulic criteria and individual economic evaluation of projects as the type of approach needed in reviewing an irrigation project's performance.

676
Bottrall, Anthony F. (1981)
Action Research Towards Improved Water Distribution. Paper presented at International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

The paper argues strongly for action research as a means for improving the management of irrigation projects, specifically in the main system water distribution level. Approaches to counteract main system inadequacies have focused on the development of procedural manuals and training programs such as those developed at the University of Roorkee and the Water and Land Management Institute at Aurangabad, Maharashta. Rather than following this view, Bottrall proposes instead a social science approach that involves five steps: diagnosis, action planning, action taking, evaluation, and specifying learning. The National Irrigation Administration (NIA) participatory approach in the Philippines is then used as an example of a type of action research for developing organizational capability in small-scale irrigation systems. In replicating the NIA approach, Bottrall lists the following

prerequisites: use a long time frame for review, introduce staff incentives, develop good site selection criteria, and improve feedback links on the new water distribution system introduced.

677
Chambers, Robert, and Roberto Lenton (1981)
Action Research on Canal Irrigation: Traps, Tactics and a Code. Paper presented at the Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

Irrigation research and action research are contrasted in this paper with a few examples from completed research in the Asian region. Seven "traps" for action researchers are identified: (1) selection of projects and sites, making results too area-specific; (2) conflict of practioners vs. researchers, and the inability to translate research into policy; (3) defining the limits of design and developing appropriate methods; (4) limiting indicators for "success" to a few technical measurements; (5) the narrow perspectives of disciplines, hampering a thorough review process; (6) undefined measurement criteria or the lack of clarity in evaluating irrigation performance; and (7) the problem of the "counterfactual" or speculating on what would have happened without intervention. A "code" for action researchers is presented in the last section--i.e., (1) identify project beneficiaries, (2) promote local participation in planning, (3) develop staff potential, and (4) make sound recommendations.

678
College of Agricultural Engineering, Tamil Nadu Agricultural University (1981)
Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

The book contains the proceedings and background papers presented in the international seminar on "Field Research Methodologies for Improved Irrigation Systems Management" held in Tamil Nadu Agricultural University, Coimbatore, India. The background papers stress the importance of action research, and case studies from India, Philippines, Sri Lanka, Argentina, and the United Kingdom are discussed.

679
Early, Alan C., and Benjamin U. Bagadion (1981)
Paddy Mapping as an Organizational Tool for Communal Irrigation System Rehabilitation/Construction/Expansion. Training Module prepared for NIA Community Organizers Training at the IRRI. Los Banos, Philippines: IRRI.

680
Kemper, W.D., et al. (1980)
Watercourse Improvement Research in Pakistan. Water Management Technical Report No. 56. Colorado State University Engineering Research Center.

This report contains the results of a follow-up survey of the causes of water losses along Pakistan's extensive watercourse network. The major causes identified were (1) high porosity of upper portions of banks due to increased animal and insect activity, (2) destruction of channel embankments, (3) rising water levels due to vegetative growth and sedimentation, and (4) nonmaintenance of conveyance structures by farmers. Design improvements included the construction of new canal structures using government-subsidized materials and the regular training of field personnel in the maintenance of irrigation structures. The description of the methodology for calculating benefit-cost ratios for various types of conveyance structure improvements in Part II of the report is especially significant to the development of project-level approaches to water management.

681
Lenton, R.L. (1980)
Field Experimentation and Generalization in Irrigation Development and Management. AAU Irrigation Management Network Paper, Overseas Development Institute.

682
Palanisami, K., and D.S. Thornton (1981)
Research Methodologies for Improved Irrigation Systems Management: Some Reflections Based on Experience in Tamil Nadu, India. Paper presented at Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

Five field research evaluation themes are discussed in the paper in terms of experience with two completed projects in Tamil Nadu, India--The Parambikden Aliyer Project (PAP) and the Lower Bhavani Project (LBP). The five "themes" are (1) evaluation of original system planning and design criteria, (2) expansion of communal area with respect to estimated irrigable service area, (3) definition of a relevant "rotation" system for water distribution, (4) operating

definition of water use efficiency, and (5) determination of an organizational setup for system operation and maintenance. Appendices 1 and 2 provide useful information on the PAP and LBP experimental studies.

683
Philippines (Republic), Local Water Utilities Administration (1977) Urdaneta Water District: Immediate Improvement Program. Boston, Massachussetts: Camp Dresser and McKee International Inc., 40 pp.

Forecasting of water demand for the municipality of Urdaneta, Pangasinan Province, Philippines, with respect to an "early action, immediate improvement program" is discussed in this report. The program involves upgrading of existing water supply facilities and provisions for expansion.

684
Reuss, John O. (1981)
Field Research on Farm Water Management in Pakistan. Paper presented at the International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

The paper discusses the major elements of the Colorado State University Water Research Project approach in Pakistan, where 40 man-years of service by 16 professionals produced 70 technical reports, 19 theses, and 16 journal articles. Section 1 provides a detailed description of the project, specifically funding arrangements with USAID and the identification of field sites in Pakistan. In Section 2, examples of changes in field experimentation are presented, such as the shift from pakka lining of canals to earthen reconstruction, and thus watercourse improvement studies were given high priority in the second phase of the program. Figure 1 provides an excellent summary of the "watercourse losses" study. Some important findings are (1) of total water inflow, 55 percent goes to overall delivery and only 34 percent to crop water use; (2) 25 percent of water losses occur in the official canals or sarkari khal, 19 percent from farmers' distributaries, and 21 percent in field applications; and (3) seepage accounts for 36 percent of inflow loss and 80 percent of total conveyance loss.

685
Sivanappan, R.K., and K. Palanisami (1981)
Appropriate Research Methodologies for Improved Irrigation System Management in Tamil Nadu. Paper presented at the International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

Results of the field research methodology in irrigation system management in the lower Bharani Pigret Main Canal in Tamil Nadu, India, are presented in this paper. An area of 26.36 acres was identified for (pilot) experimental research. At the end of a one-year trial period, increase in water use efficiency in the experimental block (contrasted to the control block) was 51.57 percent. The other experiment, using "push supply" or water flowing at full capacity for every one-week rotation, was evaluated for the Parambikulam Aliyar Project canals. Compared to the continuous supply, "rush supply" was observed as more efficient, with yields increasing by 40 to 60 percent. Proposed action research for tank irrigation over a controlled water delivery period is discussed in the last section.

686

Van, T.K. (1975)

Rice Cultivation in Peninsular Malaysia with Special Reference to the Need for Applied Studies in Agronomy/Irrigation Practices. Paper presented to National Seminar on Water Management at Farm Level, Kedah, Malaysia, 29-36.

Different rice cultivation patterns in Peninsular Malaysia were developed as a consequence of varying water availability. Where adequate water supplies were present, rotational and multiple croppings were practiced. Variations with respect to growth stages of the rice plant were also discussed. For example, when considering weed control, it was found that the optimal water standing depth was 2 to 5 inches and that water levels could be decreased by 30 to 40 percent without yield reduction.

687

Wickham, T., and R.D. Reyes (1973)

Design Management of Irrigation Systems for Improved Water Management. Los Banos, Philippines: International Rice Research Institute, 34 pp.

The first part of the paper presents field experiment results on the responses of lowland rice to water stress. The second part outlines the approaches used for scheduling, measuring, and controlling water releases to minimize water stress occurrence.

VII. ORGANIZATIONAL, LEGAL, AND POLICY ASPECTS OF WATER RESOURCES MANAGEMENT

The institutional environment where water resources management activities and tasks are organized is characterized by a hierarchical governmental and administrative structure. The six levels of government categories used in classifying bibliographic entries are enumerated in Table 7 as follows: international, national, regional, state/provincial, city/municipality, and village. This system of classification for water resources management incorporates such "actors" as international donor agencies, national government officials, regional river basin water authorities, municipal or city officers, and local village leaders.

The water resources management process, composed of the following activities and tasks--planning, design, operation, maintenance, water distribution, and conflict management--is presented in Table 8 and classified by organizational elements. These are the organizational aspects, roles of leaders and members, and significant political (government) and social (kin-based) groupings.

Parts B and C of this chapter contain materials on the sociolegal aspects of water resources management and major water resources government policies and programs.

Local Water User's Associations

The importance of local water user organizations in the operation and maintenance of irrigation systems has been recognized (Bottrall, 689; Bromley, Taylor, and Parker, 690; Hufschmidt and Bower, 701; Levine and Hart, 702) and, more recently, incorporated into standard planning and design procedures for many irrigation projects (Bhaskaran, 710; Early et al., 713; ADB, 744; Bagadion and Korten, 745). Also, the interaction of physical-technical and social organizational variables has been examined in a few case studies of canal irrigated societies.

For example, Mirza (729) has found in a multivillage study in Pakistan that the degree to which distance of the farm to canal headworks becomes a determining factor for water availability is conditioned by three social organizational variables: (1) presence of kinship factions, (2) domination of large, powerful landowners, and (3) effectiveness of water association leadership. Similar conclusions are reached by Duncan (753), and Gillespie (757) for Thailand; Robinson (772) and Cruz (200, 201) for the Philippines; and Beardsley, Hall, and Ward (780) for Japan.

Furthermore, comparative studies of irrigation societies in Asia have shown that social adaptations to the use of irrigation water vary widely in terms of the complexity and form of institutional arrangements and organization (Chambers, 691; Coward,

Table 7. Classification of Bibliographic Entries by Governmental Level and Region

Governmental Level	Region			
	Asian Region as a Whole	South Asia	Southeast Asia	Northeast Asia
International	688, 690, 694, 703, 706, 797, 803, 804, 808, 809, 836, 850, 856, 856, 857	832		786, 787
National	692, 693, 701, 702, 704, 816, 834, 847, 852, 853	713, 717, 719, 724, 732, 738, 741, 742, 798, 799, 805, 818, 822, 831, 840, 844	744, 747, 762, 763, 764, 765, 766, 770, 773, 775, 776, 806, 807, 811, 817, 819, 820, 821, 829, 838, 843, 845, 846, 848, 851	790, 791, 794, 795, 796, 810, 830, 848, 858, 859
Regional	826, 828, 837, 855	709, 716, 718, 722, 736, 737, 800, 825	755, 757, 767, 774, 777, 778, 827, 833	792, 793, 860
State/Provincial	835	710, 733, 735, 801	761, 769, 772, 812, 842, 861	779, 781, 785
City/Municipal	689, 691, 699, 700, 705, 707	708, 712, 714, 715, 720, 725, 730, 743, 824	745, 746, 749, 750, 751, 752, 759, 760, 823, 841	782, 784, 790
Village/District	695, 696, 697, 698, 815	711, 721, 723, 726, 727, 728, 729, 731, 734, 739, 740, 814, 839	748, 753, 754, 756, 758, 768, 771	780, 783, 788, 802

Table 8. Classification of Bibliographic Entries by Organizational Components and Water Resources Management Activities and Tasks*

Organizational Components	Activities and Tasks					
	Planning	Design	Operation	Maintenance	Irrigation Water Distribution	Conflict Management
Organizational aspects	690, 702, 705, 733, 734, 749, 751, 752, 763, 784	713	692, 710, 725, 726, 730, 733, 734, 753, 782, 787, 789, 792, 793	692, 710, 725, 726, 730, 733, 734, 749, 753, 782, 792, 793	690, 704, 705, 710, 713, 721, 723, 725, 733, 734, 782, 789, 790	723, 729, 734, 737, 782, 789
Roles of leaders and members	693, 699, 745, 746, 754, 776	698, 699, 745, 746, 754, 762, 776	692, 694, 697, 715, 730, 745, 746, 788, 792, 793	692, 694, 697, 715, 730, 745, 746, 788, 792, 793	690, 697, 715, 721, 723, 734, 737, 745, 746, 748, 759	729, 734, 737, 748
Significant political groups	689, 703, 711, 716, 731, 737, 742, 763, 779, 781, 786, 791	717, 731, 762, 772	709, 711, 716, 718, 737, 781, 794	716, 781, 794	700, 716, 759, 762, 795	
Significant social groups	699, 714, 729, 736, 750, 752, 772, 776, 780, 785	712, 771, 772, 776	702, 725, 730, 756, 758, 768, 769, 771, 774	725, 730, 756, 767, 768, 769, 774, 789	714, 720, 721, 725, 733, 743, 756, 759, 760, 767, 769, 774, 780	729, 743, 780

*The classification scheme is based on Coward (695), Bower and Hufschmidt (64), and Hufschmidt and Bower (701).

695, 696). Some studies (Howes, 700; Levine and Hart, 702; Thavaraj, 705) also have noted that variations in organizational arrangements depend upon the particular technology employed for water control. However, there are also marked similarities among systems of water sharing and distribution that might prove useful in evaluating the interaction of the water resources management technology adopted and the organization of water control on a larger social setting.

Chambers (691) offers, for example, an initial typology of irrigation organizations based on the manner and technology of water distribution used by a particular society. The major types are (1) direct appropriation from a natural water source, (2) acquisition through contract or agreement with a supplier of water, (3) community allocation among village members, (4) bureaucratic organization, and (5) bureaucratic-communal allocation.

Participatory approaches to development of small-scale irrigation systems have been examined, and the papers of Bagadion, Korten, and Korten (746), Bagadion and Korten (745), Illo, De Los Reyes, and Felix (759), Isles (762), and Korten (763) describe the experience of the Philippine government in implementing client-based planning and design techniques. Nickum's works (789, 790, 791) on China cite examples of the type of decentralized management of water resources starting at the commune level.

Abel (779) and Bottrall (781) describe the sequence of activities leading to the establishment of Irrigation Associations in Taiwan and propose that more detailed studies are needed to benefit fully from the Taiwanese experience. Some provincial-level case studies in Taiwan, using both historical and comparative approaches, are found in Chen (782), Cheng et al. (783), Chin (784), Hsieh (785), Lee and Yang (787, 788), Wu (795), and Young and Huang (796). Irrigation management in multipurpose, reservoir projects follows what Chambers (691) calls "bureaucratic allocation"--a state or national government agency handles operation, maintenance, and water distribution functions.

Bottrall (688, 689) suggests the use of an organizational evaluation methodology and defines guidelines for monitoring of ongoing projects. Levine and Hart (702) discuss some of these guidelines with respect to types of resources used, amount of resources needed, approaches for mobilizing local labor, operation of large-scale projects, and formation of local-level water users associations.

A useful water allocation procedure implemented in most of India's states is the warabandi system below the chak or outlet level. Malhotra (314) provides an extensive review of warabandi in historical perspective and in comparison to other distribution systems. Jayaraman (721), Pant (733), Reidinger (737), and Sundar and Rao (740) also present detailed case studies of warabandi as it is practiced within large-scale, state-run irrigation systems.

The other distribution system that required some form of cooperative organization is the karahankota water rotation. Chambers (691), Karuanayake (725), and Leach (159) describe the operation of the karahankota in Sri Lanka. A similar rotation system using a peculiar arrangement of fields to ensure direct access to water is documented in the Philippine zangjera irrigation societies by Lewis (218) and Cruz (200, 201). These patterns of water allocation can be used, as in the case of the warabandi, in large-scale water projects by maintaining local groupings and ties (see, for example, the operation of hand pumps in India in Subramanian et al., 739).

The administration of rural water supply projects also involves significant management problems. The studies of Clark (693), Watt (707), and the government of Karnataka Planning Division (716) contain case studies of the system of drinking water control.

Legal Aspects

Management of water resources for multiple purposes relies in part on the legal doctrines governing water utilization. Hayton (803) and LeMarquand (804) discuss water rights for international rivers. For individual country rules, the following provide a description of the existing legal system--Maheswaran and Gunawardane (805) for Sri Lanka, the Philippines National Water Resources Council (807), Samad (809) for Pakistan, and Takagi et al. (810) for Japan. The works of Radosevich (808) and Trelease (811) present a regional comparison of water rights and laws.

A. INSTITUTIONAL AND ORGANIZATIONAL FACTORS

A.1. GENERAL

688
Bottrall, Anthony F. (1979)
Evaluating Organization and Management: A Proposed Methodology for Use on Large Irrigation Projects. In Institutions, Management and Agricultural Development. Occasional Paper 3:44-61. London, U.K.: Agricultural Administration Unit, Overseas Development Institute.

The paper outlines a proposed methodology for evaluating the organization and management of large-scale irrigation schemes. The conclusions are based mainly on observations made in South and Southeast Asia, most of them long established and conspicuously lacking well-planned procedures and monitoring systems. Emphasis is accordingly laid on the importance of external evaluation that will go beyond the measurement of performance and probe deeply into the causes of observed shortcomings. On many irrigation schemes these are likely to include fundamental flaws in organizational structure as well as unclear objectives, badly-devised procedures, inadequate training facilities, and poor motivation. Evaluation is here seen as the first step toward the introduction of new structure and management methods on existing schemes and as a guide to pitfalls to be avoided in the planning of new schemes.

689
Bottrall, Anthony F. (1981)
Comparative Study of the Management and Organization of Irrigation Projects. World Bank Staff Working Paper No. 458. Washington, D.C.: World Bank.

The paper presents an analytical framework for monitoring and evaluating administration of irrigation projects in developing countries. A review of four field studies in South and East Asia is included, which focuses on the organizational procedures affecting tail-end farmers. The appendix summarizing "Guidelines for Analysis Using a Checklist Format" is particularly useful for monitoring and evaluating irrigation projects.

690
Bromley, Daniel W., Donald C. Taylor, and Donald E. Parker (1980)
Water reform and economic development: Institutional aspects of water management in the developing countries. Economic Development and Cultural Change 28(2):365-87.

This article focuses on gravity canal irrigation systems, particularly the reliability, predictability, and security of water delivery at the farm level. Water management and equity issues are discussed with respect to a re-examination of canal position as the primary indicator of differential access to water. Part III discusses some alternative approaches toward equalizing benefits from water use. The application of Rawl's principles of justice as applied to a small-scale irrigation system in the Philippines is presented as an alternative approach to dealing with water misallocation.

691
Chambers, Robert (1980)
Basic Concepts in the Organization of Irrigation. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 28-50. Ithaca, New York: Cornell University Press.

The paper focuses on the relationship of the human (institutional) aspects of irrigation management and the technical components of project design. A typology of irrigation systems, in terms of the system of water allocation, is presented by using examples from Sri Lanka and India. A comparison of a bureaucratic and locally-managed system in Sri Lanka is also included.

692
Chin, L.T. (1972)
Management, Operation and Maintenance of a Completed Project. Irrigation and Drainage Paper No. 12, 230-42. Rome: Food and Agriculture Organization.

693
Clark, R. (1978)
Institutional alternative for managing groundwater resources: notes for a proposal. Natural Resources Journal 18:158-60.

694
Coward, E.W., Jr. (1972)
Irrigation and organization research in progress. Philippine Sociological Review 20(1/2):171-76.

695
Coward, E. Walter, Jr. (1980a)
Irrigation Development: Institutional and Organizational Issues. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 15-27. Ithaca, New York: Cornell University Press.

With the increased awareness of the critical role of institutions and organizations in irrigation development, more studies are now being made to explain irrigators' behavior and corresponding organizational responses. Concepts regarding the key organizational rules, important roles of actors in the irrigation system, and the usefulness of social groups are examined with respect to specific irrigation system activities of water allocation, system maintenance, and conflict management. An ecological approach allows the interaction of behavioral rules and patterns and the irrigation system environment. Three types of such interaction are found in community systems, bureaucratically managed (full government control) systems, and in the jointly-managed systems.

696
Coward, E. Walter Jr., ed. (1980b)
Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences. Ithaca, New York: Cornell University Press.

A collection of relevant studies on the organization of irrigation systems in Asia is presented. The studies are classified into those (1) dealing with introductory concepts on irrigation institutions, (2) describing community or indigenous systems, and (3) evaluating bureaucratic and large-scale projects.

697
Cruz, Helen A. (1981)
The Ditchtender (or watermaster, perhaps?): A Study of the Bases of Lower-Level Management Behavior. Paper presented to the Agricultural Development Council Workshop on Investment Decisions to Further Develop and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

698
Early, Alan C., and Benjamin U. Bagadion (1981)
Custom Fit Design of Farm Ditches: A Participatory Approach to Making Irrigation Systems Responsive to the Needs of the Farmers. Training Module prepared for NIA Communal Irrigation Committee Workshops. Los Banos, Philippines: IRRI.

699
Gebalier, Dietrich M.E. (1980)
The Importance of Farmers' Participation for the More Effective Organization of Irrigation Systems. England: Agricultural Extension and Rural Development Centre, Reading University.

700
Howes, Mick (1981)
Alternative Approaches to Small Scale Irrigation: The Implications for Production Distribution and Social Organization. Brighton, England: Institute of Development Studies, University of Sussex.

701
Hufschmidt, Maynard M., and Blair T. Bower (1982)
The Reconnaissance Study on Asian Water Resources Management: Objectives, Scope, and Content. Paper presented to Workshop on Asian Water Resources Management. Honolulu: Environment and Policy Institute, East-West Center, 19 pp.

A reconnaissance study of Asian water resources management was initiated by the Environment and Policy Institute of the East-West Center (EAPI-EWC) in May 1982 in collaboration with the Resources for the Future (RFF) and the University of Hawaii (UH). A small core staff of one research fellow, one research associate, and two research interns comprised the study team. An agricultural economist from Kasetsart University in Thailand joined the study team for one month. The geographic scope of the reconnaissance included (1) South Asia--Pakistan, India, Nepal, Sri Lanka, and Bangladesh; (2) Southeast Asia--Thailand, Malaysia, Indonesia, and the Philippines; and (3) North Asia--China, Japan, and Korea. The physical scope covered all freshwater surface and ground resources such as streams, natural and artificial lakes, and diffused surface waters. An analytical framework was formulated, defining the process, linked activities and tasks, and system outputs for water resources management projects in Asia.

702
Levine, Gilbert, and Henry C. Hart (1981)
Mobilizing Local Resources for Irrigation, Interpretive Summary of a Seminar by the Agricultural Development Council. Research and Training Network Program, Colombo, Sri Lanka.

The seminar had three objectives: (1) to provide an opportunity for comparative evaluation of South and Southeast Asian experience in the management of irrigation systems, (2) to identify common problems and their solutions, and (3) to suggest areas for research relevant to government programs. Theme papers and reactions from participants are summarized in this report. The major propositions are divided into the (1) types of resources used in irrigation, mainly labor vs. capital resources, (2) amount of resources needed, (3) approaches used for mobilizing resources, especially communal labor, (4) administration and operation of large-scale irrigation systems, and (5) strategies used in the formation of water user organizations.

703
Macpherson, George (1981)
Irrigation scheme turns tide for rural poor (on new irrigation in Maharashtra). International Agricultural Development (April):22-23.

704
Sigurdson, J. (1977)
Water policies in India and China. Ambio 6(1):70-76.

Two water management administrative structures are contrasted--China uses a centralized planning approach while India maintains a decentralized type of management, giving responsibility for water planning and implementation to constituent states. China relies heavily on small projects, emphasizing supplementary facilities and encouraging the use of people's communes and work teams. India, on the other hand, uses large-scale projects, and local involvement is centered on the use of tubewells. Comparative resource data with respect to water resources, land area, climate, agricultural production, and population are presented in the first section.

705
Thavaraj, S.H. (1978)
Management of Irrigation Projects--the Link Between Engineering Concepts and Institution building. Proc. ICID 2nd Reg. Agro-Asian Conf. Tech. Paper No. 7, 89-99. Manila, Philippines.

706
United Nations Secretariat (1980)
Administrative arrangements for water resources planning. Natural Resources Forum 4(4):415-24.

707
Watt, S. (1978)
Nor any drop to drink. Mazingira 6:46-52.

The article examines the effects of large-scale water supply projects for rural communities in Thailand and Vietnam. The results show that while the domestic water supply programs are technically sound, institutional mechanisms involving local participation are weak leading to abandoned (and eventually dry) wells and unsanitary use of community water supply. The author attributes such problems to the gap between water delivery techniques and approaches for village organization.

A.2. SOUTH ASIA

708
Andreou, P. (1979)
Economic appraisal of irrigation cooperatives in agricultural development in Ganges-Kobadak Project, Bangladesh. Agicultural Administration 6(2):111-22.

This article discusses the organization of small-scale farmer's cooperatives in Bangladesh. The organizational structure and administration of these cooperatives are presented.

709
Bhargana, B.S. (1980)
Minor Irrigation Development Administration. New Delhi, India: Ashish Publishing House.

710
Bhaskaran, P. (1980)
Emergence of Farmers' Organizations: A Survey (in Kerala). Workshop Paper. Bangalore, India: Indian Institute of Management.

711
Chadha, O.P. (1981)
Irrigation System Management and Research Priorities. Paper presented to International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

Research priorities for irrigation system management, specifically the distribution of water from the main canal to the farm, are discussed in this paper. Three types of irrigation linkages are identified--water, crop, and product linkages. The first linkage, water, concerns the various physical and institutional arrangements for water delivery between the government-controlled canal headworks and the farm outlets. The crop linkage relates farm-level production activities to government support programs (credit, extension). Product linkages deal with storage, delivery, marketing, and pricing of crops produced. Approaches to analyzing these linkages and their interaction involve (1) diagnostic studies to evaluate the nature of the problem identified within each linkage and (2) organizational (management) studies, focusing on the administration of government programs. A few examples of agricultural development programs in India are presented in the last section.

712
Coward, E.W., Jr., and B. Ahmed (1979)
Village technology and bureaucracy: Patterns of migration organization in Comilla District, Bangladesh. Journal of Developing Areas 13(4):431-40.

Bureaucratic arrangements that have developed in Bangladesh as part of the Thana Irrigation Program (TIP) are discussed. The TIP links village cooperative societies with the government agency, the Bangladesh Agricultural Development Corporation, in order to achieve the distribution, operation, and maintenance of irrigation pumps used for the production of winter and dry season crops. A case study of the Nabagram village in the Comilla district is presented.

713
Early, Alan C., et al. (1976)
Institutional Framework for Improved On-Farm Water Management in Pakistan. Fort Collins: Colorado State University.

714
Elumalai, G. (1980)
Farmers' Organizations for Efficient Water Use in Irrigated Agriculture: A Case Study in Tamil Nadu. Workshop Paper. Madras, India: Madras Institute of Management.

715
Foss, Philip, et al. (1970)
Organization of Water Management for Agricultural Production in West Pakistan. Fort Collins: Colorado State University.

716
Government of Karnataka Planning Division (1976)
Project Report on Small Farmers Development Agency, Bangalore, India.

The report contains a good description of India's small-scale rural development program, using local participation in the building of village-level water projects. Part III provides an example of a village water supply project.

717
Hamid, M.A., et al. (1978)
Irrigation Technologies in Bangladesh. A Study in Some Selected Areas. Rajshahi, Bangladesh: Department of Economics, Rajshahi University.

The book examines existing institutional arrangements in the rural economy and discusses their adequacy for the full-scale

utilization of modern technologies. Part I discusses irrigation techniques and institutional arrangements for delivery. Part II looks at some projects such as low lift pumps and deep tubewells managed by cooperatives, large-scale projects managed by an external agency, and traditional means of irrigation. Part III consists of statistical tables.

718
India, Central Board of Irrigation and Power (1974)
Proceedings of the Symposium on Management Problems in Irrigation and Power Systems. Publication No. 122, Vols. 1 to 3. New Delhi: Central Board of Irrigation and Power.

A symposium was held to discuss various issues involved in the proper management of irrigation and power projects and the role of State Electricity Boards. The accompanying volumes to the main text contain the technical papers on the economic, personnel management, and feasibility reports for the development of irrigation and power projects in India.

719
Islam, T.R. (1979)
Low lift pump irrigation and agricultural development in Bangladesh. Farm Economics 1(1):103-18.

The study estimates the efficiency of low lift pump irrigation and analyzes relevant socioeconomic and institutional factors. These include the farmer's return from irrigation, credit, roles of group managers and members, and repair and maintenance. Policy implications indicate changes in administration, for example, on the efficiency of irrigation rather than on the number of pumps made available.

720
Jayaraman, T.K. (1980a)
Farmers' Organizations in Surface Irrigation Projects: Two Empirical Studies from Gujarat State, India. Workshop Paper. Bangalore, India: Indian Institute of Management.

721
Jayaraman, T.K. (1980b)
Implementation of warabandi: A management approach. Administrative Change 7(2).

722
Jayaraman, T.K. (1982)
Evaluation of implementation phase of rural development projects: A case study from Gujarat, India. Agricultural Administration 10(2):85-100.

For their successful implementation, rural development projects need sufficient care with regard to the various organizational options at a fairly early stage in the project cycle. In particular, when there is no previous experience in handling a project such as a watershed management project requiring a multidisciplinary team for its implementation, a great deal of planning is called for in assembling the team. It is also necessary to spell out the various tasks assigned to each member of the team and to fill key positions with adequately skilled persons. Furthermore, at the higher executive levels, what is critically needed is a reactive capacity to meet unexpected problems and take unplanned action. In addition, the principle of management-by-exception is much more valid in the implementation of rural projects, since critical linkages with external agencies are not always easily made and support from internal staff belonging to various disciplines is not often readily forthcoming. In these circumstances, the chief manager has to look to those areas that are deviating from the normal--or desired--course and take timely and corrective managerial action.

723
Jones, Garth N. (1972)
The problems of water scheduling in west Pakistan: Research studies and needs. Journal of Rural Development and Administration 9(4):1-22.

The article presents some institutional alternatives to management of irrigation in the dry zones of Pakistan. For example, development of research and extension projects for more efficient use of surface and groundwater sources is recommended, particularly in limiting conveyance losses of water flow from the head to the tail.

724
Jones, Garth N., et al. (1974)
Information Sources on Water Management for Agricultural Production in Pakistan with Special Reference to Institutional and Human Factors. Fort Collins: Colorado State University.

The report contains an exhaustive list of valuable reference materials on water management in Pakistan--administrative and organizational structures for planning and implementing irrigation projects, summary tables on water resources problems and potentials, and a bibliography of relevant water management studies (as of 1975).

725
Karuanayake, M.M. (1980)
Farmer organizations and irrigation leadership in Sri Lanka: Retrospect and prospect. Marga 6(1):1-17.

The article examines the experience of farmer organizations in Sri Lanka in farm management and raises issues that have practical implications for policy information. Special reference is made to the role of cultivation committees and of irrigation agents. The Mahaweli model of farmer groups is also examined. Special attention is paid to the role of local irrigation management. It is suggested that priority be given to setting up higher level authority to deal with problems of water allocation in major irrigation systems and in the Mahaweli scheme.

726

Kathpalia, G.N. (1981)

Improved Irrigation Systems Management. Paper presented at the International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

Three types of irrigation system management for water delivery from the main headworks to the farm are contrasted for a selected group of irrigation systems in India. The first type emphasizes the control of water at the head of the minor canal such as those in the Punjab, Harjana, Uttar Pradesh, and parts of Madhya Pradesh. In this system, water drainage is computed from field to field and dependent on type of crop grown. The second type of management is where government controls water distribution up to the outlet (chak) and thus water charges are computed in terms of volume of water received and size of irrigated area. The third type, where the government regulates water flow up to the distributing head of the main or branch canal, assesses water charges on the basis of area irrigated and type of crop grown. A brief review of these approaches is presented and some organizational solutions are discussed.

727

Kemper, W.D., M. Haq, and A. Saeed (1979)

Farm Water Management in Upland Areas of Baluchistan. Water Management Technical Report No. 51. Fort Collins: Colorado State University.

Compared to the Punjabi Canal, water losses are less in Baluchistan due to topographic and physical differences (soil type) and to the policy of charging higher water fees leading to more efficient water use. In spite of these, farmers in Baluchistan have been observed to overirrigate due to lack of farm gate control. For farmers with tubewells, overapplication of water is also high because of inadequate management (extension) and to the fixed monthly charge on electricity rather than on a volumetric method. The authors suggest radical changes in the program and the encouragement of local participation in decision making.

728
Merrey, Douglas J. (1978)
Reorganizing Local Level Water Management in Pakistan. Symposium on Desertification and Anthropology. Jodhpur, India: Central Arid Zone Research Institute.

729
Mirza, A.H. (1975)
A Study of Village Organizational Factors Affecting Water Management Decision-Making in Pakistan. Water Management Technical Report No. 34. Fort Collins: Colorado State University.

730
Mirza, A.H., and D.J. Merrey (1979)
Organizational Problems and Their Consequences on Improved Watercourses in Pakistan. Water Management Technical Report No. 55. Fort Collins: Colorado State University.

A survey of ten "improved" watercourses in the Pakistan Punjab project of Colorado State University and USAID was conducted using quality of maintenance of watercourses as the major indicator of social organization and management. The survey results show that (1) better water management practices occurred in the 6.5 to 25 acre landsize range, (2) educational level played an important role in watercourse maintenance (measured by formal schooling and percentage listening to radio regularly), and (3) social groupings (such as the single-biradari kinship group) were important in organizing farmers to perform maintenance tasks. A detailed proposal for organizing a Water User's Association is presented in the last section.

731
Murthy, Y.K. (1980)
The Irrigation Engineer and the Farmer. 5th Bhaikaka Memorial Lecture. Calcutta, India: Institution of Engineers.

732
Pakistan Planning Commission (1965)
Design for Pakistan. New York: Ford Foundation and Harvard University Project.

Part III of the report by the Pakistan Planning Commission, in coordination with Harvard University consultants, details the bureaucratic setup and organizational links between the Water and Power Development Authority (WAPDA) and the provincial governments. The major provinces, Lahore and Dacca, were identified as the initial areas for pilot projects in irrigation. The report provides an historical background of

the development of WAPDA and reviews the various administrative structures involved in water resources management activities in Pakistan.

733
Pant, Niranjan (1981)
Some Aspects of Irrigation Administration: A Case Study of Kosi Project. Naya Prakash, Calcutta, India.

734
Radosevich, George E. (1975)
Water User Organizations for Improving Irrigated Agriculture: Application to Pakistan. Water Management Technical Report No. 44. Fort Collins: Colorado State University.

Farm-level water user organizations are analyzed with respect to existing legal structures in Pakistan. The first part contains a good review of water user organizations in Asia and the second part focuses on Pakistan. The water user organizational chart, detailing links with hydraulic structures (e.g., water masters for laterals), provides an excellent review of organizational links among various sectors of an irrigation district.

735
Radosevich, George E., and Craig Kirkwood (1975)
Organizational Alternatives to Improve On-Farm Water Management in Pakistan. Fort Collins: Colorado State University.

736
Reidinger, Richard B. (1971)
Canal Irrigation and Institutions in North India: Micro-Study and Evaluation. Unpublished Ph.D. dissertation, Duke University.

737
Reidinger, Richard B. (1974)
Institutional rationing of canal water in northern India: Conflict between traditional patterns and modern needs. Economic Development and Cultural Change 23:71-74.

Large-scale irrigation systems in India comprise roughly 37 percent of total irrigated areas. Canal irrigation potential from such systems is much larger than for the tubewell-augmented areas. Reidinger examines one such system in the Hissar District in the state of Haryana by examining the rationing system used in the Bhakra canals. Three forms of water distribution are evaluated: (1) allocation of water

from the reservoir, (2) water rotation among canals, and (3) water rotation among farmers (called the warabandi) along a single watercourse.

738
Srivastava, K.B. (1981)
Administration of major-medium irrigation projects in Indian federation. Agricultural Administration 8(5):343-56.

The administrative structure for operation of major and medium irrigation projects in India (those costing more than Rs 5 million and greater than 100,000 hectares, and those costing between Rs 2.5 million to Rs 5 million and ranging from 2,000 to 10,000 hectares respectively) is discussed with respect to a set of policy and procedural changes that can be undertaken toward improvement of inter-state water resources programs. While the primary responsibility for water development lies with the state (as stipulated in the Indian constitution), the Central government has been playing a dominant role in planning, coordinating, monitoring, and financing inter-state major and medium irrigation projects. Three proposals are presented: (1) to set up a national water resources commission that would integrate all major water projects, (2) to coordinate inter-state utilization of shared water resources, and (3) to promote development of state capacity to administer large-scale irrigation projects. Central and state organizational links are not evaluated and community-level water management structures are not discussed.

739
Subramanian, R., et al. (1979)
Local caretakers for handpumps in Tamil Nadu, India. Assignment Children 45/46:145-50.

The use of handpumps in Tamil Nadu, India, is especially interesting from the viewpoint of local level organization. The article examines the three-level system of handpump operation--an assistant engineer mechanic for every 1,000 pumps at the highest technical level, and a caretaker at the village level. The latter position is voluntary, having to do mainly with minor repairs, education on the proper use of handpumps, and to point out cases where the block fitter is needed. This is an excellent study of local (village) and agency level cooperation in water maintenance.

740
Sundar, A., and P.S. Rao, eds. (1980)
Farmers' Organizations for Efficient Water Use in Irrigated Agriculture. Bangalore, India: Indian Institute of Management.

741
Veeman, Terence S. (1978)
Water policy and water institutions in northern India: The case of groundwater rights. Natural Resources Journal 8(3):569-88.

The need for predictable and reliable water supplies to maximize the effectivity of using the new high yielding varieties (HYVs) has resulted in groundwater problems for northern India. Water supply problems are viewed in this paper as intrinsically related to existing groundwater rights and the lack of institutions for regulating such rights. The "correlative rights doctrine" is used in analyzing the economic value of having groundwater rights and groundwater regulations.

742
Wade, Robert (1975)
Water to the fields: Institutional innovation in India's CAD programme. South Asian Review 8:301-21.

The article examines the impact of the Command Area Development (CAD) Programme in terms of improving the efficiency of water use, increasing crop yields, and maintaining land fertility levels on a large scale. The use of such methods as land consolidation and realigning field boundaries and reallocation of lands to farmers is evaluated with respect to their effects on decreasing conflicts in water use and increasing collection of water fees. Wade examines further the effects of the CAD on the institutional design for water sharing at the farm level and suggests that socioeconomic research is needed in evaluating the long-term impact of such projects.

743
Wade, Robert (1979)
The social response to irrigation: An Indian case study. The Journal of Development Studies 16(1):3-26.

Since canal irrigation implies a certain form of collective management, the organization of water users for the purpose of water distribution becomes important. This paper examines the relationship between the degree of corporate organization and scarcity of water supply for several villages in a south India district.

A.3. SOUTHEAST ASIA

744
Asian Development Bank. (1980)
Irrigation Development and Management: Proceedings of the ADB Regional Seminar on Irrigation and Management. Manila, Philippines: Asian Development Bank.

Part I records the proceedings of the ADB Regional Seminar on Irrigation Development and Management to identify measures to improve and expedite the preparation and implementation of bank-assisted projects and contains several valuable recommendations that may substantially improve the preparation and implementation of such projects. Conclusions of the three major technical issues of the seminar are summarized: Chapter 2 discusses the institutional and organizational aspects of irrigation development and management; Chapter 3, cost benefits and socioeconomic benefits of irrigation projects and Chapter 4, project implementation and loan administration. The field visit to Central Luzon and Laguna is described in Chapter 5, followed by policy discussions in Chapter 6; Chapter 7 summarizes the conclusion. Part II reviews the bank's experience in irrigation development in Afghanistan, Bangladesh, Burma, China, India, Indonesia, Korea, Laos, Malaysia, Pakistan, and Philippines during the 1970s in the context of the three major technical issues. Part III contains edited versions of technical and policy papers presented by the participants during the seminar.

745
Bagadion, B., and F.F. Korten (1980)
Developing viable irrigators' associations: Lessons from small-scale irrigation development in the Philippines. Agricultural Administration 7(4):273-87.

The National Irrigation Administration (NIA) of the Philippines introduced a participatory planning approach to developing viable irrigator's associations in the small-scale irrigation systems. These systems, scattered over some 500,000 hectares throughout the country, provide promising results from such an approach due to their small size and their long history of cooperative organization in water use and allocation. A review of NIA's experience in this area and proposals for developing new methodologies are also discussed. Both authors provide insights on the new approach largely from experience with local irrigators' groups.

746
Bagadion, B., F.P. Korten, and D. Korten (1980)
Promoting Participatory Management on Small Irrigation Schemes: An Experiment from the Philippines. AAU Irrigation Management Network Paper, Overseas Development Institute, England.

747
Cablayan, O.M., and R.S. Gamboa (1978)
Water Management Training and Practices in Special Projects of the NIA. Proc. ICID 2nd Reg. Agro-Asian Conference, Manila, Philippines.

748
Coward, E.W., Jr. (1972)
A Farmer Solution to Water Control in Philippine Irrigation Systems: The Role of the Water Guard. Silang, Philippines: International Institute of Rural Reconstruction, 21 pp.

749
Coward, E.W., Jr. (1975)
Institutional and Social Organizational Factors Affecting Irrigation: Their Application to a Specific Case. Silang, Philippines: International Institute of Rural Reconstruction.

Organizational concepts affected by social behavior are studied and evaluated using three gravity irrigation systems in Southern Luzon, Philippines, as examples. Topics discussed include the nature of interaction between farmers and the administrators of these systems, the role of ditchtenders, and the importance of institutional factors in irrigation behavior.

750
Cruz, D.A., and B.R. Realuyo (1973)
The Katipunan Farmers' Association, Inc.: A Case Study of An Irrigator's Cooperative Undertaking. Los Banos: University of the Philippines.

751
De Los Reyes, Romana P. (1980a)
Forty Seven Communal Gravity Systems: Organization Profiles. Quezon City: Institute of Philippine Culture, Ateneo de Manila University.

752
De Los Reyes, R.P. (1980b)
Managing Communal Gravity Systems: Farmer's Approaches and Implications for Program Planning. Quezon City: Institute for Philippine Culture, 125 pp.

The report contains the results of a National Irrigation Administration (NIA)-funded survey of 51 communal, small-scale gravity systems in the Philippines. The survey was done in nine provinces with a total sample size of 627 farmers. Three major aspects of the administration of such systems are covered: (1) geographic or area coverage, (2) irrigation structure, and (3) local practices regarding water distribution, system maintenance, and conflict management. An important finding regarding the relationship of area coverage and organization is that as the size of the irrigation system increases, the degree of complexity of organization correspondingly increases.

753
Duncan, S. (1977)
Local Irrigator's Groups: Assessment of Their Operations and Maintenance Functions. In Irrigation Policy and Management of Irrigation Systems in Southeast Asia, eds. D.C. Taylor and T.H. Wickham, 185-91. Bangkok, Thailand: Agricultural Development Council.

The paper presents the findings of a research project undertaken to analyze factors affecting farmers' willingness and ability to operate and maintain on-farm irrigation systems and explores organizational aspects of local irrigators' groups. It is based on a study of the Channasut Land Consolidation Project in Thailand, but the findings may be valid for other areas. Findings indicate only a modest response of farmers participating in the new irrigators' groups and in following recommended irrigation schedules and practices. While this may in part reflect unfavorable social attitudes, other factors are also involved. The principal factor is undependable water delivery in main irrigation systems, and without added attention to operation and maintenance, expecting greater participation by farmers would be unrealistic. In the short run, the government will need to assume greater responsibility in providing reliable supplies of water to local irrigators' groups. If this is achieved, there should emerge a growing capacity for effective farmer participation in operation and maintenance.

754
Duncan, H.S. (1980)
The Social Organization of Irrigation: A Study of the Channasut Land Consolidation Project in Thailand. Unpublished Ph.D. dissertation, UCLA.

At the Channasut Land Consolidation Project in Central Thailand, officials supposed that farmers would operate and maintain the farm-level irrigation facilities as well as contribute financially to the support of supervisory personnel. Other assumptions were made about the new technology connected with the Green Revolution. However, a lack of information, a concern with formal economic categories, and a wide-scale macroperspective all contributed to a failure to comprehend farmers' decisions and attitudes. This study examines the social, organizational, technical, and environmental factors influencing farmers and emphasizes the disparities in perspective and values between farmers and officials.

755
Faisal, K. (1974)
Farmers' Organizations as a Vehicle for Rural Development: A Case Study in Muda Irrigation Scheme, West Malaysia, 1972-1973. Unpublished M.S. thesis, University of the Philippines at Los Banos.

756
Geertz, Clifford (1980)
Organization of the Balinese Subak. In Irrigation and Agricultural Development in Asia, ed. E. Walter Coward, Jr., 70-90. Ithaca, New York: Cornell University Press.

Geertz describes the Tihingan village irrigation system (subak) in Bali, Indonesia. The first part discusses the geographic and cultural setting. Settlement networks, in terms of residential and agricultural units, provide a framework for evaluating the type of water distribution system used. Lastly, the enforcement of rules and sanctions is linked to the "temple system" where norms and rules of conduct are defined.

757
Gillespie, V.A. (1974)
Farmer Irrigation Associations and Farmer Cooperation. Los Banos, Philippines: International Rice Research Institute, 76 pp.

The Royal Irrigation Department (RID) of Thailand organizes two types of irrigation associations: the water user association (WUA) and the people's irrigation association (PIA). This paper contains the results of a case study of a WUA in Lam Pra Plerng, Thailand. The study analyzes the (1) elements within the project's physical environment and the history of the WUA, (2) methods used by the WUA in attracting

members, and (3) manner in which the WUA leadership carries out its functions subject to the rules and regulations of the WUA.

758
Hutapea, R., Prajarta Dirjasanyata, and N.G.S. Nordholt (1978)
The Organization of Farm-Level Irrigation in Indonesia. Irrigation Policy and Management in Southeast Asia, 164-74. Los Banos, Philippines: International Rice Research Institute.

Four types of farm-level irrigation water management in Indonesia are evaluated in this paper. These are the (1) subak in Badung and Negara regencies, (2) ulu-ulu or village ditchtenders in Grabongan and Demak regencies, (3) pembagian in Brebes regency, and (4) dharma tirta in Brebes and Sragen regencies. Case study results in these four types of village organization show that the boundaries of an irrigator group's area of responsibility should reflect the irrigation system's command area and village jurisdiction over water distribution. With respect to leadership roles, the quality of local leadership, nature of local values, and extent of economic and social disparity are significant in water distribution. When water is shared communally, local village organizations become more stable than when government plays a dominant role in water distribution.

759
Illo, J.F.I., R. De Los Reyes, and N.S. Felix (1981)
Developing a Communal System through the Participatory Approach: Lessons from a Camarines Sur System. Quezon City: Institute of Philippine Culture.

760
Inos, F.I. (1981)
A Survey of Farmers' Participation in Development, Operation, and Management of Selected Irrigation Systems in the Philippines. Unpublished Ph.D. dissertation, Rutgers University.

761
Institut Pertanian Bogor (1973)
Organization of Rural Irrigation in Bali. Bogor, Indonesia: Bogor Agricultural University.

762
Isles, Carlos D. (1980)
Irrigation organization and social participation: The NIA experience. Philippine Sociological Review 29(1-4):145-52.

Many political and social problems confront local irrigation organizations in the Philippines. Four problems are discussed based on the experience of the National Irrigation Administration (NIA) in community organization. These are (1) the presence of what the author claims are "fly-by-night" organizers who are detached from the local community, (2) the practice of building irrigation infrastructure before development of the local organizations, (3) the top-down planning approach used by government technicians ignoring indigenous technical knowledge, and (4) the elimination of traditional organizations existing in most communities in favor of new associations.

763
Korten, Frances F. (1982)
Building National Capacity to Develop Water Users' Associations: Experience from the Philippines. Staff Working Paper No. 528. Washington, D.C.: World Bank.

The Philippines National Irrigation Administration (NIA) introduced a participatory approach to the planning and implementation of small-scale irrigation systems, affecting some 5,500 locally-managed gravity systems with an average command area of 100 hectares. This paper discusses the context and rationale for the use of such an approach. In the second part, major features of the participatory scheme are described in terms of the program's general applicability to other contexts. These approaches include the collection of relevant sociotechnical background data, farmer involvement in all phases of project operation and design, and the introduction of financial and other technical training programs. The last part enumerates some policy and program implications for donor agencies and governments in the developing countries.

764
Leutorio, M. (1977)
Country Reports: Philippines. In Farm Water Management for Rice Cultivation. Tokyo, Japan: Asian Productivity Organization.

The report contains a description and brief evaluation of the Philippine government's Ten Year Irrigation Development Program (1977-1986). The major components of the program are (1) new construction of small-scale (communal) and pump systems, (2) upgrading of existing systems, and (3) feasibility studies for opening up new sites. The second part reviews the organization of irrigator's associations and the prospects for developing viable groups that can take over the maintenance and operation functions of irrigation headworks.

765
Llorente, R.R. (1980)
Angat-Magat: Pioneering integrated agricultural development in the Philippines. ADB Quarterly Review 1:5-7.

The Asian Development Bank funded the Angat-Magat Agricultural Development Project of the National Irrigation Administration (NIA) of the Philippines. This paper describes the water management study of the project and evaluates the bank's experience with organizing farmers into production units and irrigator's associations (which the bank calls compact farm).

766
Mohamed, K.H. (1969)
Malaysian Social Structure in Relation to the Development of Farmers' Associations (with special reference to the Muda irrigation project). Paper presented to the Second Seminar Cum-Study Tour on Farmers' Organizations in Asia and the Far East, Kuala Lumpur, Malaysia, 18 pp.

767
Mohan, S. (1969)
The Organizations Managing Rural Irrigation in Indonesia. Bogor, Indonesia: Ministry of Agriculture, Directorate of Rural Irrigation.

768
Ongkingco, P.S. (1975)
Organization and Operation of 15 Communal Irrigation Systems in the Philippines. Water Management in Philippine Irrigation Systems: Research and Operations, 235-42. Los Banos, Philippines: International Rice Research Institute.

The paper presents the results of case studies of 15 communal, village-level irrigation systems in Laguna province, Philippines. Common problems cited are (1) insufficient water supplies in the dry season, (2) failure of established authorities to distribute water to farmers, (3) dissatisfaction with water tenders in the distribution of water to tail-end farms, and (4) the influence of politicians over conflict resolutions.

769
Paranakian, K. (1978)
Summary Report on Terminal Level Irrigation Organizations in the Nong Wai Pioneer Irrigated Agriculture Project Areas, Khon Kaen, Thailand. Bangkok, Thailand: Faculty of Social Sciences, Kasetsart University.

The purpose of this study was to perform a benchmark survey on terminal-level irrigation organizations established in the Nong Wai Pioneer Irrigated Agriculture Project Areas. It was carried out in 1976-77, with a total of 125 farmer respondents. The findings on the formation and structure of the irrigation organizations are presented, with respect to water management practices and patterns of social irrigation. Suggestions are made regarding improvement of irrigation organizations.

770
Philippines (Republic), National Water Resources Council (1977)
Water Resources Coordination Directory. Report No. 27. Quezon City: National Water Resources Council.

A compilation of 40 agencies, arranged chronologically as they were created and classified by department or ministry, is contained in this report. The agencies are listed according to their role in water resources development, investigation, and data collection. Functions, key officials, and organizational charts of the agencies are reviewed in this report.

771
Robinson, David M. (1975)
Making an Irrigation Association a Vehicle for Development: Preliminary Observations on a Group of Philippine Rice Farmers. Water Management in Philippine Irrigation Systems: Research and Operations, 259-70. Los Banos, Philippines: International Rice Research Institute.

The organization of a farmers' association for managing three irrigation pumps in Barrio Pajo, San Isidro, Catanduanes Province, Philippines, is examined in this paper. A major problem identified was the low payment rate for the pumps installed. Without tenure regulations, tenants ended up paying higher amortization fees than landowners. The farmers' association then proposed the use of the 70-30 share of harvests (instead of the traditional 50-50 share) to cover the increase in payments for the pumps. Estimates were made (Table 1) showing that the breakeven yield for farmers, under the 70-30 arrangement, would be 3.14 tons/ha.

772
Robinson, David M. (1982)
Water Users' Organizations in Two Large Philippine Irrigation Systems: Constraints and Benefits of a Participatory Approach to Water Management. Unpublished Ph.D. dissertation, Cornell University, Ithaca, New York.

773
Rubin, H. (1980)
Integrating Rural Development: The Problem and the Solution. Bloomington, Indiana: International Development Institute.

The paper is part of a series of reports on the Programme of Advanced Studies in Institution Building and Technical Assistance Methodology study of the International Development Institute of Northern Illinois University. The objective of the study is to evaluate incentives for inducing independent line agencies involved in water resources management and rural development to coordinate activities at the field level. The second part presents the Bicol River Basin Project in the Philippines. Major conclusions include the primacy of the integrating role of basin authorities, the need to introduce career motivation programs, and consideration of sensitive issues such as regional autonomy for the basin authority.

774
Sektheera, R., and A. Cornavich (1974)
Irrigation in the Chiang Mai Valley: Organization and Management. Paper prepared for the Agricultural Development Council Seminar on Developing Systems of Irrigation Management that Link Human and Physical Resources More Effectively, Taiwan, 22 pp.

775
Soenarjo, G. (1976)
Country Report of Indonesia. Paper presented to Symposium on Water Management of Rice. Ibaraki, Japan: Tropical Agriculture Research Center, Ministry of Agriculture and Forestry.

Parts I to IV contain a summary of Indonesia's population, nutrition program, and land resources. Part V presents the water resources development program for irrigation, reclamation of deltaic and swampy areas, and flood control. A chart of the directorate for water resources development is included together with two other useful charts--the management structure of terminal unit teams and the organizational setup for water user associations.

776
Takahashi, A. (1977)
Mobilizing Peasants for Irrigation Development. Farm Water Management for Rice Cultivation. Tokyo, Japan: Asian Productivity Organization.

The paper discusses the problem of lack of local participation in the Angat River Irrigation Project of the Philippines. Reasons given were lack of incentives to mobilize peasants and

strong presence of government officials in operating the irrigation system. In the second part of the paper, the author lists three requirements for improving local participation in irrigation projects: (1) providing feedback and communications channels between water users and irrigation agency officials, (2) developing water user organizations among permanent or long-time settlers in the community, and (3) introducing land reform and other distributive programs.

777
Thailand, International Land Development Consultants (1977)
Evaluation of the Implementation of On-Farm Development Works During Fiscal Year 1977: Chao Phya Irrigated Agriculture Development Project Stage I. Technical Notes No. 35. Bangkok, Thailand: Ministry of Agriculture and Cooperatives.

On-farm development works in the dry season of 1977 are evaluated with a quantification of area covered and costs. Organizational and engineering aspects of the project are studied and a number of recommendations made for more efficient implementation of works.

778
Thailand Royal Irrigation Department (1973)
Regional Workshop on Irrigation Water Management for Thailand. Bangkok, Thailand: Royal Irrigation Department, 67 pp.

A.4. NORTHEAST ASIA

779
Abel, M.E. (1975)
Irrigation Systems in Taiwan: Management of a Decentralized Public Enterprise. Staff Paper Series No. P75-15. Department of Agricultural and Applied Economics, University of Minnesota.

The paper describes the operation of canal irrigation systems in Taiwan, which are generally considered quite efficient with regard to water use. The factors judged to be important have been distilled from available literature. Four particularly important factors are (1) recognition of water as a scarce factor to be used as efficiently as possible; (2) centralized planning of irrigation investment, but decentralized management of irrigation systems (up to 1975); (3) information systems within the irrigation associations permitted exchange of agronomic and engineering information between users and

managers; and (4) the irrigation associations use incentive systems for both managers and users.

780
Beardsley, Richard K., John W. Hall, and Robert E. Ward (1980) Japanese Irrigation Cooperatives. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 127-52. Ithaca, New York: Cornell University Press.

A study of a buraku, or small rural settlement in Japan, consisting of "households grouped together as a community" was made in Niiike, Honshu, Japan. Irrigation water was supplied from a variety of sources including small ponds owned and managed by individuals, ponds managed by communities, canals owned and operated by irrigation cooperatives, and publicly-owned rivers. In one pond, Obara, over ten acres of land, operated by 16 households, is irrigated. Heads of households take turns as water guards, rotating over a period of 16 years and without written rules and contracts. Water rights claimed by upstream villages have resulted in largely unequal water distribution. Since there is no codified law concerning water rights, it is difficult to reconcile conflicting interests.

781
Bottrall, Anthony F. (1977)
Evolution of irrigation association in Taiwan. Agricultural Administration 4(4):245-50.

The Irrigation Associations of Taiwan, in which very substantial responsibilities for decisions about water allocation and system maintenance are delegated to farmers and their representatives, have attracted considerable attention as a possible institutional model that might be introduced into irrigated areas in other developing countries. After a brief description of their current methods of operation, their historical development is reviewed. It emerges that the present decentralized approach to irrigation administration in Taiwan is of fairly recent date, having evolved over time from what was originally a very authoritarian government-directed approach. It is concluded, therefore, that if Taiwanese Irrigation Associations have any value as a model, it is more likely to be found by drawing conclusions from the sequences in which they have developed over time rather than by trying to reproduce them elsewhere in their present form.

782
Chen, C.L. (1961)
Organizational Rules of Irrigation Associations in Taiwan. Proceedings Far East Regional Irrigation Seminar, 342-51. Taipei, Taiwan.

783
Cheng, C.S., et al. (1980)
A Study on Area's Agricultural Productivity for Farmers' Capability for Membership Fee for Irrigation Association. Chungli, Taiwan: Agricultural Engineering Research Center.

Farmers find the Irrigation Association membership fee a heavy burden because of low income, rather than the level of the fee. The study examines agricultural productivity and farmers' ability to pay the irrigation fee. It is argued that the government should continue to subsidize irrigation and try to increase agricultural productivity and farm families' revenue. In the long run, a soundly organized, self-governed Irrigation Association is desirable.

784
Chin, L.T. (1972)
Irrigation Associations (a case study in Taiwan). Irrigation and Drainage Paper 12, 243-53. Rome: Food and Agriculture Organization.

785
Hsieh, S.C. (1963)
Farmers' Organizations in Taiwan and Their Trends of Development. Industry of Free China (Taipei) 23-28 (December issue).

786
Kanazawa, N. (1977)
Roles of Government and Farmers in Irrigation Water Utilization and Management. In Farm Water Management for Rice Cultivation. Tokyo, Japan: Asian Productivity Organization.

Irrigation administration is generally directly controlled by the government or completely managed by local water users associations. Three types of approaches are contrasted for Japan, Taiwan, and the Philippines. In Japan, autonomous irrigators' associations are formed at the village level while in Taiwan, the organizations are formed alongside existing government bureaucratic units. In the Philippines, the role of the ditchtender is emphasized especially in providing the crucial link between local water users and irrigation officials. Charts of various types of irrigation organizations in these countries are included in the report.

787
Lee, C.Y., and Y.J. Yang (1971)
An Analysis of Business Management of Agricultural Irrigation Associations in Taiwan. Taichung, Taiwan: Research Institute Agricultural Economics, National Chung University, 91 pp.

788
Lee, C.Y. and Y.J. Yang (1972)
A case study of the operation and management of Changhua and Touliu farm irrigation associations. J. Agric. Econ. (Taiwan) 13:189-90.

789
Nickum, J.E. (1979)
The organization of water resources in the People's Republic of China. Agricultural Administration 6(3):169-86.

The article focuses on the organization, economics, and technology of water conservancy in China. Particular attention is given to the role of the rural collective systems in mobilizing large amounts of labor and to the impact of state-collective dichotomy on the choice of technology. The operation of irrigation management, which is separate from the regular administrative apparatus, is also noted. Specific examples are cited from projects visited in 1974 by the U.S. Water Resources Delegation.

790
Nickum, James E. (1980)
Local Water Management in the People's Republic of China. In Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, ed. E. Walter Coward, Jr., 289-98. Ithaca, New York: Cornell University Press.

In the People's Republic of China (or China), an irrigation district is established by the lowest administrative level. The xian or county, for example, founded the Red Flag Canal, which covers communes or townships within Lin Xian Province. Once established, the district operated as an autonomous unit with its own accounting and auditing staff. Water fees were charged yearly to production teams. In the Red Flag Canal, the amount of the water fee was determined by the canal administration before the summer wheat harvest and approved by the xian. Various forms of water fees were used. In a semiautonomous district, the Meich' uan, irrigation management is performed in close coordination with the regular administrative setup. The district party committee or qu appointed a secretary to manage the irrigation district. The reservoir management office secretary in turn participated in the qu party committee. In this setup, the author observed a more efficient irrigation management decision-making system

where close cooperation with the central government facilitated the inflow of government capital and other resources.

791
Nickum, James C., ed. (1981)
Water Management Organization in the People's Republic of China. New York: M.E. Sharpe, Inc.

792
Oh, H.S. (1976)
Customary rules of water management for small irrigation reservoirs in Korea. Journal of Rural Development 1(1):96-110.

An account is given of publicly funded small irrigation reservoirs managed by autonomous organizations in Korea. The rules and regulations of each scheme are deeply influenced by traditional customs related to old irrigation systems. As a result most of the reservoir systems have failed to meet the basic goals. Physical maintenance is also poor. The lack of security for water rights, the unbalanced nature of the incidence structure of benefits and costs among competing users, and lack of economic incentives for the managers have led to significant depletion of water resources in the schemes.

793
Tsuchiya, H. (1973)
Farmers' Organizations for the Operation and Maintenance of Water Facilities in Japan. In (Report) Seminar on Water Management and Control for Agriculture, 225-40. Tokyo, Japan: Government of Japan and FAO.

794
Water Resources Planning Commission (1961)
Organization of River Valley Projects in the Republic of China. Republic of China, 12 pp.

795
Wu, C.H. (1974)
An Economic Study of the Operation of Irrigation Associations in Taiwan. Taipei, Taiwan: Chinese Society of Agricultural Engineers.

796
Young, F.W., and Ta-Chou Huang (no date)
Irrigation Facilities and Social Organizations in Taiwan. Ithaca, New York: Cornell University (mimeographed).

B. LEGAL ASPECTS OF WATER RESOURCES MANAGEMENT

797
Agrawal, N.K. (1975)
Institutional and Legal Factors of Irrigation Projects. Paper presented at the UN-ECAFE Symposium on Social and Non-Social Factors in Water Resources Development, Bangkok, Thailand.

A review of Nepal's agricultural development program and on-farm water management projects, emphasizing institutional and legal factors affecting irrigation projects.

798
Bhatty, K.M. (1979)
Social Determinants of Water Management in Dandzai. Peshawar, Pakistan: Academy for Rural Development.

A survey of 40 farmers in ten villages of the Dandzai Markoz irrigation system was conducted in order to evaluate the local water delivery system, particularly conflict resolution approaches. The approaches to defining water rights were found to be modified in customary law that was revised in the land resettlement act of 1930. However, tribal authority remained the major decision force, with elders continuing to enforce rules and regulations. The survey concludes that legalizing customary, traditional laws are impractical and that privately-owned canals need to be converted into public property to reduce conflict in the area. Part II contains an accurate description of the history of water rights in the area.

799
Chadha, O.P. (1975)
Growth of Administrative and Legal Structures for Irrigation Command in India. Paper presented at the UN-ESCAP Symposium on Social and Non-Economic Factors in Water Resources Development, Bangkok, Thailand.

The Fifth Five-Year Plan of India provides for 55 million hectares of land to be irrigated for multiple cropping. To implement this plan, administrative and legal structures were created to supervise funds allocation and project

implementation. This paper reviews the process by which the administrative structures and legal instruments for project implementation were created.

800
Chandrasheklar, A.K. (1978)
Perspectives and strategy for water resources development in India: An inter-regional approach. Journal of Indian Central Board of Irrigation and Power 35(4):473-92.

Of the various technical baseline studies done for interbasin transfer projects for India, Chandrasheklar provides the most detailed physical-topographic and engineering analysis. He estimates that the present water potential (from transfers) lies between 650 to 800 billion m^3. He approaches the problem of augmenting water supplies strictly from an engineering viewpoint. Environmental considerations are apparently absent.

801
Choksi, C.K. (1979)
Factors affecting speed, economy and causing disputes in river valley projects. Indian Journal Power River Valley Development 29(8):201-06.

802
Hatate, I. (1979)
Irrigation Water Rights Disputes in Japan--As Seen in the Asuza River System. Tokyo, Japan: The United Nations University.

Irrigation and drainage improvement, consolidation of farm land, and other forms of land improvement can be undertaken only with respect to fairly substantial tracts of land; the greater the area involved, the more efficient such improvements will generally be. In the case of Japan, the predominance of small farmers and canal irrigation leads to sharp confrontation between individual farmers, between villages, and between different regions in connection with the extension of irrigation systems. The first part of the paper discusses irrigation systems and local leadership, looking at land improvement and irrigation clashes, landowners and government authorities, and financial capability and technology in relation to land improvement. The second half examines interregional rivalry over water rights, illustrated by the problem of water rights that arose in connection with modification of the Niimura Canal in 1916, and priority rights of old paddy fields in connection with the Azusa River Land Improvement Project.

803
Hayton, Robert D. (1981)
International aquifers and international rivers. Water International 6(4):158-65.

804
LeMarquand, David G. (1981)
International action for international rivers. Water International 6:147-57.

805
Maheswaran, A., and G.J.P. Gunawardane (1975)
The Associated Institutional and Legal Systems in Sri Lanka. Paper presented at the Symposium on Social and Non-Economic Factors in Water Resources Development, Bangkok, Thailand.

A review of principal water resources development projects in Sri Lanka with respect to programs geared toward strengthening of institutional and legal structures for project implementation is contained in this report. Several multipurpose water projects are used as examples of the different types of administrative structures for project implementation and planning.

806
Malabanan, I.P. (1976)
Investment in Irrigation Systems: Past, Present, and Future Directions. Los Banos, Philippines: University of the Philippines at Los Banos Continuing Education Center.

A historical overview of irrigation development in the Philippines is provided in this paper. Problems encountered by the National Irrigation Administration (NIA) such as negotiating for right-of-way, insufficient funding, and political interference are evaluated in relation to the future developmental objectives of NIA.

807
Philippines (Republic), National Water Resources Council (1979)
Philippines Water Code and the Implementing Rules and Regulations. Quezon City: National Water Resources Council, 58 pp.

The 1976 Water Code of the Philippines and the Implementing Rules and Guidelines are summarized in this document. The code covers (1) basic principles related to the appropriation, control, and conservation of water resources, (2) rights and obligations of water users and owners, (3) rules governing ownership and transfer, and (4) the administrative agencies in charge of enforcing the code.

808
Radosevich, George E. (1977)
Improving Agricultural Water Use, Organizational Alternatives. Fort Collins, Colorado: Resource Administration and Development, Inc.

The report reviews the state-of-the-art of studies dealing with the legal aspects of water user associations (WUAs) and other related organizations. An overview of the operation and functional relationships between local WUAs and the government is presented for 28 countries. Models of particular Asian country organizations are used in describing the various types of WUAs. For example, the Taiwanese associations belong to the autonomous type while WUAs in India are centralized. The Asian countries included in the report are Sri Lanka, China, India, Indonesia, Japan, Korea, Singapore, Thailand, Taiwan, and the Philippines.

809
Samad, M.A. (1970)
Pakistan's water problems and the law of international rivers. Pakistan Horizon 23 (3):265-74.

The conflict between India and Pakistan over the diversion of 40,000 to 46,000 m^3 of water from the Ganges barrage system in east Pakistan through the Farakka Dam (11 miles upstream of the Ganges barrage area) is discussed. The various arguments establishing riparian disputes over international waters are presented in terms of the following (1) the "equitable apportionment" doctrine, (2) the need to respect sovereignty in the use of international rivers, and (3) the utilization of shared water resources and the proper management required to carry out development of such resources.

810
Takagi, A., et al. (1978)
Laws and development of gully channel networks--Study of slope erosion (II). Transactions Japanese Society Irrigation Drainage Reclamation Engineers 76:47-52.

811
Trelease, F.J. (1975)
Current Needs for Improvement of Philippine Water Law, With Special Reference to Groundwater. Rome: United Nations Development Programme and Food and Agriculture Organization.

In December 1974, the National Water Resources Council (NWRC) of the Philippines established a national water code governing the aquisition, distribution, and control over water resources in the country. This report describes the water law practice and urges the modernization of the Irrigation Law to repeal

the private water concept. An effective licensing procedure for water use that can regulate water resources development is recommended. A law for regulating groundwater well drilling and controlling waste disposal into streams, lakes, and ponds is needed, especially in areas with limited groundwater supplies.

C. GOVERNMENT POLICIES AND PROGRAMS

812
Adams, M.E. (1981).
Water Management Extension Among Small Farmers in Central Java. Rome: Food and Agriculture Organization.

813
Alejandrino, A.A. (1979)
Philippine Water Resources Policies: An Appraisal. Paper presented to International Centennial Symposium of the U.S. Geological Survey. Quezon City: National Water Resources Council.

A discussion of water resources development policies in the Philippines is presented in this paper, focusing on the organizational concepts, priorities in development, and economic considerations used in project planning. Multipurpose projects, using the integrated area development concept, are preferred by the Philippine government as a response to changing demand for water.

814
Ali, Syed Hashim (1981)
One Season of Integrated Water Management. Paper presented to the International Seminar on Field Research, Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

India's Command Area Development (CAD) Program was started in 1973 to integrate the various functions of government ministries involved in the development of irrigated agriculture. Andhra Pradesh was one of the states who adopted the CAD Program by creating a separate government unit to handle its four CAD projects. These projects are situated in seven canal systems on the Godavari, Krishna, and Tungabhadra river systems. A brief review of these projects is discussed in the first section as background information for the integrated water management program. In Section II, case studies of various canal segments in selected CAD projects are

presented to point out problems in implementation. A listing of major conclusions drawn from the case studies is outlined in the last section. These are classified into problems of administration, engineering design, operation and maintenance, and farmer participation.

815
Ambegaonkar, L.V. (1982)
Utilisation for irrigation potential: Basis for assessment. Southern *Economist* 20(21):21-22.

816
Asian Development Bank (1980)
Irrigation Development and Management: Proceedings of the ADB Regional Seminar on Irrigation Development and Management. Manila, Philippines: Asian Development Bank.

The report contains a summary of seminar proceedings held in Manila, January 27 to February 16, 1979. Part I of the report contains a general description of the seminar program and the recommendations of seminar participants for future ADB irrigation projects. In Part II a review of the bank's activities over the past 12 years is presented with a listing of the 41 ADB-assisted irrigation projects. The review includes an evaluation of such institutional programs as the administration of irrigation projects by government agencies, interministerial levels of cooperation in irrigation development, and the imposition of water charges and fees. The last part contains revised versions of technical reports submitted by seminar participants.

817
Bagadion, B., et al. (1978)
The Water Management Training Program of the Upper Pampanga River Project, National Irrigation Administration, Philippines. In Irrigation Policy and Management in Southeast Asia, 103-8. Los Banos, Philippines: International Rice Research Institute.

An evaluation of the water management technologists' training program in the Upper Pampanga River Project of the Philippines is made by estimating actual improvements in irrigation performance of selected laterals in the project. The training program is divided into five phases (1) 4-week orientation and field experience, (2) 3-week seminar on water management, (3) two seasons of field training, (4) 2-week evaluation and planning workshops, and (5) evaluation of trainee performance during the first two years of field assignments.

818
Bhatia, Ramesh (1977)
Energy and Rural Development in India: Some Issues. In Energy and Agriculture, ed. W. Lockeretz. New York: Academic Press.

819
Boedidarmo, B. (1977)
Sederhana (Simple) Irrigation Program in Indonesia. Technical Paper No. 24, 14 pp. Jakarta, Indonesia: Ministry of Public Works and Electric Power and United Nations Water Conference.

The Second Indonesian Five-Year Development Plan includes the development of simple irrigation and reclamation projects, covering about 550,000 hectares of agricultural lands. These simple sederhana systems are easy to construct and are capable of rapid execution and are relatively inexpensive.

820
Booth, A. (1974)
Ipeda: Indonesia's Land Tax. Bulletin of Indonesian Economic Studies 10(1).

821
Cheong, C.L. (1973)
Irrigation Development and Water Management in Peninsular Malaysia. Paper presented at the National Seminar on Water Management at the Farm Level, Alor Star, Malaysia, 17 pp.

822
Crow, Ben (1980)
Politics and the Development of Water Resources in the Ganges Basin. Swansea, England: Development Studies Association Annual Conference.

823
Demaine, G., and C.J. Dixon (1972)
Land tenure patterns and agricultural development in Thailand: A case study of the Lam Pao irrigation area in Changwat Kalosin. Journal of the Siam Society 40(2).

824
Devendra, T. (1975)
Peasant Resettlement Under an Irrigation Scheme: Kantali (Sri Lanka)--A Case Study. Paper presented at the UN-ESCAP Symposium on Social and Non-Economic Factors in Water Resources Development, Bangkok, Thailand.

The resettlement scheme of the Kantalai Irrigation Reservoir in Sri Lanka is evaluated in this paper with respect to its impact on regional development. The administrative framework used, historical background of the resettlement policy, and other relevant features of the program are discussed.

825
Gopinath, C. (1979)
Technology for Groundwater Use in India: The Dilemma of the Rural Poor. Paper prepared for the Seminar on Research, Technology and the Rural Poor, Institute of Development Studies, Sussex, England.

826
Hanumantha Rao, K., and K. Mohan Rao (1982)
Irrigation and labor use in semi-arid agriculture. Journal of Rural Development 1(2):261-70.

827
Holloran, S., et al. (1982)
Sederhana: Indonesia Small-Scale Irrigation. Project Impact Evaluation Report No. 39. Washington, D.C.: USAID Bureau for Asia.

828
Indian Institute of Science (1971)
Water Resources, Seventh Symposium. Bangalore, India: Indian Institute of Science, the Civil and Hydraulic Engineering Department.

The major findings of the symposium are summarized in this report. For example, interbasin water transfers were proposed to redistribute water to semiarid and arid zones where 30 percent of total cultivated area needs to be irrigated to counteract aridity and to grow an annual food crop.

829
Kambhu, M. (1963)
Water Resources Development in Thailand and Its Policy. Bangkok: Royal Irrigation Department.

830
Kanazawa, N. (1957)
Rice Farming and Irrigation in Japan. Tokyo, Japan: Ministry of Agriculture and Forestry, 15 pp.

831
Khan, Hamidur Rahman, and Jeff Romm (1978)
Some Issues of Water Resource Management in Bangladesh. Dacca, Bangladesh: The Ford Foundation.

An overview of the water resources development program in Bangladesh is contained in the first part of the report. Several issues are raised in the last part regarding the development of water resources, in particular, guidelines for choice of projects requiring labor vs. capital inputs. A second important issue concerns the use of adaptive techniques through observation of traditional village water systems. With respect to the management of international rivers, the authors suggest a specification of actual water needs by Bangladesh and to identify potential conflicts with neighboring countries.

832
Lazaro, R., D. Taylor, and T. Wickham (1977)
Irrigation Systems in Southwest Asia. ADC Seminar Report. New York and Singapore: Agricultural Development Council.

The report provides a good review of the main and tertiary level water management problems of selected irrigation systems in Indonesia, Malaysia, Philippines, and Thailand. The main issues discussed were (1) alternative strategies to develop irrigation infrastructure, (2) approaches to operation and maintenance (O&M) functions, and (3) policy options for irrigation development. The third issue set the stage for a renewed interest in incorporating the social sciences to policy and planning of irrigation infrastructure. In the last day of the seminar a panel discussion of government representatives provided an interesting forum for the exchange of ideas between researchers and practitioners in irrigation development.

833
Leeds, Hill, and Jewett, Incorporated (1976)
Assistance to the National Water Resources Council, Republic of the Philippines. San Francisco, California: Leeds, Hill, and Jewett, Inc., and United Nations Development Programme, 118 pp.

The need to coordinate water resources programs and policies for efficient development of water resources in the Philippines led to the establishment of the National Water Resources Council (NWRC) in 1974. The council was organized through the initiative of the United Nations Development Programme (UNDP) and technical assistance was provided by Leeds, Hill, and Jewett, Incorporated. Recommendations for future NWRC projects are provided.

834
Lenton, Roberto (1978)
Doubling Rice Production in Asia Through Investments in Irrigation: Some Perspectives on Training and Research Needs. Paper prepared for the Trilateral Commission Expert's Meeting, Tokyo, Japan.

The paper discusses some policy issues concerning the conversion of about 30 million hectares of rainfed lands and 17 million hectares of inadequately irrigated lands in Asia. Two types of programs are presented: (1) the construction of irrigation delivery systems and (2) the improvement of land and water development activities. The Command Area Development Programme in India is described as an example of the second program. The appendix includes a listing of Ford Foundation activities in land and water management in India.

835
Levine, Gilbert, and E. Walter Coward, Jr. (1979)
Managing water resources for food production. World Food Issues 4(7).

836
Motooka, Takeshi (1966a)
International Aid. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: The Center for Southeast Asian Studies, Kyoto University, 37-49.

Water resources projects in developing countries receive international aid in three forms: (1) by the terms of financial assistance--i.e., whether it is bilateral or multilateral (90 percent of aid in developed countries is bilateral), (2) by the form of aid--i.e., whether capital or technical (in general, technical aid is always supported by capital aid), and (3) by the type of capital aid given--i.e., whether the capital aid is a "gift" or a loan (for Southeast Asia, Japanese aid comes mainly in the form of "indemnity gifts"). This paper examines the sequence and process of international aid and support for the Mekong River Basin project. In 1955, for example, the UN-ECAFE and the U.S. International Cooperation Agency (ICA) supported a U.S. Bureau of Reclamation field reconnaissance survey. Then in 1957 capital aid was extended by Japan, France, and the United States, which later led to the formation of the "Mekong Committee." In the same year, the U.N. Technical Assistance Agency (UN/TAA) conducted a reconnaissance survey of the Lower Mekong Basin and recommended a five-year survey plan costing $9.2 million.

837
Motooka, Takeshi (1966b)
Problems of Developing and Utilizing the Water Resources in Southeast Asia. Paper presented to Symposium on Water Resource Utilization in Southeast Asia. Kyoto, Japan: The Center for Southeast Asian Studies, Kyoto University, 11-20.

Countries in Southeast Asia, when taken as a single geographic area, have much in common in terms of a basic natural background, history and social system, although great diversities exist in terms of the local variations in landscape, culture, and colonial influence. Several social and political factors are identified as crucial in the development of water resources in the region. First, nearly all water projects in the region are carried out by the central government. This accounts for the highly centralized type of international aid received. There is no financial assistance given, for example, by international agencies to dvelopment of local water organizations. Second, projects are operated by separate government units. The case of Thailand is cited, where a complete separation of functions among government agencies is practiced. The third point is that village irrigation systems are not well organized as observed in some Thai villages where conflict over water use is widespread.

838
Muda Agricultural Development Authority (1972)
The Muda Irrigation Scheme, an Exercise in Integrated Agricultural Development. Kedah, Malaysia: Muda Agricultural Development Authority.

839
Muhammad Ali Chaudhary (1978)
Determination of cost of tubewell water and estimation of economic rent in canal irrigation. Pakistan Development Review 17(2):139-68.

Economic rent is defined in this paper as the "residual of the value of surface irrigation at its market price," and computed as the "value of tubewell water cost less water rates." Of the various types of irrigation systems in Pakistan, canal irrigation generates the highest economic rent. The author suggests that to remove economic rent, especially for segments of the irrigation system disadvantaged by canal position, water rates have to be revised in accordance with net income from crop production. Furthermore, to justify increases in water rates, the increments from revenue must be channeled to improvements in water delivery efficiency. Detailed estimates of selected irrigation systems in Pakistan are included in the paper.

840
Neghazzi, H.M., and James A. Seagraves (1976)
Efficiency in the use of water for irrigation: The role of prices and regulations. Natural Resources Forum 3(1):53-72.

841
Noranitipadungkarn, C. (1977)
Bangkok Metropolitan Immediate Water Improvement Program, Honolulu: Technology and Development Institute, East-West Center.

842
Ongkingco, P.S. (1976)
Irrigation Fee Policies for the Upper Pampanga River Project, Philippines. Unpublished Ph.D. dissertation, University of Arizona, 146 pp.

An irrigation fee policy for the Upper Pampanga River Project (UPRP) in the Philippines is formulated from an analysis of the project's costs and benefits computed for different phases. The phases included in the estimation are the hydroelectric power phase, the Aurora-Penaranda Systems Irrigation sub-project phase, and the Tarlac Irrigation Systems Improvement phase. The fee schedule was estimated from allocated irrigation benefits and farmers' ability to pay.

843
Philippines (Republic), National Economic and Development Authority (1979)
Water for the countryside. Philippine Development 7(5):10-13.

This report outlines the program of the Philippine government's Local Water Utilities Administration (LWUA) as a lending agency for the improvement and expansion of water supply districts. Three loan categories are described--comprehensive funding, interior improvements in water supply facilities, and small-scale or initial funding activities.

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Rao, V.K.R.V. (1970)
New Challenge Before Indian Agriculture. Dr. Panse Memorial Lecture. New Delhi, India: Institute of Agricultural Research and Statistics.

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Short, D.E. (1971)
Some Aspects of the Role of Irrigation in Rural Development in Malaya. Unpublished Ph.D. dissertation, University of Hull, U.K.

846
Short, D.E., and J.C. Jackson (1971)
The origins of irrigation policy in Malaya: A review of developments prior to the establishment of the drainage and irrigation department. J. Malaysian Branch Royal Asiatic Soc. 44:78-103.

847
Singh, Jaswant (1981)
Identification of Basic Issues. Paper presented at International Seminar on Field Research Methodologies for Improved Irrigation Systems Management. Coimbatore, India: Tamil Nadu Agricultural University.

The paper addresses the problem of defining appropriate field research methodologies for irrigation development by examining nonagro-engineering variables. These variables relate to government priorities in rural development, income distribution, and level of poverty among rural families. Data from the government of India Draft Sixth Plan were included as supporting tables.

848
Tagarino, R.N. (1976)
Economic and Financial Policy Issues in Philippine Irrigation Systems. Los Banos, Philippines: University of the Philippines at Los Banos Continuing Education Center.

The irrigation pricing policies of the Philippine government are evaluated in this paper with respect to income distribution, water use efficiency, and economic growth. The major conclusion of the paper is that water charges must be based on both benefits and costs of the project and their implications to farmers' income and government revenue.

849
Taiwan Provincial Water Conservancy Bureau (1973)
A Study on Irrigation Fee Collection Criterion in Taiwan. Water Economics Studies Series No. 21. Taipei, Taiwan.

850
Takase, K. (1972)
The Strategy of Irrigation Water Management in the Asian Development Bank. Paper presented to Seminar on Water Management at the Farm Level, Bangkok, Thailand, 104-10.

Graphs showing the Asian Development Bank's (ADB) involvement in irrigation development as of 1972 indicate the comparatively low priority given by the bank to irrigation and agricultural development. Of the total loans allocated in 1972, only 17.4 percent were used for agriculture, compared to 32.3 percent for industry, and 28.1 percent for public utilities. Irrigation investments accounted for a little over 10 percent of total loans. One of the irrigation projects that received a large amount of capital assistance from ADB was the Angat Multipurpose Reservoir Project in the Philippines.

851
Takase, K. (1981)
Integrated Agricultural Development in the Philippines. Manila: Asian Development Bank.

The Asian Development Bank (ADB) program for integrated agricultural development is discussed in this paper. Part I elaborates on the bank's new policy of funding small-scale and institution-building projects instead of the usual high-technology, capital-intensive projects funded in the past. In Part II this new policy is evaluated in terms of the bank's involvement in small-scale, irrigation rehabilitation projects such as the Angat-Magat Integrated Agricultural Development Project in the Philippines (started in 1968). Aside from the usual agroengineering studies, the bank has embarked on such nontechnical studies as land reform, cooperative, compact farming, and training of National Irrigation Administration (NIA) staff.

852
Taylor, Donald C. (1980)
Economic Analysis to Support Irrigation Investment and Management Decisions. Report of a Planning Workshop on Irrigation Water Management, 39-81. Los Banos, Philippines: International Rice Research Institute.

Alternative approaches to irrigation infrastructure investments and their implications for irrigation policy and management in Asia are the major themes that this paper discusses. Data for analysis of feasibility of various types of irrigation technologies are provided to support different alternatives to main and tertiary level management. The last part evaluates the distributional effects of each alternative

with respect to trade-offs between more investments in irrigation infrastructure and improved organizational and managerial capacity of water users.

853
Tripathy, R.N. (1980)
Command area development. Kurushetra 28(23):25-37.

The article analyzes India's major agricultural development program--the Command Area Development or CAD. The fundamental constraint remains to be the lack of legal support to enforce new cropping patterns and rotation schemes. The author proposes that a shift to comprehensive planning in the framework of integrated area development is needed in order to make the CAD more effective. However, the author fails to elaborate on this alternative.

854
Tsutsui, H. (1978)
Rice Production and Irrigation Development Strategy in South and Southeast Asia. In Proc. ICID 2nd Reg. Afro-Asian Cong., Additional Technical Papers, 1-24. Manila, Philippines.

855
United Kingdom, University of Sussex, Institute of Development Studies (1980)
Who Gets the Last Resource? The Potential and Challenge of Lift Irrigation for the Rural Poor. Brighton, United Kingdom: University of Sussex.

The proceedings of the Institute of Development Studies Seminar on Lift Irrigation and Rural Poverty in South Asia is contained in this report. The benefits from government subsidies of lift irrigation schemes need to be redistributed from large farmers through such measures as "zoning" of technologies to protect the poorer farmers, increasing research efforts to improving simple and indigenous irrigation techniques, providing better extension services, and reorienting international and bilateral funding toward equalization of access to new technologies. Seminar reports are included as a separate document.

856
United Nations Economic and Social Commission for Asia and the Pacific (1977)
Report of the ESCAP Regional Preparatory Meeting for the U.N. Water Conference. Bangkok: UN-ESCAP, 73 pp.

This report contains a summary of 19 member country reviews of current water resources development programs and policies. A

consolidated regional report by ESCAP is appended. The individual country reports are divided into (1) existing water resources requirements, (2) major problems encountered, and (3) recommendations for development of water resources management programs.

857
United Nations, Report of the Secretary General (1980)
Financing arrangements for international cooperation in the development of water resources. Natural Resources Forum 4(1):43-60.

The report reviews financing arrangements for selected international donor agencies in Asian water resources projects. World Bank and the Inter-American Development Bank allocate 23 percent and 39 percent of their total budgets, respectively, to water resources projects in Asia. Both funding agencies provide over one-half of the water budget to irrigation, followed by hydroelectric power (15 percent). The Asian Development Bank spends 17 percent of its budget for irrigation, but more than half of this goes to training and research. The UNDP, which has 8 percent to 10 percent of its funds committed to water projects limits its operation to preinvestment technical assistance, appropriating an average of $35 to $40 million per year on feasibility and exploratory studies. Counterpart investments by developing country governments comprise about 15 percent of the total capital outlay for water projects in Asia. These investments represent from 1.5 percent to 7 percent of gross fixed capital formation in developing countries (excluding hydroelectric power investments).

858
Wade, R. (1980)
The state of irrigation reform in South Korea. Journal of Rural Development, Korea 3(2):253-67.

This paper describes the South Korean irrigation reform of 1979, the attempt to arrest certain trends in financial allocations of Farmland Improvement Associations, and to restructure the decision-making environment of canal managers in such a way that they have a monetary incentive to decide on a more productive use of resources. The ways in which the central government attempts to control local parastatal agencies are examined, a comparison is made with irrigation reform in Taiwan, and the extent to which differences are due to differences in the value of irrigation water between two countries or to differences in politics is considered.

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Wade, R. (1982)
Irrigation and Agricultural Politics in South Korea. Boulder, Colorado: Westview Press.

860
Wang, Y.T. (1973)
Development Impact and Management of Irrigation in Taiwan. In Regional Workshop on Irrigation Management, Philippines, Thailand and Indonesia, 211-25. Manila: Asian Development Bank.

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Wardoyo, I.R. (1981)
Farmer Agency Interaction for Irrigated Agriculture Development: The Indonesia Experience. Paper presented to Agricultural Development Council Workshop on Investment Decisions to Further Develop and Make Use of Southeast Asia's Irrigation Resources, Bangkok, Thailand.

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SUBJECT INDEX

	Reference code
ABRA RIVER	
Development, potential, projects, water use analysis, Philippines	95
ABULOG RIVER	
River basin, plans, developmental analysis, Philippines	92
ACCESS (see WATER ACCESS, DIFFERENTIAL ACCESS)	
ACCOUNTABILITY MODEL	
Management scheme for gravity irrigation, indigenous irrigation systems, organizational approach	116
ACTION PROGRAMS	
Farmers' participation, watershed management projects, India	296
ACTION RESEARCH (see also APPLIED RESEARCH)	
Canal irrigation, traps, tactics, codes	677
Participatory approach, water distribution, Philippines	676
Water resources development, Nepal	28
ADAPTIVE RESEARCH	
Water resource development, Nepal	28
ADMINISTRATION	
Agricultural development, decentralization, organizational setups	125
Agricultural development, efficiency, Taiwan	779
Central government, local units, coordination and close interaction, India	129
ADMINISTRATIVE ARRANGEMENTS	
Water resource planning	706
ADOPTION RATES	
Conservation techniques, watershed management, India	296
AERIAL PHOTOGRAPHY (see also REMOTE SENSING)	
Ditch and dike design layouts, Thailand	191

AFFORESTATION
Damodar Valley Corporation, multipurpose projects, India 179

Effects on water yield, Malaysia 413

Pasture land development, watershed management, India 305

AGNO RIVER (PHILIPPINES)
Multipurpose project, San Roque, feasibility studies 89,561

Sediment problems and solutions 392,398

AGNO RIVER BASIN (PHILIPPINES)
Lower Agno Development Plan, multipurpose projects 88

AGRICULTURAL COASTAL LANDS (see COASTAL LANDS)

AGRICULTURAL CREDIT
Institutional, tenure, communal irrigation, Philippines 230

AGRICULTURAL DEVELOPMENT
Forest conversion, hydrological problems, Malaysia 356

Integrated, irrigation, Philippines 119

Technical and economic problems, Mekong Basin 98,110

Water management, institutional and legal factors, irrigation projects, Nepal 797

Water resources development, irrigation water management, Taiwan 113

AGRICULTURAL ECONOMIC EVALUATION
River basin development projects, reservoirs, Taiwan 528,529,530 539,540

AGRICULTURAL EXTENSION
On-farm development, water management, Chambal Project, India 129

AGRICULTURAL INPUTS
Water management, crop production 122

AGRICULTURAL MODERNIZATION
Irrigation systems, local culture, Japan 267

AGRICULTURAL PATTERNS (see CROPPING PATTERNS)

AGRICULTURAL POLICY
Irrigated agriculture, Thailand 63

AGRICULTURAL PRODUCTION
Climatic water balance, Java, Indonesia 229

Deep tubewell areas, CARE, Bangladesh 662

Dry zone, Sri Lanka 623

Irrigated agriculture, Thailand 63

Irrigation projects, rice self-sufficiency, Korea 266

Resource allocation, Terai, Nepal 143

Slopelands, Taiwan 452

Water problems, east and west coast, Malaysia 409

AGRICULTURAL PROJECT ANALYSIS SYSTEM (APAS)
Data processing, agroeconomic data, BCA 481

AGRICULTURAL RESEARCH
Water use, river valley projects, India 103

AGRICULTURAL WATERSHEDS (see also WATERSHEDS)
Parametric models, runoff estimation, India 312

AGROECONOMICS
Development of water resources, master plan, Indonesia 112

AGROFORESTRY
Erosion control, forest management, Philippines 349,415

Tree planting, erosion and sedimentation control 280

Watershed rehabilitation 282

ALGAE (see AQUATIC WEEDS)

ALGORITHM
Irrigation planning, linear programming, Bangladesh 535

ALKALI SOILS (see SALINE SOILS)

ALLOCATION
Farm resources, Eolo River Basin, Indonesia 583

ALLOCATION PRINCIPLES
Irrigation development 475

ALTERNATIVE CROPPING SYSTEMS
Upland irrigation, Malaysia 519

ALTERNATIVE IRRIGATION TECHNIQUES
Irrigation impact, economic analysis, India 173,292

AMBUKLAO DAM
Operational capacity, Philippines 89

Watersheds, problems, Philippines 406

ANGAT MULTIPURPOSE RESERVOIR PROJECT
Capital assistance, ADB, Philippines 567,850

ANGAT-MAGAT AGRICULTURAL DEVELOPMENT PROJECT
Irrigators' associations, compact farms, NIA, Philippines 765,776

Small-scale irrigation rehabilitation, integrated agricultural development, ADB, Philippines 851

APPLIED RESEARCH
Irrigation efficiency, waterlogging, salinization, Pakistan 345

APPROPRIATE TECHNOLOGY
Irrigation, ADB 119

Rural sanitation, manpower development, information dissemination, Indonesia 361

Rural water supply, hand-operated pump, Philippines 582

AQUATIC PLANTS
Potential growth, Lower Mekong Basin, Thailand 390

AQUATIC WEEDS
Algae multiplication, water quality, Laguna Lake, Philippines 417

Man-made lakes, management and control, Indonesia 408

AQUIFERS
Groundwater supply, inflow and outflow of freshwater, Metro Manila 45

International Law 803

Wells hydrology and hydrogeology, withdrawal urban areas, Philippines 102

ARID LANDS
Irrigation, technology transfer 78

Waterlogging, salinity, cropping patterns, Pakistan 283

ARTESIAN WATER
Supplies, recharge zones, forest cover maintenance, Nepal 291

ASIA BUREAU (see also USAID)
USAID public health, water supply, case studies 124

ASIAN DEVELOPMENT BANK
Budget allocation to water resources projects in Asia 857

Integrated agricultural development, compact farms, financing, Philippines 765,851

Irrigation, appropriate technology, small schemes 119

Irrigation development and management regional seminar 816

Loans breakdown, irrigation development Angat Multipurpose Reservoir Project, Philippines 850

Seminar on irrigation development 744

ASIAN PRODUCTIVITY ORGANIZATION
Farm management, rice cultivation, Nepal 176

Surveys, farm water management, rice cultivation, Asia 659

ASSOCIATIONS (see also IRRIGATION ASSOCIATIONS)
Water users, government agencies, big landowners 149

AUTONOMOUS IRRIGATION ASSOCIATIONS
Japan 786

Taiwan 808

AZUSA RIVER BASIN
Land improvement, agricultural development, Japan 428

BAMBOO TUBEWELLS
Costs, alternative irrigation systems, Bangladesh 128

BANGKOK SEWERAGE SCHEME
Pollution study, Chao Phya River, Thailand 411

BEAS PROJECT (INDIA)
Beas-Sutlej system 534

Dam construction project 168

Watershed management 298

BEHAVIOR
Irrigators 118

BENEFIT-COST ANALYSIS
Alternative domestic water supply, water district, Philippines 495

Chao Phya Irrigation Project, economic and social analysis, Thailand 481

Price levels, water and land development projects, Taiwan 508

Water development projects, Chao Phya Project, Thailand 513

BENEFIT-COST RATIOS
Local community resource mobilization, capital formation, irrigation rehabilitation, Philippines 206

Multiple objective investment program 493

BHAKRA-NANGAL MULTIPURPOSE PROJECT (INDIA)
Multipurpose projects, irrigation efficiency, local consequences 183

Siltation rate 330

Watershed management 298

BHUMIPHOL DAM (THAILAND)
Hydroelectric power, large-scale dam projects 192

Reservoir sedimentation, watershed problems 410

BICOL RIVER (PHILIPPINES)
Flood simulation models 347,348

Salinity barrier, dike and drainage design 355

Spatial analysis, water management 536

BICOL RIVER BASIN DEVELOPMENT PROJECT (PHILIPPINES)
Bicol River, flood control measures, salinity intrusion 348

Comprehensive planning, flood control, irrigation 97

Groundwater, Rinconada Project 54

Hydrological analysis, fisheries, crop diversification 416

Independent line agencies, field coordination 773

Investment, component 393

Irrigation development, surface water analysis 81

Salinity intrusion, flood control, drainage projects 348

Water balance study 570

BIOGAS PRODUCTION
Local technologies, farm wastes, water pollution control, China 439

BLOCK IRRIGATION
Extension, Muda irrigation, Malaysia 670

BRAHMAPUTRA RIVER
Feasibility basinwork planning, Bangladesh 498

CADASTRAL SURVEYS
Ditch and dike design and layout, Thailand 191

CAGAYAN RIVER BASIN
Hydroelectric projects, Philippines 399

CANAL-BASED ORGANIZATION UNIT
Irrigation management, gravity irrigation 116

CANAL DESIGN
Topography, irrigation facilities, Malaysia 381

CANAL IRRIGATION
Water users organizations, collective management, India 672,736 743

CANAL IRRIGATION SYSTEMS
Centralized planning, decentralized management, Taiwan 779

Economic rent estimation, tubewell water costs, Pakistan 839

Institutional water rationing, water distribution forms, India 737

Irrigation research action, traps, tactics, and codes 672

CANAL POSITION
Gravity irrigation, water delivery, differential access, institutional aspects 690

CANAL SYSTEM
Cropping scheduling, secondary and tertiary canals, Indonesia 651

Remodeling, rotation system, maintenance, India 164,165

CANALS
Designs, unlined, incised canals, India 627

Irrigation main systems, design, and operation management 654

Operation and maintenance, Taiwan 779

Red Flag Canal, China 259

Structure designs, water loss, Pakistan 680

Yangtze River, transportation, China 55

CAPACITY ESTIMATES
Resources potential, plan, Chico River Basin, Philippines 606

CAPACITY UTILIZATION
Low-lift pumps, Bangladesh 613

CAPITAL ALLOCATION
Water conservancy and irrigation, China 450

CAPITAL-INTENSIVE
Multipurpose dams, labor mobilization, water projects, China, Yellow River Basin 250

CASE STUDIES 714
Canal irrigation, water distribution, India 743,814

Conflict between rice and sugarcane farmers over irrigation water, Thailand 235

Cooperatives, pump irrigation bureaucratic arrangements, Thana Irrigation Project, Bangladesh 133,712

Development of Kitakami River Basin, water control, Japan 268

Diagnostic analysis, irrigation system management, IRRI, Philippines 461

Diezmo Irrigation System, Philippines 233

Economic appraisal, social BCA, irrigation projects, India 503

Environmental consequences, Kosi Project, India 332,783

Farm-level water management, village organization, Indonesia 758

Farmers organization, Muda Irrigation scheme, Malaysia 755

Gravity irrigation, indigenous systems, Organizational approaches 116

Groundwater use, tubewells, Gangetic Plains, India 142,170

Health problems, water supply, sanitation 124

Irrigated dry season crop producton, profitability, farm assets, risks, Thailand 196,823

Irrigation associations, Taiwan 784,788

Irrigation associations, Thailand 757

Irrigation water management, organizational arrangements, village-level 125

Irrigation, water pricing, irrigation potential benefit 509,650

Irrigators cooperative, Philippines 201,203
750,768

Linear programming, planning irrigation projects, irrigation methods, Bangladesh 535

Multiobjective decision model, India 588

Nam Pong project, Thailand 232

On-farm and off-farm irrigation, water delivery, Taiwan 254

Outlet command area, problem identification, water management, Pakistan 161

Rural water supply, water pricing, water allocation 73

Waterlogging, salinity problems, irrigation effects, Pakistan 294,345

Watershed management, agricultural water supply, Philippines 407

Watersheds, land and water use planning, India 342

CATCHMENT AREAS (see WATERSHEDS)

CAUVERY BASIN
Optimum water use, proposal, India 525

CENTRAL GOVERNMENT
Administration of major and medium irrigation projects, India 738

Water management, coordination, local units 125

Water management, close interaction, local units, India 129

Water projects, international aid 837

CENTRALIZED PLANNING
Water management, people's communes, work farms, China 704

CENTRALIZED WATER USERS' ASSOCIATION
India 808

CHAINAT DAM, THAILAND 513

CHAMBAL VALLEY DEVELOPMENT PROGRAM
On-farm development, agricultural extension, water management, India 119,129

CHANNASUT LAND CONSOLIDATION PROJECT
Social organization of irrigation, Thailand 753,754

CHANNELS
Earthen, gravity irrigation, lift irrigation, Bangladesh 133

CHAO PHYA BASIN (THAILAND)
Water operations system, operation and maintenance 618,620

Water problems, environmental problems 410

CHAO PHYA DELTA
Irrigation and drainage, historical development, Thailand 609

CHAO PHYA DIVERSION DAM
Hydroelectric power, large scale projects, Thailand 192

CHAO PHYA IRRIGATION PROJECT (THAILAND) 481
Economic and social benefit-cost analysis 505,513

Historical development, economic perspective 231

Preliminary studies 617

Organizational and engineering aspects 777

Surface drainage system 227

CHAO PHYA RIVER (THAILAND)
Hydraulic model, drinking water supply, water diversion 346

Hydrodynamic models, river flow investigation 351

Salinity causes and preventive measures 388

Water pollution study 411

Water resource projects, problems of implementation 38

CHECK DAMS
Sediment control, loess plateau, China 442

Siltation, erosion control, watershed management, India 302

CHEMICAL RESIDUES
Irrigation water quality, Chao Phya Basin, Tnailand 410

CHICO RIVER
Hydroelectric projects, flood frequency curves for spillway and diversion works, Philippines 399

CHICO RIVER BASIN
Framework plan, resources potential, Philippines 606

CISTERN SERVICES
Hydraulics, Sri Lanka 546

CLIMATE
Humid tropical Asia natural resource development 6

Rainfall, evapotranspiration, water resources, Malaysia 52

Rainfall, water loss, water supply, India 8

Types, rainfall distribution, via culture, Philippines 37

Water balance, climate 7

Water balance, India 24

Water balance, maps 5

COASTAL LANDS
Protection, design, and construction of sea dikes, Malaysia 414

COLLECTIVE DECISION MAKING
Land allocation, cultivation, water distribution, Sri Lanka 159

COLLECTIVE MANAGEMENT
Canal irrigation, water distribution, India 743

COLORADO STATE UNIVERSITY, WATER RESEARCH PROJECT
Field research, water management, Pakistan 684

COMMAND AREA
Irrigation systems, pump irrigation, tubewells, Bangladesh 134

Social science research, India 470

Warabandi irrigation improvement, India 186,496

COMMAND AREA DEVELOPMENT (INDIA) 462,814
Integrated water management approach 815,853

Land and water improvement activities 834

Water use efficiency, water sharing research needs 742

COMMUNAL GRAVITY SYSTEMS
Organization profiles, Philippines 751,752

COMMUNAL IRRIGATION
Economic impacts, labor mobilization, credit, Philippines 230

COMMUNAL IRRIGATION SYSTEMS 39,239
Operation and organization, problems, Philippines 679,768

COMMUNAL LABOR USE
Local resource mobilization, irrigation rehabilitation, benefits, Philippines 206

COMMUNAL MANAGEMENT
Water distribution, small-scale projects, India 180

COMMUNAL SYSTEMS
Participatory approach, Philippines 203,759

COMPACT FARMING
Integrated agricultural development, ADB, Philippines 851

COMPACT FARMS (see also IRRIGATORS' ASSOCIATIONS)
Water management irrigators' association, Philippines, ADB 765

COMPARATIVE ANALYSIS
Irrigation performance, life and gravity vs. lift, case studies, Bangladesh 133

COMPLEMENTARITIES
River water use, systems analysis, Lower Ganges-Brahmaputra Basin, Bangladesh 471

COMPUTER PROGRAM
Evapotranspiration estimates, India 515

Water release, diversion points, irrigation delivery schedule, UPRP, Philippines 531

COMPUTER SIMULATION
Investment appraisal, BCA, Muda scheme, Malaysia 504

CONFERENCES
United Nations, water, Mar del Plata, Argentina; water development, supply and management 1

CONFLICT RESOLUTION
Water delivery system, customs, water rights, Pakistan 798

CONFLICTS
Irrigation development, irrigation delivery, Sri Lanka 174

Irrigation and farmers, Philippines 199

Organizational and institutional issues 695

River water diversion, international rivers, resolution, Ganges River 809

Traditional patterns, modern needs, water allocation, India 310, 737, 742

Water distribution, rice and sugarcane farmers, Thailand 235

Water rights, interregional, Azuza River Systems, Japan 802

Water use, head-end vs. tail-end location, canal system, Philippines 241

Water use, irrigation vs. urban use, Japan 580

CONFRONTATIONS (see CONFLICTS)

CONGRESSES/CONFERENCES
Regional conference on Water Resources Development, Asia 76

CONSERVATION IMPLEMENTATION
Planning, tropics 273

CONSERVATION PLANNING
Implementation, tropics 273

CONSTRAINTS
Farmers' reaction, water management, Indus Basin 516

CONSTRUCTION PROJECTS
Environmental deterioration, causes and effects, Himalayas 324

CONTINUOUS IRRIGATION
Water distribution, rotational irrigation, UPRP, Philippines 209, 242

CONVEYANCE CONDITIONS
Water management, improvements, crop-water relationships, Philippines 640

CONVEYANCE LOSSES
Dams, reservoirs, tertiary levels, Indus River, Pakistan 146,723

COOPERATION
Competition, water use, labor mobilization, Pakistan 163

Farmer-to-farmer, water distribution 127

COOPERATIVE ACTION
Government and water users 122

COOPERATIVE DEEP TUBEWELL
Irrigation performance, cropping practices, Bangladesh 150

COOPERATIVES
Case study, Philippines 750

Low-lift pumps, deep tubewells, irrigation 708
management, Bangladesh 712,717

CORRELATIVE RIGHTS DOCTRINE
Groundwater rights and regulations, economic value, India 741

COST ALLOCATION
Multipurpose projects, Philippines 567

COST-BENEFIT ANALYSIS (see also BENEFIT-COST ANALYSIS)
Minor irrigation projects, theoretical formulation 483

COSTS
Water resources development, dam construction, irrigation water 643

COTABATO-AGUSAN RIVER DEVELOPMENT PROJECT
Multipurpose project, profile, Philippines 82

CRASH PROGRAM
Interfarm, ditch and dike design, Thailand 191

CREDIT
Low-lift pump irrigation, institutional factors, Bangladesh 719

CRITICAL WATERSHED (see also WATERSHEDS)
Watershed problems, Ambuklao and Binga, Philippines 406

CROP DIVERSIFICATION
Evaluation project, hydrological analysis, Bicol River Basin, Philippines 416

Terminal facilities, rotational units, water distribution, Malaysia 237

Water management, simulation analysis, Sri Lanka 527

CROP GROWTH
Water pollution, industrial waste water, Taiwan 423

CROP PRODUCTION
Irrigation scheduling, wheat, maize, fodder, Indus Basin, Pakistan 146

Water environment, water management 122

CROP RESPONSE
Irrigated vs. nonirrigated crops, water use efficiency, Thailand 194

Irrigation, water fee, water management 127

Water deficiency, waterlogging and salinity, underirrigation, Pakistan 308

CROP SHARING
Distribution system, sharebidders, land cultivation, Sri Lanka 159

CROP WATER REQUIREMENTS
Dry zones, Sri Lanka 160

CROP YIELDS
Irrigation efficiency, water deliveries, Pakistan 144

CROPPING INTENSITY
Sederhana irrigation program, yield increase, Indonesia 204,222

CROPPING SYSTEMS
Irrigation water management practices, recent studies 3

CROPPING PATTERNS
Arid lands, waterlogging and salinity control, Pakistan 283

Comparative analysis of shallow tubewells, deep tubewells, and low-lift pumps, Bangladesh 150

Erosion control, pepper, Malaysia 363

Gradient levels, watersheds, crops, India 326

Irrigation calendar, rainfall pattern, Sri Lanka 135

Irrigation water supply, economic study, Taiwan 256

River basin 84

Simulation, water management, Pakistan 187

Water distribution, crop water needs, Indonesia 222

CULTIVATION COMMITTEES
Farmer organizations, local irrigation management, Sri Lanka 725

CULTIVATION CYCLES (see CROPPING PATTERNS)

CUSTOMARY IRRIGATION SYSTEM (see TRADITIONAL IRRIGATION SYSTEMS) 261

CUSTOMS (see TRADITIONS)

CYCLONES 283

DAM CONSTRUCTION
Cost increases, water resources development, irrigation water 643

DAMODAR RIVER
Data, Damodar Valley Project, India 592

DAMODAR VALLEY CORPORATION
Flood control, multipurpose project, malaria project, India 179

History, canals, irrigation, benefits, India 592

DAMS
Construction, labor intensity, employment, small scale, India 178

Indus Basin, conveyance loss, Pakistan 146

Large-scale projects, Chao Phya Diversion Dam, Sirikit and Bhumiphol dams, Thailand 192

Reservoirs, projects, Philippines 39,46

Rockfill dam at Kiso River, irrigation water supply, Japan 251

DATA BANK
Water resources, Data Bank Project, Philippines 42

DECENTRALIZED ADMINISTRATION
Irrigation associations, historical development, Taiwan 781

DEEP TUBEWELLS (see also TUBEWELLS)
Agricultural production, Bangladesh 605,662

Comparative analysis of shallow tubewells and on lift pumps, Bangladesh 150

Cooperative management, Bangladesh 717

DEFORESTATION
Effects on agricultural production, downstream effects, Indonesia 376

Environment and development, South Asia 341

Environmental problems, industrial and agricultural activities, India 328

Land-use change, effects on water yield, Malaysia 413

DELTAIC AREAS
Development, planning approaches 285

DEMOGRAPHY
Data base, geography, project proposals, water supply and sanitation, Philippines 114

DESERTIFICATION
Case study, waterlogging and efficiency, Pakistan 345,728

Environment and development, Asia 274

Heavy siltation, soil erosion, terai, Nepal 337

Shelterbelts, localized management approaches, China 418, 422,456

UN conference 284

DESERTS
Water supplies augmentation, rainwater storage, India 292

DESIGN CRITERIA
Farm irrigation and drainage ditches, rice cultivation, Taiwan 391

Layout, ditches and dikes, interfarm, irrigation improvement, Thailand 191

DESIGNS
Farm ditches, custom fit, participatory approach, Philippines 698

Salinity, barrier, dike and drainage construction, Bicol River, Philippines 355

Unlined, incised canals, India 627

Water resource systems 468

Water supply, standards and production, Nepal and Bhutan 547

DEVELOPMENT AGENCIES
Watershed management and rehabilitation, Pakistan 289

DEVELOPMENT COSTS
Irrigation, regional levels, drainage 121

DEVELOPMENT PATTERNS
Alternatives, lifestyles, water resources development, Asia 274

DEVELOPMENT PLANS
Irrigation, water supply of hydropower, surface and groundwater, Philippines 108,764

Laguna Lake, urban expansion, Philippines 85,86

Water resources, groundwater irrigation, Indonesia 111,112

Watersheds, soil and water conservation 279

DEVELOPMENT POLICIES
Multipurpose projects, integrated area development concept, Philippines 813

DEVELOPMENT PROCESS
Improving irrigation water management 616

DEVELOPMENT PROGRAMS
Water resources, problems, social or economic aspects, Indonesia 599

DEVELOPMENT PROJECTS
Environmental consequences, Kosi Project, India 332

Water resources, soil conservation, management, Asia 76

DHARMA TIRTA (see also IRRIGATION ASSOCIATIONS)
Village ditchtenders, village organization, farm-level water management, Indonesia 205,758

DIAGNOSTIC ANALYSIS
Case studies, field research methods, irrigation system management, IRRI, Philippines 461

DIFFERENTIAL ACCESS (see also WATER ACCESS AND WATER DISTRIBUTION
Gravity irrigation, water delivery, institutional aspects 200,690

Water distribution, tail-end syndrome, social and institutional factors, Philippines 201

DIKES (see also DITCHES)
Programs, Thailand 663

DIRECTORY
Water resources, development agencies, Philippines 770

DISEASE
Statistics on waterborne, WHO, drinking water supply, sanitation, ASPAC countries 2

DISPUTES (see CONFLICTS)

DISSOLVED SEDIMENT LOAD
Drainage basins, Malaysia 366

DISTRIBUTION CHANNEL
Irrigation performance, Philippines 243

DITCH DENSITY
Effect on irrigation performance, Philippines 243

DITCHES (see also LATERALS)
Design participatory approach, Philippines 698

Dikes design, interfarm, irrigation improvement, Thailand 191,663

DITCHTENDERS
Institutional and social factors, gravity irrigation, Philippines 697,749

Link between water users and irrigation officials 241,786

Ulu-ulu, farm level irrigation, water management, Indonesia 222,758

DIVERSION IRRIGATION SYSTEMS
Water scheduling, area estimation, Philippines 674

DIVERSION WEIRS
Indus Basin, storage dams, conveyance losses, Pakistan 146

DOCUMENTARY
Historical evidence, irrigation studies 666

DOMESTIC WATER DEMAND
Per capita, present and future estimates, urban populations, sanitation pollution, ESCAP region 4,683

DOMESTIC WATER SUPPLY
Damodar Valley Corporation, multipurpose project, India 179

Feasibility studies, improvement programs, water rates, water districts, Philippines 553,555,556 557,558,559

Institutional mechanisms, local participation, Thailand and Vietnam 707

Provisions for drinking water, projects, treatment methods, Thailand 33

DOUBLE CROPPING (see also MULTIPLE CROPPING)
Drainage problems, crop yields, Malaysia 401

DRAINAGE
Deltaic areas, flood control, irrigation 285

Dikes and ditches, design, interfarm, Thailand 191

Double cropping, crop yields, Malaysia 401

Historical development, Japan 56,252,429

Indian subcontinent 13

Irrigation withdrawal rates, flood control, Bicol River Basin, Philippines 348

Large-scale projects, Philippines 107,354

Programs and projects, status and accomplishments, Metro Manila, Philippines 396

Rice cultivation, problems 121

DRAINAGE BASINS
Suspended and dissolved sediment load, Malaysia 366

DRAINAGE LAYOUT
Irrigation, rice cultivation, Malaysia 632

DRINKING WATER
Community supply, sanitation, waterborne diseases, WHO, Asian-Pacific countries 2

Contamination, handpumps, water quality, WHO, India 343

Water diversion, hydraulic model, pumping station, Chao Phya River, Thailand 346

Wells, water supply, project proposals, Philippines 114

DRIP IRRIGATION 569

DROUGHT PRONE AREA PROGRAMME
Economic evaluation, watershed management projects, India 296,303

DROUGHTS 287

DRY FARMING
Irrigation, economics, Thailand 614

DRY SEASON IRRIGATION
Economic analysis, Thailand 196,614

ECONOMICS
Irrigation, dry farming, Thailand 614

Irrigation investment, Taiwan 497

ECONOMIC ANALYSIS
Demand-supply study of physical and human resources, Mekong River Basin, Resources for the Future 110

Dry season irrigation, Thailand 614

Energy alternatives, irrigation pumps, India 170,477

Gravity irrigation, economic performance, Philippines 488

Historical development, Chao Phya River Development, Thailand 231,513

Irrigated river basin 480

Irrigation 118

Irrigation investment, management decisions 852

Irrigation investment and management decisions, Asia 509

Irrigation, paddy production, Malaysia 236

Irrigation projects, social benefit-cost analysis, case study, India 158,484 503,512

Irrigation role, farm modernization, Japan 607

Irrigation water supply, crop pattern, Taiwan 256,610

Project planning, water resources, Philippines 813

River basin project, Taiwan 258

Shallow tubewells, multiple cropping, Bangladesh 484

Small-scale irrigation systems, tubewells, Bangladesh 591,605

Water development projects, feasibility, evaluation tools 489

Water use, production data, linear programming, India 157

ECONOMIC BENEFITS
Command area, India 496

ECONOMIC EVALUATION
Integrated project, irrigation, drainage, land consolidation, Taiwan 60,541

Tubewell irrigation, India 494

Water control, Chao Phya Project, Thailand 505

Water projects, benefits and costs, Philippines 74

Watershed management programs, Drought Prone Areas Program, India 296

ECONOMIC GROWTH
Irrigation development, Thailand 220

ECONOMIC IMPACT
Resource use optimization, water augmentation, India 500,501

Sederhana (simple) irrigation, Indonesia 598

ECONOMIC INCENTIVES
Irrigation planning, water management, Sri Lanka 491

ECONOMIC RENT
Cost of tubewell water, canal irrigation, Pakistan 839

ECONOMIC SURPLUS
Irrigation 117

EFFECTIVE RAINFALL
Least amount of irrigation lowland rice production, Philippines 619

EFFICIENCY (see also IRRIGATION EFFICIENCY)
Farm level water use, approaches, Thailand 457

Irrigation, estimation method 122

Irrigation water use, rice production, improvement Indonesia 111

Water use, efforts, India 166

EMPLOYMENT
Forestry component of watershed management, India 338

EMPLOYMENT OPPORTUNITIES
Mahaweli Development Project, Sri Lanka 188

New rice technology, irrigation, Indonesia 608

ENERGY
Hydroelectric, power, potential, hydropower program Nepal 105

Rural development, India 477,818

ENERGY SOURCES
Irrigation pumps, alternatives, economics, India 476,477

ENVIRONMENT
Development patterns, lifestyles, Asia 274

ENVIRONMENTAL ASSESSMENT
Thailand 404

ENVIRONMENTAL IMPACTS
Development projects, Kosi Project, India 332

ENVIRONMENTAL QUALITY
Nepal 340

EROSION
Cause, soil conservation, and watershed management programs, Nepal 96,315

Dams, solutions, Philippines 392

Effects of forest clearing, solutions 280

Gully channel, slope erosion, Japan 434,810

Runoff induced, hilly grassland, monsoon rain 350

Watersheds, India 335

EROSION CONTROL
Manual (handbook) on agroforestry, forest management, Philippines 349

Simulation models, management schemes, practices 277

Terracing, vegetative covering, check dams, Loess Plateau, China 443

Use of para-rubber plantation, Thailand 403

Watersheds, experimental watershed, India 302

Watersheds management, integrated village forestry, taungya 276

ESTIMATION
Flood, rational methods, urban areas, Malaysia 360

Water supply and demand, projections, water utilization, Philippines 43

EVALUATION
Irrigation potential 815

Methodology, organization, and management 688,689

EVALUATION TOOLS
Water projects, economic analysis 489

EVAPORATION
Estimation methods, Malaysia 633

Water loss, seepage, low irrigation, efficiency, India 183

EVAPOTRANSPIRATION
Estimates, computer program, India 515

Irrigation scheduling, irrigation efficiency, Pakistan 146

Rainfall, climate, water resources, Malaysia 52

Water loss, rainfall, water resources, India 8

EXPERIMENTAL WATERSHEDS
Erosion control, runoff and sediment control, India 302

EX-POST EVALUATION
River basin development, Pakistan 479

EXTENSION
Effective delivery, irrigation projects, rice self-sufficiency, Korea 266

Water management, small farmers, Indonesia 812

EXTERNAL EVALUATION
Evaluation, systems analysis, lower Ganges-Brahmaputra Basin, Bangladesh 471

Feasibility study of Pampanga River, Philippines 394,560

Flood risk mapping, Japan 449

Goal programming, Ganges Basin 522

Hydrological investigations, data collection and analysis, Malaysia 380,405

Ilog-Hilabangan River Basin Project, multipurpose projects, Philippines 226

Land conservation, flood forecasting, Japan 425,430

Land-use plans, land management, Malaysia 380

Large capacity outlets, Japan 425

Multipurpose reservoirs, Japan 444

Organization and management, large-scale irrigation 688

Pa Mong Project, Thailand 374

Prediction of design floods, Thung Ma Hiu Irrigation Project, Thailand 400

Projects, drainage programs, status and accomplishments, Metro Manila, Philippines 354,396

Projects, technical and economic programs, China 59

Salinity intrusion, projects, drainage, Bicol River Basin, Philippines 348

Simulation models, modifications, Bicol River Basin, Philippines 347

Spillway structure, Laguna Lake, Philippines 566

Urban river, urbanization, Japan 431

Water management, large-scale projects, Thailand 192

Water resources management, Nepal 337

FARAKKA BARRAGE
International rivers law, riparian disputes, Ganges River 809

FARM ASSETS
Fixed assets, profitability, risks, irrigated dry season crop production, Thailand 196

FARM DITCHES (see also DITCHES)
Density turnouts, water use efficiency, Philippines 655

FARM INCOME
Irrigation development, rice production, Malaysia 602

Rice production, support prices, irrigation projects, Korea 266

FARM-LEVEL ANALYSIS
Water management, irrigation 126

FARM MANAGEMENT
Rice cultivation, terai, tubewell irrigation, Nepal 176

FARM MODERNIZATION (see also AGRICULTURAL MODERNIZATION)
Role of irrigation, economic evaluation, Japan 607

FARM PRODUCTION COSTS
Irrigated or nonirrigated crops, crop yields, Thailand 194

FARMERS' ASSOCIATION
Irrigation pumps, repayment rate, Philippines 771

Muda irrigation scheme, social structure, Malaysia 767

Social laboratory project, water management problems and solutions, Philippines 198

FARMERS' ATTITUDES
Irrigation development, India 132

Irrigation, gravity systems, farmers' location, NIA, Philippines 241

Local irrigators group, operation and maintenance activities, Thailand 753

Water management, irrigation operation, Pakistan 161

FARMERS' COOPERATION
Relative to water adequacy, Philippines 241

FARMERS' LOCATION
Canal system, head-end vs. tail-end, conflicts on water use, Philippines 241

FARMERS' ORGANIZATION
Case study, Muda Irrigation Scheme, Malaysia 755

Development trends, Taiwan 785

Empirical studies, surface irrigation, India 710,722

Irrigation leadership, local irrigation management, Sri Lanka 725

Operation and maintenance, water facilities, Japan 793

Water use efficiency, case study, India 714,740

Zangjeras, organization and management of water, Philippines 201

FARMERS' PARTICIPATION (see also PARTICIPATORY APPROACH)
Block irrigation, extension, Muda irrigation, Malaysia 670

Effective organization, irrigation systems 699

Irrigation water management, institutional development, training programs 70

Management and operation, irrigation systems, Philippines 760

Water distribution, rotational vs. continuous irrigation, UPRP, Philippines 242

FARMERS' RESPONSES
Farm irrigation constraints, comprehensive field survey, Pakistan 467

Irrigation, socioeconomic factors, Thailand 216

Water management constraints, Indus Basin 516

FARMERS' SYSTEMS
Irrigation, diagnostic evaluation, flexible water delivery 70

FARMERS' TRAINING
Watershed management, India 330

FARM-LEVEL WATER MANAGEMENT
Asia 660

Burma 195

Gravity irrigation, problems, procedures, India 136,184

Irrigated systems, Thailand 638

Pakistan 138

Supplemental irrigation, rice yield increases, Philippines 127

FEASIBILITY STUDIES (PHILIPPINES)
Domestic water supply, water district level 551,552,553 554,555,556 557,558,559

Flood control program, Pawpanga River 560

Laguna Lake, hydraulic control 571

Multipurpose projects 562,563,565

San Roque Multipurpose Project, Agno River 89

Upper Cagayan River Basin, water projects 568

FERTILIZATION
Interaction with water, rice yields, Philippines 656

FIELD CAPACITY
Upland irrigation, irrigation model, Malaysia 365

FIELD CHANNELS
Economics of water management, India 630

FIELD EXPERIMENTS
Generalization, irrigation management, and development 681

FIELD RESEARCH
Evaluation, improved irrigation systems, India 682

Farm water management, Colorado State University, Pakistan 684

Water stress, rice cultivation, Philippines 687

FIELD RESEARCH METHODOLOGIES
Improved irrigation systems 678

Irrigation system management, case studies, IRRI, Philippines 461

FIELD SURVEYS
Irrigation constraints, farmers' responses, Pakistan 467

FIELD WATER USE
Dry zone crops, irrigation management, Sri Lanka 622,623

FISH POPULATION
Quality and quantity, effects of water control projects, India 310

FISHERIES
Multipurpose project, river basins, Philippines 226,416

Water quality and management, Laguna Lake, Philippines 417

FIXED ASSETS (see also FARM ASSETS) 196

FIXED ROTATION (see also WARABANDI) 169

FLAT WATERSHEDS (see WATERSHEDS)

FLOOD CONTROL
Deltaic areas, drainage and irrigation 285

Drainage, water quality, urban, Philippines 107,354

FLOOD ESTIMATION
Procedures, Malaysia 364

Rational Method, application, watersheds, Malaysia 360
384,386

FLOOD FORECASTING
River development, flood control systems, Japan 430

FLOOD FREQUENCY CURVES
Hydroelectric projects, spillways, and diversion works, Chico River, Philippines 399

FLOOD PLAIN MAPPING
Flood control, Malaysia 405

FLOOD PROTECTION (see also FLOOD CONTROL) 285

FLOOD RELIEF PROJECTS (see FLOOD CONTROL)

FLOOD RISK MAPPING
Flood control, nonstructural informational source, Japan 449

FLOODS
Damages 287

Design, watersheds, Thailand 370

Forests, rainfall interception, runoff, watersheds, India 300

High population density, water-related environmental problems, Pakistan 306

Hydrological data, Panpanga River Basin, Philippines 370

Magnitude, frequency, estimation, Malaysia 364

Reservoir operations, India 319

Slopelands, land reclamation, Japan 451

FOOD AND AGRICULTURE ORGANIZATION
Mahaweli Development Project, Water Resources Development Project, WB, Sri Lanka 162

Water resource study, WB, FAO, Harvard, Bangladesh 17

Watershed management project, UNDP, Philippines 389

FOOD PRODUCTION
Water resources management 835

FOOD REQUIREMENTS
Water resources programs, management techniques 286

FORD FOUNDATION
Financial support, Nam Pong Project, Thailand 367

IRRI, HYV's of rice, water resources, Bangladesh 17

Land and water management, India 834

Projects, water resource development, Asia 465

FOREST CONSERVATION
Watershed management, taungya, integrated village forestry 276

FOREST CONVERSION (see also DEFORESTATION)
Agriculture, erosion and sedimentation, watershed management 280

Rates, agricultural lands, Nepal 337

Watersheds, agricultural development, hydrological problems, control and management, Malaysia 356

FOREST DEGRADATION
Environmental deterioration, causes and effects, Himalayas 324

FOREST DEVELOPMENT
German Foundation for Developing Countries, forest management, Philippines 362

FOREST MANAGEMENT
Demonstration and training manual, watersheds, Philippines 359,362

Resources development, research improvement, humid tropical Asia 6

FOREST RESOURCES
Nepal 100

FORESTRY
Integrated research, Pakistan 473

Philippines 349
359,362

Support for agriculture, conservation, Indonesia 376

Watershed development, employment opportunities, land productivity, India 330,338

FORESTS
Floods, rainfall interception, runoff, watersheds, India 300

FUELWOOD
Watersheds, forest exploitation, India 330

GANGES BASIN
Impacts of optimal water use, population reinvestment 517,522

Induced groundwater recharge, simulation-optimization model, India 526,588

Integrated system studies, water resources development, India 460, 514,822

GANGES-KOBADAK SCHEME
Lift and gravity irrigation, irrigation performance, Bangladesh 133,708

GANGES RIVER
International rivers law, water diversion problems 809

Water utilization estimate, tubewells, India 23,142

GANGETIC PLAINS
Tubewell irrigation, India 140,142

GERMAN FOUNDATION FOR DEVELOPING COUNTRIES
Forest development of rehabilitation, watershed, Philippines 362

GOAL PROGRAMMING
Flood management, Ganges Basin 522

Indus Basin model, alternative approach 518

GOVERNMENT AGENCIES
Water control, state government warabandi, India 169

Watershed rehabilitation, Pakistan 289

GRASSLAND
Slopes, erosion control, effects on rain and runoff 350

Upland research programs, Philippines 415

GRAVITY IRRIGATION
Comparative analysis, lift irrigation, performance, case studies, Bangladesh 133

Economic evaluation, irrigation performance, Philippines 488

Farm level management problems and procedures, India 184

History, irrigation development and rehabilitation, Indonesia 189

Indigenous system, organization approaches, traditional system 116

Institutional social factors, organizational concepts, Philippines 200,203 213,749

Water delivery, canal position, differential access, institutional aspects 690

GRAZING
Controlled use, watershed management, India 335

Land clearing, erosion, and sedimentation 280

GROUNDWATER
Aquifer, total freshwater storage, Metro Manila 45,102

Available estimates, use and development, India 8,10,16,22 141,142,484 741,825

Bicol River Basin, physical characteristics, Philippines 54,570

Development and exploitation, Pampanga River Basin, Philippines 51 551,572

Development, irrigation, Terai, Nepal 11,96

Induced recharge, simulation-optimization model, alternative schemes, India 22,526

Industrial water needs, problems, urban areas, Japan 432

Irrigation, economic evaluation, Taiwan 60

Institutional alternatives, management 693

Large-scale projects to counteract salinity and waterlogging problems, Pakistan 294

Population growth supply, proposed projects, Philippines 114,544

Project planning, regulation, irrigation, NIA, Philippines 108

Recharge, estimates, availability, water loss, Sri Lanka 12,541

Storage, water supply facilities, government agencies, Philippines 47

Survey results, Cagayan Basin, Philippines 35

Utilization potential for irrigation, Indonesia development plans, Indonesia 111

Water loss, potential terai legal and organizational aspects of development, Nepal 26

Water supply, 100-Cities Project, urban improvement, Philippines 101

GROUNDWATER RECHARGE
Artificial, technological development, Japan 58

Estimation, Malaysia 40

GROUP ACTION
Pump irrigation, tubewells, small-scale irrigation, problems, Bangladesh 134

GULLY CHANNELS
Slope erosion, Japan 810

GULLY CONTROL
Structures, runoff, watersheds, India 334

GULLY PLUGS (see CHECK DAMS)

HAN RIVER
Chungju Multipurpose Dam, ISWACO, development projects, Korea 57

HANDPUMPS
Local level organization, maintenance system, India 343,739

HEAD-END LOCATION
Canal system, tail-end, conflicts on water use, Philippines 241

HEALTH CARE (see also PUBLIC HEALTH)
Policies, Asia Bureau (USAID), water supply, sanitation 124

HIGH-YIELDING VARIETIES
Moisture stress, irrigation design and management, Philippines 656

Rice culture, multiple cropping, water availability, India 172

Rice technology and irrigation, labor requirements, Indonesia 608

Water management, agricultural inputs, crop production 122

HILLY GRASSLAND
Conservation effects, monsoon rains, runoff, erosion 350

HIMALAYAS
Environmental deterioration, natural and human activities 25, 311,324

Gully control structures, runoff, watersheds, India 334

HOLISTIC UNIVERSE (see SYSTEMS ANALYSIS)

HYDRAULIC ENGINEERING
China 59

HYDRAULIC MODEL
Water diversion, urban drinking water supplies, Chao Phya River, Thailand 346

HYDROELECTRIC POWER
Development programs generation, industries location, India 103,106, 109,718

Large-scale dams, Chao Phya Dam, Sirikit Dam, Bhumiphol Dam, Thailand 192

Potential, water sources, projects, Nepal 20,27,28, 100,105

Projects, water resources development, China 59

HYDROGEOLOGY
Map, groundwater, aerial photogrammetry, Sri Lanka 12

Survey, methods and approaches, India 10

Wells and aquifers, groundwater, water quality, urban areas, Philippines 51,102

HYDROLOGICAL PROBLEMS (see EROSION, FLOODS, DROUGHTS)

HYDROLOGY
Natural resources development, humid tropical Asia 6

Stations, history, groundwater, Nepal 11

Wells and aquifers, water quality evaluation, urban areas, Philippines 102

HYDROPOWER
Indus River and tributaries, power simulation studies, Tarbola Dam, Pakistan 69

Large-scale projects, Philippines 89,107,399
520,562,554

IFUGAO RICE TERRACES
Water distribution, mountain tribes, village organizations, Philippines 193

IMPROVEMENT SCHEMES
Evaluation, irrigation performance 646

Irrigation water management 645

Water management, NIA, Philippines 640

INCENTIVE SYSTEMS
Irrigation associations, managers and users, Taiwan 779

INCOME DISTRIBUTION
Muda Irrigation Projects, Malaysia 211

INDIGENOUS IRRIGATION
Management, case studies, organizational approaches 116

INDIGENOUS SOCIAL RELATIONSHIPS
Irrigation management, water use program 577

INDIRECT ECONOMIC IMPACT
Project appraisal, risk and uncertainty, Muda scheme, Malaysia 504

INDUS BASIN
Salinization, Pakistan 333

INDUS RIVER
Discharge, coverage water development, Pakistan 21,69,306

Farmers' reactions, water management contraints 516

Groundwater projects, salinity and waterlogging control, India 294

Indus River, historical development, potential, Pakistan 69,146

Irrigation water management, Pakistan 307

Model, goal programming 518

INDUSTRIAL GROWTH
Water resources activities, Taiwan 245

INDUSTRIAL SITES
Hydropower development, power intensive industries, India 109

INDUSTRIAL WASTE WATER
Collection and treatment, public sewerage system, urban areas, Philippines 354

INDUSTRIAL WATER
Needs, groundwater supplies, urban areas, Japan 432

INDUSTRIALIZATION
Land and water pollution, Japan 448

INFILTRATION
Ipil-ipil plantation, watersheds, Philippines 353

Water loss, water course improvement, Pakistan 307

INFORMATION DISSEMINATION
Rural sanitation, manpower development, Malaysia 361

INFORMATION SOURCES
Reference materials water management, Pakistan 724

INFORMATION SYSTEM
Feedback links, irrigation, India 67

INSTITUTION BUILDING
Engineering aspects, irrigation project management 705

INSTITUTION-BUILDING PROJECTS
Integrated agricultural development, ADB, Philippines 851

INSTITUTIONAL DEVELOPMENT
Irrigation, training programs, farmer participation 70

INSTITUTIONAL FRAMEWORK
Improved on-farm water management, Pakistan 713

INSTITUTIONAL STRUCTURE
Flood control, river development, Japan 430

INSTITUTIONALIZATION
Irrigation management, main and tertiary levels, Sri Lanka 151

INSTITUTIONS
Domestic water supply, sanitation, project proposals, Philippines 114

Irrigation development 695

On-farm water management, legal factors, agricultural development, Nepal 797

INSURANCE
Irrigated dry season crop production, risk-bearing, subsidies, price supports, Thailand 196

INTEGRATED AGRICULTURAL DEVELOPMENT
Angat-Magat Agricultural Development Project, compact farms, ADB, Philippines 765

Muda Irrigation Scheme, Malaysia 838

Small-scale irrigation, institution-building projects, ADB, Philippines 851

INTEGRATED APPROACH
Command area development, India 462

Irrigation design, socioeconomics and engineering 459

Water resource management, rural areas 469

INTEGRATED AREA DEVELOPMENT CONCEPT
Project planning, multipurpose project, Philippines 813

INTEGRATED PROJECT
Economic evaluation, Taiwan 541

INTEGRATED RESEARCH (see also RESEARCH INTEGRATION)
Forestry resources, Pakistan 473

INTEGRATED RURAL DEVELOPMENT
Irrigation improvement, agricultural development, ICA, NIA, Philippines 576

INTEGRATED SYSTEM (see SYSTEMS ANALYSIS)

INTEGRATED VILLAGE FORESTRY
Watershed management, erosion control, forest conservation, China 276

INTEGRATED WATER MANAGEMENT
Command area development, India 814

Reservoirs, Yodo River Basin, Japan 83

INTENSIVE AGRICULTURE
Environment, development, South Asia 341

INTENSIVE CROPPING
Pump irrigation tubewells, traditional environment, Bangladesh 134

INTER-AMERICAN DEVELOPMENT BANK
Budget allocation to water resources project in Asia 857

INTERBASIN TRANSFER PROJECTS
Interregional approach, engineering aspect, India 800

INTERBASIN WATER TRANSFERS
Water redistribution, semiarid and arid zones, India 828

INTERDISCIPLINARY APPROACH
Problem identification, water management problems, Pakistan 161

INTERDISCIPLINARY RESEARCH (see also RESEARCH INTEGRATION)
Water resource management 464

INTERIM DEMONSTRATION PROGRAM
Pilot study, water quality, Philippines 395

INTERMEDIATE RESERVOIRS (see TANKS)

INTERNAL RATE OF RETURN
BCA, Muda scheme irrigation appraisal, Malaysia 504

Local community resource mobilization, capital formation, irrigation, rehabilitation, Philippines 206

INTERNATIONAL AIDS
Mekong Committee, capital and technical aids 836

Water projects, central government, problems 837

INTERNATIONAL APPROACH
Interbasin transfer projects, engineering expert, India 800

INTERNATIONAL BANK FOR RURAL DEVELOPMENT (see also WORLD BANK)
Mahaweli Development Project, water resources development, Sri Lanka 162

Water resources study, FAO, Harvard, Bangladesh 17

INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE 1,119
Irrigation development, rice cultivation, Taiwan 673

INTERNATIONAL COOPERATION
Hydropower exchange, India and Nepal 27

INTERNATIONAL COOPERATION AGENCY (JAPAN)
Feasibility study, multipurpose project, Philippines 576

INTERNATIONAL CREDIT
IDA, deep tubewells, evaluations, Bangladesh 474

INTERNATIONAL DEVELOPMENT ASSISTANCE
Credit, deep tubewells, evaluation, Bangladesh 474

INTERNATIONAL DONOR AGENCIES
World Bank, Inter-American Development Bank, ADB, UNDP 857

INTERNATIONAL LINKAGE
Sri Lanka 29

INTERNATIONAL RICE RESEARCH INSTITUTE
Irrigation system management, field research methods, case studies, Philippines 234, 243,461

Rice HYV's, Ford Foundation, water resources, Bangladesh 17

INTERNATIONAL RIVERS
Actual water needs, potential conflicts, Bangladesh 17,831

International actions 804

Riparian disputes, river water diversion, Ganges River 809

INVESTMENT APPRAISAL
Irrigation and small farm projects, Malaysia 504

INVESTMENT DECISIONS
Development and utilization of irrigation, SEA 506

INVESTMENT-INDUCEMENT RATIO
Subsidi desa case, irrigation loans, subsidies, Indonesia 212

INVESTMENTS
Directions and problems, irrigation systems, Philippines 74, 225,806

Irrigation and power, planning, India 106,178

IPIL-IPIL (see LEUCAENA LEUCOCEPHELA)

IRRIGATED AGRICULTURE
Japan 596

Labor absorption, surface irrigation, efficiency, India 155,166, 171,531

Thailand 217,238

IRRIGATED CROPPING (see IRRIGATED AGRICULTURE)

IRRIGATED RIVER BASIN (see also RIVER BASINS)
Economic analysis 480

IRRIGATION ADMINISTRATION
Case study, Kosi Project, India 733

IRRIGATION ALTERNATIVES
Bamboo tubewells, costs, Bangladesh 128

IRRIGATION AND DRAINAGE
Japan 56,429,445

Malaysia 358

Water problems, projects, China 59

IRRIGATION ASSOCIATIONS 784,787
Case study, Taiwan 788,795

Evolution, institutional model, decentralized administration, Taiwan 781,779

Irrigation pumps, repayment water, Philippines 771

Membership fee, farmers' ability to pay, irrigation subsidy, Taiwan 782
783,795

Operation, water distribution, Japan 780

Water users association, peoples' irrigation association, Thailand 757

IRRIGATION BENEFITS (see also BENEFIT-COST ANALYSIS)
Distribution of benefits, India 182

Economic benefits 117

Evolution, assessment 815

Nepal 482

IRRIGATION BUREAUCRACIES
Organization and operation, management control, India 185

IRRIGATION CALENDAR (see also IRRIGATION SCHEDULING)
Optimal cropping pattern, rainfall pattern, Sri Lanka 135

IRRIGATION CANALS (see also CANALS)
Water distribution and control, management factors, India 185

IRRIGATION CHANNELS (see also CHANNELS)
Density, effective water management, Taiwan 391

IRRIGATION CLASHES (see CONFLICTS)

IRRIGATION COMMITTEE
Communal decision making, activities, water distribution, tertiary units, Indonesia 205

IRRIGATION CONSTRAINTS
Water supply, farm location, field levelness, water-course conveyance, Pakistan 144

IRRIGATION COOPERATIVES (see IRRIGATION ASSOCIATIONS)

IRRIGATION DESIGN 118
Canal system, upstream water control, operation, Sri Lanka 5,135

Crop water needs, farmer water requirements, problems 577

Crop water requirements, management, HYV's, Philippines 656

Integrated approach, socioeconomics and engineering 459

Parameters, Bangladesh 668

Terminal system, water delivery, rotation units, Malaysia 237

IRRIGATION DEVELOPMENT
Critical issues 62

Economic growth, Thailand 220

Evaluation of allocation principles 475

Farmers' attitudes, India 132

Japan 252

Major works, village schemes, flood protection, drainage and reclamation works, lift irrigation, Sri Lanka 148

Water management, Malaysia 821

IRRIGATION DISTRICTS
Local water management, autonomous units, water fees, China 790

IRRIGATION ECONOMICS
Dry season, Thailand 614

India 594

IRRIGATION EFFICIENCY (see also IRRIGATION PERFORMANCE) 133
Applied research, waterlogging and salinization, case study, Pakistan 345

Crop diversification, Indonesia 214

Estimation 122

Land preparation, water management, yield response, Thailand 194

Management, operation of canal systems, decentralization, Taiwan 779

Overall project, UPRP, field efficiency, Philippines 197

Rotational vs. continuous, yield charge and cost, Philippines 209,219

Scheduling, improved crop production, Indus Basin, Pakistan 146,156

Tertiary subsystem irrigation delivery, Pakistan 144

Weaknesses in project design, water loss, India 183

IRRIGATION EXTENSION (see also AGRICULTURAL EXTENSION)
Block irrigation, farmers' participation, Malaysia 670

IRRIGATION FEE COLLECTION
Criteria, Taiwan 849

IRRIGATION FINANCING
Water charges, water tax, operation and maintenance costs, Indonesia 510

IRRIGATION IMPACT
Productivity increase, agricultural production, India 173

Social conditions, reservoir area, Taiwan 593

Socioeconomic changes, Lam Pao Project, Thailand 378

IRRIGATION IMPROVEMENT (see also IRRIGATION MAINTENANCE)
Ditch and dike design and layout, Thailand 191

IRRIGATION INFRASTRUCTURE
Sederhana irrigation program, USAID, Indonesia 204

UPRP, NIA, water management, Philippines 197

Water management, agricultural inputs, crop production 122

IRRIGATION INVESTMENT
Feasibility, priority and repayability criteria, Taiwan 497

Intensification, economic analysis, Asia 509

Irrigation technologies, management decisions 852

Philippines 225

Power sector, India 106

IRRIGATION LEADERSHIP
Farmers' organization, local irrigation management, Sri Lanka 725

IRRIGATION LINKAGES
Water, crop and product linkages, interactions, India 711

IRRIGATION LOANS (see also SUBSIDIES)
Village subsidy program, administration, government financing, Indonesia 212

IRRIGATION MAINTENANCE
Canal system, India 164

IRRIGATION MANAGEMENT
Agricultural development, Taiwan 113, 244,610

Gravity, case studies, organizational approaches 115, 116,126

Pilot programs, Bangladesh 130

Problems, planning weaknesses, field research methodologies, IRRI, Philippines 461

Water management, land and water conservation, policy formulation, Asia 601

IRRIGATION METHODS
Sederhana (simple), economic impact, Indonesia 598

Upland crop, Malaysia 365

IRRIGATION OPERATION (see also IRRIGATION MANAGEMENT)
Canal system, village tanks, upstream water control, Sri Lanka 135

IRRIGATION ORGANIZATIONS
Agricultural inputs, crop production, water management 122,125

Honor concept, cooperation and competition on water use, labor mobilization, Pakistan 163

IRRIGATION PERFORMANCE
Evaluating improvements 646

Factors, ditch density, distance, Philippines 243,488

Irrigation schemes, costs, types, Malaysia 511

Lift and gravity vs. lift irrigation, case studies, Bangladesh 133

IRRIGATION PLANNING 118
Cropping patterns, waterlogging and salinity, pricing, plans and prospects 3,78

Development plans, water utilization, NIA, Philippines 108

India 64

Water deficits, simulation models 537

IRRIGATION POLICY 118
Developments and history, Malaysia 846

IRRIGATION PONDS (see also WATER HARVESTING STRUCTURES)
Watershed management, local labor, India 344

IRRIGATION POTENTIAL
Utilization and assessment 815

IRRIGATION PRACTICES
Factors for Improvement, Philippines 612,848

Reclaimed alkali soils, India 323

Year-round irrigation, Indus River, WAPDA, Pakistan 21

IRRIGATION PRICING
Benefits and costs, farmers' income and government revenue, Philippines 848

IRRIGATION PROJECT EVALUATION
Agricultural economic evaluation, Taiwan 540

IRRIGATION PROJECTS
Aichi Irrigation Project, Japan 265

Economic evaluation, social BCA, case study, India 175, 501,503

History, national, communal, private, Philippines 48, 107,233

Ilocos Norte Irrigation Project, Philippines 576

Institutional and legal factors, Nepal 797

Kemubu Irrigation Project, Malaysia 210

Korea 255,266

Lift and gravity, Ganges-Kobadak, performance, Bangladesh 133,134

Mae Klong Irrigation Project, conflicts in water use, Thailand 235,661

Muda scheme, indirect economic impacts, project appraisal, Malaysia 504

Pekalen Sampean Irrigation Project, Indonesia 32,222,510

Technical and social problems and solution, Sri Lanka 491,527

Terai, groundwaters, hill areas, Nepal 96

IRRIGATION PUMPS
Agricultural development, appropriate technology, ICID, sun pumps 119

Low-lift capacity utilization, Bangladesh 613

Small scale, effects on rice yield, Indonesia 189

Techno-economic alternatives, India 502

IRRIGATION REFORM
Monetary incentives, decision-making restructuring, central government, Korea 858

IRRIGATION REHABILITATION
Korea 248

IRRIGATION RESEARCH
Traps, tactics and codes 677

IRRIGATION SCHEDULING
Potential evapotranspiration, improved crop production, Punjab, Pakistan 146

IRRIGATION SCHEMES
Costs and performances, Malaysia 511

IRRIGATION SOCIETY
Zangjera, water user organizations, Philippines 201,218

IRRIGATION STATISTICS
Large-scale projects, communal, pump irrigation, Philippines 39

Nepal 28

USAID budget allocation for Asia, development strategies 70

Water demand estimates, Indian subcontinent 13

IRRIGATION SYSTEMS
Bamboo tubewell, costs, Bangladesh 128

Communal gravity, case studies, Philippines 203,213
230,239

Farm-level development, water and land management, India 136,485

Lift, gravity, lift and gravity, performance, case studies, Bangladesh 133
134,154

Main and tertiary level after management 626,832

Muda Irrigation Scheme, Malaysia 72

Sprinkle vs. surface 147

Water control, Japan 247,649

IRRIGATION TECHNOLOGIES
Institutional arrangements, cooperatives, Bangladesh 717

Shallow tubewell, deep tubewell, low-lift pumps, Bangladesh 150

IRRIGATION WATER DISTRIBUTION
Farmer-to-farmer cooperation, water management 127

IRRIGATION WATER QUALITY
Agricultural production, water resource development, Taiwan 447

Chemical residues and salinization, Chao Phya Basin, Thailand 410

IRRIGATION WATER QUANTITY
Agricultural production, water development, Taiwan 447

IRRIGATORS' ASSOCIATIONS (see also IRRIGATION ASSOCIATIONS)
Compact farms, water management, Philippines 765

Cooperative organizations, participatory planning, Philippines 745

Viable groups, operation and maintenance of irrigation headworks, Philippines 766

KARNALI BASIN
Erosion problems, watershed management programs, Nepal 315

KEY ECONOMIC AREAS
Water regions, public waterworks, China 55

KINSHIP
Community, China 263

Factors of technical adoption, social custom, Philippines 207

KITAKAMI RIVER
Research on social implications, development program, Japan 601

KOSI PROJECT
Irrigation administration, India 221,733

LABOR ABSORPTION
Irrigated agriculture, surface irrigation, India 155, 168, 178

New rice technology, irrigation, Indonesia 608

LABOR MOBILIZATION
Honor concept cooperation, social organization, Pakistan 163

Irrigation rehabilitation, communal system, Philippines 206,230

Water management, irrigation, China 450,789

LABOR SAVING
Piped water, water management, pipe-network-rotation, Japan 246

LABOR USE
Irrigation, semiarid agriculture 826

Mahaweli Development Project, Sri Lanka 188

Muda Irrigation Project, Malaysia 211

Self-help work, canal excavation, local initiative, Bangladesh 153

LAGUNA LAKE
Feasibility survey, hydraulic control 571

Flood control, spillway construction 566

Water quality, projects 80,397,417

Watershed, development plan, LLDA 85,86

LAKE WATER
Preservation, recreation and navigation, India 16

LAM PAO PROJECT
Land use, irrigation impacts, Thailand 378

LAND ALLOCATION
Collective decision, cultivation, tank water level, Sri Lanka 159

LAND CAPABILITY
Watersheds, hills, India 339

LAND CONSOLIDATION
Economic evaluation, Taiwan 541

Institutional innovation, CAD, conflict reduction, India 742

On-farm development, irrigation projects, Korea 255

Water management, rice culture, Thailand 215,513,754

Water resources development, history, Japan 272

LAND DEGRADATION
Water resources problems, Nepal 309

LAND EXPANSION
Agricultural technology, profitability, irrigation investments 492

LAND LEVELING
Irrigation management program, Pakistan 307

LAND MANAGEMENT
Irrigation systems development, farm level, water management, Sri Lanka 136

LAND PREPARATION
Water management, crop yield response, irrigation efficiency, Thailand 194

LAND PRODUCTIVITY
Forestry, watershed management, employment, India 338

LAND RECLAMATION
Plant community, microrelief, Japan 436

River bed development, Taiwan 446

Tidal lands, problems in reclamation and management, Indonesia 357

Water absorption, physical effects, Japan 441

LAND RESOURCES
Forest, irrigated lands, water resources, India 8

LAND TENURE
Agricultural development, Lam Pao Irrigation Area, Thailand 823

Agricultural patterns, land morphology, Lower Mekong Basin, Thailand 368,378

Irrigation projects, Korea 438

Laguna Lake, urban expansion, Philippines 85,86

Watersheds, dry land crops, irrigated land crops, India 342

LAND-USE PLANNING
Watersheds, land capability, India 339

LANDSLIDES
Environmental deterioration, causes and effects, Himalayas 324

LARGE-SCALE IRRIGATION SYSTEMS
Bhakra-Nangal Multipurpose Project, local consequences, India 183

Efficient use and maintenance, farm level, China 652

Methodology for evaluating organization and management 688

Water management approaches, Sri Lanka 579

LARGE-SCALE WATER PROJECTS
Large dams, RID, operation and maintenance, Thailand 192

Water management, pilot project, India 167

Water resources development projects, watershed conservation, sedimentation control, Philippines 107

LATE OPERATIONS (see also CROPPING PATTERNS)
Causes and effects, pumps, tubewells, Bangladesh 615

LATERALS (see also DITCHES) 191

LEAST AMOUNT OF IRRIGATION
Rainfall distribution, effective rainfall, Philippines 619

LEGAL FACTORS
Irrigation projects, Nepal 797

LEGAL RIGHTS
Access to water, location, water source, crop yields, Thailand 194

LEGAL STRUCTURES
Water users organizations, Pakistan 734

LEUCAENA LEUCOCEPHALA
Infiltration studies, watersheds, Philippines 353

LIFT IRRIGATION (see also IRRIGATION PUMPS, PUMPS)
Comparative analysis, performance, gravity irrigation, case studies, Bangladesh 133

Government, subsidies, benefit redistribution 855

Management, pilot research, India 23,639

LIMNOLOGICAL INVESTIGATIONS
Water use, pollution loading, Laguna Lake, Philippines 417

LINEAR PROGRAMMING
Planning irrigation projects, irrigation methods, Bangladesh 535

Water development, farm production possibilities, Indonesia 521

Water use, synthetic farm plans, returns to scale, India 157

LIQUID FERTILIZERS
Local technologies, human and farm wastes, China 439

LIVESTOCKS
Development program, watershed areas, India 330

LOAN REPAYMENT
Water districts, domestic water supply projects, Philippines 495

LOCAL COUNCIL
Water distribution, local participation, small-scale projects, India 180

LOCAL CULTURES
Irrigation systems, agricultural modernization, Japan 267

LOCAL INNOVATION
Tubewells, India 137

LOCAL INVOLVEMENT (see LOCAL PARTICIPATION)

LOCAL IRRIGATIONS GROUP
Organizational aspects, farmers' attitudes, Thailand 753

LOCAL LABOR
Mass mobilization, watershed development, India 344

LOCAL LEADERS
Labor utilization, self-help, canal excavation, Bangladesh 153

LOCAL LEADERSHIP
Irrigation systems, land improvement and irrigational clashes, Japan 802

LOCAL LEVEL ORGANIZATION
Hand pumps, maintenance system, India 739

LOCAL ORGANIZATIONS
Irrigation development, village council, irrigation headmen, Sri Lanka 174

LOCAL PARTICIPATION
Domestic water supply, institutional mechanism, Thailand, Vietnam 707

Problems and solutions, irrigation development, Philippines 776

Water distribution, small- or large-scale projects, local council, India 180,716

LOCAL RESOURCE MOBILIZATION
Irrigation development 702

LOCAL TECHNOLOGIES
Waste water pollution control, fertilizer production, biogas production, China 439

LOCAL WATER SUPPLY
Funding agency, Philippines 843

LOESS PLATEAU
Soil erosion, control measures, 424
Yellow River, China 437,443

LOGGING METHODS
Erosion and sedimentation 280

LOW-COST TECHNOLOGY
Irrigation improvement, lowland rice farming, Philippines 655

LOW FLOW OF RIVERS
Water supply availability, estimating procedure, Malaysia 385

LOW-LIFT PUMPS
Capacity utilization, Bangladesh 613

Comparative analysis with shallow and deep tubewells, Bangladesh 150

Efficiency, socioeconomic and institutional factors, Bangladesh 717,719

LOWER GANGES--BRAHMAPUTRA BASIN
Floods, flood control evaluation, systems analysis, Bangladesh 471

LOWER GANGES RIVER
Feasibility of basin work planning, Bangladesh 498

LOWER-LEVEL MANAGEMENT BEHAVIOR
Ditchtender, watermaster, Philippines 697

LOWER MEKONG BASIN
Drainage area, stream flow, quantity and quality evaluation 34

Land use, land morphology, Thailand 368,390

Nong-Wai Project, financing, World Bank, Thailand 202

Salinity intrusion, Chao Phya River, Thailand 388

LOWER MEKONG BASIN COMMITTEE (or MEKONG COMMITTEE) 34

LOWLAND RICE IRRIGATION
Water losses, water balance studies 373

MACROECONOMIC ANALYSIS
Productivity increase, multipliers, agricultural production, irrigation impact, India 173

MAGAT MULTIPURPOSE PROJECT
Magat River, output capital formation, Philippines 39,87

MAHAWELI DEVELOPMENT SCHEME (SRI LANKA)
Farmer oganizations and irrigation leadership 725

Implications on migration, labor use, employment opportunities 188

Master plan, water resources development, UNDP, FAO, IBRD 148,162

Water control, village tanks, Sri Lanka 135

MAHAWELI RIVER
Comprehensive survey, UNDP, Sri Lanka 162

MAIN CANAL (see also MAIN SYSTEM)
Research priorities, water distribution, India 711

MAIN CANAL SYSTEMS
Design and operation, management 654

MAIN SYSTEM
Mix of management approaches, methodological issues, Philippines 675

MALARIA CONTROL PROJECT
Damodar Valley Corp., multipurpose project, India 179

MAN-MADE LAKES (see also RESERVOIRS)
Aquatic weeds management, Indonesia 408

MANAGEMENT-BY-EXCEPTION
Implementation phase, rural development projects, India 722

MANAGEMENT ISSUES
Irrigation development policy issues, Philippines 657

MANPOWER DEVELOPMENT
Rural sanitation, manpower development, appropriate technology, Indonesia 361

MANPOWER TRAINING
Labor mobilization, water conservatory and irrigation, China 450

Water supply, sanitation projects, Philippines 114

MANUALLY OPERATED SHALLOW TUBEWELLS (MOST)
Small-scale irrigation, benefits, water table, Bangladesh 145

MAPPING
Paddy, organizational tool, communal irrigation, Philippines 679

MAPS
Water balance, climate 5

MARGINAL COSTS
Irrigation investment, agricultural output 492

MARKETING COOPERATIVES (see also COOPERATIVES)
Irrigation technologies and institutional arrangement, Bangladesh 717

MASS MOBILIZATION
Watershed management, people's participation, India 305,344

Watershed management, soil conservation units 295

MASS TRANSFER (see SEDIMENTATION)

MATHEMATICAL MODELS (see MODELS)

MEDIUM IRRIGATION
Project financing, workforce requirement, India 168

MEKONG BASIN RESERVOIR SYSTEM
Operation, Thailand 642

MEKONG COMMITTEE (see also MEKONG RIVER BASIN PROJECT)
Capital aid, technical assistance 232,836

MEKONG RIVER 34,542

MEKONG RIVER BASIN
Demand-supply study on physical and human resources, RFF, agricultural development, water quality control 110,463

Technical and economic problems, agricultural development 98,99,617

MEKONG RIVER BASIN PROJECT
Navigation channel feasibility, Thailand 542,836

MEKONG SECRETARIAT
Nam Pong Management, Research Project, Ford Foundation, Thailand 367

MEMBERSHIP FEE
Irrigation association, farmers' ability to pay, low income, Taiwan 783

METRO MANILA
Groundwater supply, aquifers, freshwater storage 45

MICRO-WATERSHED (see WATERSHEDS)

MIGRATION
Mahaweli Development Project, Sri Lanka 188

MINI-UNIT ORGANIZATION APPROACH
Irrigation management scheme, gravity irrigation 116

MINOR IRRIGATION
Project evaluation, India 653,709

MODELING (see also SIMULATION)
Cropping pattern, water management, Pakistan 187

MODELS
Hydrodynamic, river flows, Chao Phya River, Thailand 351

Irrigation management, China 669

Runoff estimation, agricultural watersheds, India 312
314,329

MOISTURE STRESS
Location and water supply, laterals, Philippines 234

MONITORING SYSTEMS
Organization and management, evaluation methodology 688,689

MOUNTAIN TRIBES
Rice terraces, water distribution, traditional systems of water distribution, Philippines 193

MOUNTAINOUS WATERSHEDS (see WATERSHEDS)

MUDA IRRIGATION SCHEME (MALAYSIA)
BCA, indirect economic impact, risk and uncertainty 72, 604,838

Irrigation extension program, block irrigation, farmers' participation 651,670

Social structure, farmers' associations 755,767

Watershed protection 375

MULTIOBJECTIVE ANALYSIS
Water resource project, India 584

MULTIOBJECTIVE DECISION MODEL
Attribute space, objectives space, India 588

MULTIOBJECTIVE SCREENING MODELS
Water resources investment 574

MULTIPLE CROPPING
Rice culture, water availability, HYV's, India 172

Shallow tubewell irrigation, irrigated vs. nonirrigated farms, Bangladesh 487

Water availability, rice cultivation, Malaysia 686

MULTIPLE OBJECTIVE INVESTMENT
Benefit-cost ratio for projects 493

MULTIPURPOSE BASINWIDE MODEL
Ganges Basin, India 587

MULTIPURPOSE PROJECTS
Bhakra-Nangal Mult. Project, local consequences, India 183

Bicol River Basin Development Program, components, Philippines 393

Capital-intensive approach, water management, Yellow River Basin, China 250

Cost allocation operational guidelines, Angat River Mult. Project, Philippines 567

Cotabato-Agosan River Development Project, water resources, Philippines 82

Damodar Valley Corp., malaria control project, India 179

Development policies, integrated area development, planning, Philippines 46,197,561 563,565,813

Flood control, Japan 444

Hydraulic model investigations, Agno River, Philippines 88,89,561

Ilog-Hilabangan River basin, irrigation, power, wildlife and fisheries, Philippines 226

Institutional and legal systems, Sri Lanka 805

Mogat River Project, Philippines 87

River basins, dams, reservoirs, Korea 58

Srinagarind Multipurpose, Thailand 629

UPRP, NIA, water management plans, Philippines 197

NAM PONG BASIN
Case study, research phases, organization and administration, Thailand 232

NAM PONG PROJECT (THAILAND)
Environmental and sociocultural effects, Ford Foundation 367

Water quality, Ubolratana reservoir 368,369

NATIONAL IRRIGATION ADMINISTRATION (PHILIPPINES)
Communal gravity systems, small scale 213,239 752,762,765

Farmers' attitudes toward irrigation, socio-economic study 241

Investments directions and problems, irrigation systems 108,224 576,806

Irrigators' associations, small-scale irrigation development, Philippines 745,763

Pilot studies, sedimentation control in river and irrigation canals 397

Rotational irrigation vs. controlled continuous irrigation 242

Special project, water management and training 640,747

UPRP, multipurpose projects, water management plans 197 242,676

Water management study, IRRI, UPLB 234,243,619

NAVIGATION
Lakewater, India, recreation 16

NAVIGATION CHANNELS
Feasibility Mekong River, Thailand 542

Sedimentation problem, sediment transport, Thailand 412

NEW RICE TECHNOLOGY (see also HYV's)
Irrigation impact labor absorption, HYV's, Indonesia 608

NOMOTHETIC STATEMENT
Documentary and historical evidence, irrigation studies 666

NONG WAI PROJECT (THAILAND)
Financing, WB, pilot area 202

Irrigation organizations, structures 769

ON-FARM WATER MANAGEMENT
Development, extension service, Chambal Valley Development Program, India 129

Irrigation, study mission, problems 115

Japan 115

Mix of management approaches, methodological issues, Philippines 675

Small-scale irrigation systems, Indonesia 621

Taiwan 116

Thailand 115

Water delivery, Taiwan 254

OPTIMAL CROPPING SYSTEMS
Identification and evaluation, watersheds, India 523

OPTIMAL WATER USE
Impacts on population reinvestment, Ganges Basin 517

ORGANIZATIONAL APPROACHES
Irrigation management, gravity irrigation, case studies 116

ORGANIZATIONAL LINKAGES
Water users organizations, irrigation districts, Pakistan 734

ORGANIZATIONAL PROCEDURES
Monitoring and evaluating administration, tail-end farmers 689

ORGANIZATIONAL RESEARCH
Irrigation 694

ORGANIZATIONS
Groundwater development, Philippines 47

Irrigation development 118,695

Irrigation management, Thailand 774

Rural irrigation, Indonesia 761,767

Water management, China 791

OUTLETS
Large capacity, flood control, Japan 425

OVERGRAZING
Watershed problems, India 330

PA MONG PROJECT
Flood control, Thailand 374

PADDY CULTIVATION (see RICE CULTIVATION)

PAMPANGA RIVER (PHILIPPINES)
Flood control feasibility project 560

UPRP, NIA, multipurpose projects 197

PAMPANGA RIVER BASIN
Groundwater development and exploitation, Philippines 370,551

PARAMETRIC MODELS (see also MODELS)
Runoff estimation, agricultural watersheds, India 312

PARTICIPATORY APPROACH (PHILIPPINES)
Constraints and benefits, water users association 746, 759,772

Farm ditches design, farmers' needs 698

Water distribution, action research 676

Water users association, small-scale irrigation 745, 746,763

PASIG RIVER
Water pollution, Napindan control structure, river wall alignments, Philippines 397

PEAK FLOWS
Watersheds, estimation, flood prediction, China 421

PEKALEN SAMPEAN IRRIGATION PROJECT
Water management, planning and operation, water distribution, Indonesia 222,510

PEOPLE'S COMMUNES
Work teams, water management, China 704

PEOPLE'S IRRIGATION ASSOCIATION
Irrigation association farmers' cooperation, Thailand 757

PEOPLE'S PARTICIPATION
Mass mobilization, watershed management, India 305,344

Watershed management, U.S. and Chinese models, India 298

PERCOLATION
Water loss, rainfall, water resources, India 8

PERMANENT WILTING POINT (see also MOISTURE STRESS)
Upland crop irrigation, water depletion, Malaysia 365

PILOT AREAS
NIA study, water distribution, rotational vs. continuous irrigation, UPRP, Philippines 242

PILOT PROJECTS (see also FIELD RESEARCH)
Administrative structures, water management activities, Pakistan 732

Concrete pipelines, demand irrigation schedule, Sri Lanka 634

Irrigation management, Bangladesh 130

Nong Wai Project, WB, financing, Thailand 202

Sedimentation control of river and irrigation canals, Agno River, NIA, Philippines 395,398

Water management, large-scale project, India 167,344,639

PIPE-NETWORK ROTATION
Water management, augment water supply, rotuna-flow, Japan 246

PIPELINES
Concrete, pilot projects, demand irrigation, Philippines 634

PLANNING
Basin work, feasibility, Bangladesh 498

Investment for irrigation and hydropower, India 64
75,106

Irrigation, arid lands technology transfer 78

Physical strategy, water resources, Philippines 107

Water resources, India 75

Water resources, Taiwan, watershed 68

PLANS
Mekong River Basin, agricultural development, water management, RFF 110

Water management, Philippines 97,197

PLANT-WATER RELATIONSHIP
Irrigation water, water use efficiency, conveyance conditions, Philippines 640

PLANTATION CROPS
Para-rubber, erosion control, Thailand 403

POLICIES
Health care, Asia Bureau (USAID), water supply, sanitation 124

Irrigation development, traditional systems 116

Water pricing, rural water supply, water allocation 73

POLITICAL FACTORS
Water resource development, SEA 604

POLITICS
Irrigation, Korea 859

POLLUTION LOADING (see also WATER POLLUTION)
Water quality monitoring, limnological investigations, Laguna Lake, Philippines 417

POND IRRIGATION
Irrigation patterns, rice farming, Japan 548

PONDS
Rural water source, water quality, seasonal supply of water, Thailand 372

POPULATION
Reinvestment, impacts of optimal water use, Ganges Basin 517

POPULATION GROWTH
Effects on water resources, water management, Indonesia 104

Future water demand groundwater resources, projections, Philippines 114

POWER PROJECTS (see HYDROELECTRIC POWER)

PRICE POLICY (see also WATER PRICING)
Irrigation water 3

PRICE SUPPORTS
Dry season crop production, risk, fixed assets, Thailand 196

PRICING (WATER)
Rural water supply, water allocation, case studies 73,840

PROBABILITY DISTRIBUTION
Internal rate of return, BCA, project appraisal, Malaysia 504

PROBLEM IDENTIFICATION
Interdisciplinary approach, water management, Pakistan 161

PRODUCTION DISTRIBUTION
Small-scale irrigation, social organization 700

PRODUCTION EFFICIENCY
Field water use, crops, dry zone, Sri Lanka 622,623

PRODUCTION FUNCTION APPROACH
Economic analysis, water management systems, India 512

PRODUCTIVITY
Rice farming, irrigation systems, Japan 649

PROFITABILITY
Irrigation investment and expansion 492

PROFITS/PROFITABILITY
Farm assets, water use, dry season irrigation, risks, Thailand 196

PROGRAMMING APPROACH
Economic analysis, water management systems, India 512

PROJECT APPRAISAL
Irrigation project, Korea 597

Irrigation projects, indirect economic impacts, Muda scheme, Malaysia 504

PROJECT DESIGN (see also DESIGNS)
Institutional aspects, technical components, irrigation systems, India 691

PROJECT EFFICIENCY (see also IRRIGATION EFFICIENCY) 197

PROJECT EVALUATION
Before-after basis, engineering and hydraulic and economic criteria, Philippines 675

Minor irrigation, India 653

PROJECT FINANCING
Nong Wai Project, WB, pilot study, Thailand 202

PROJECT IMPLEMENTATION
Administrative structures, legal instruments, India 799

Institutional and legal structures, Sri Lanka 805

PROJECT LEVEL MANAGEMENT
Irrigated systems, Thailand 638

PROJECT PLANNING
Irrigation, water supply and hydropower, NIA, Philippines 108

Major components, economic feasibilities 489

PROJECT PROPOSALS
Water resources development, Bangladesh 152

PROJECTS
Irrigation, Terai, Nepal 96

Planning, water resources, multipurpose, Philippines 48,813

Rural water supply, Thailand 33,38

Water and power, Indus Basin, food grain production, Pakistan 69

PROTECTION WORKS
Deltaic areas, drainage and irrigation 285

PUBLIC HEALTH (see also SANITATION)
Urban centers, water pollution, shelter water demand, ESCAP region 2,4

Water supply, sanitation, problems, case studies, Asia Bureau 124

Water supply, sanitation, sewerage, development plans, Philippines 114

PUMP IRRIGATION
Costs and practice, Philippines 39,198,603

Small-scale, command areas, tubewells, problems, Bangladesh 134,613
615,712

PUMPING DEVICES
Chain and washer pumps, design and operation, China 573

PUMPING STATIONS
Water diversion, urban water supplies, Sam Lac, Thailand 346

PUMPS
Energy alternatives, economics, India 476,477

Self-energized, engines for development 119,499

Small scale, effect on rice yield, rehabilitation, Indonesia 189,240

PUSH SUPPLY
Experimental research, full capacity waterflow, India 685

QUARRYING
Environmental deterioration, causes and effects, Himalayas 324

QUARTENARY CANALS
Canal design, farm water management, Malaysia 381

QUARTENARY LANDSCAPE DEVELOPMENT
Seraya River Basin, Indonesia 383

RAINFALL
Distribution, climate, Philippines, rice culture 37

Monsoon erosion, hilly grassland 350

RATIONAL METHOD (see also FLOOD ESTIMATION)
Flood estimation, applications, Malaysia 386

RAWL'S PRINCIPLE OF JUSTICE
Organizational approach, water allocation 690

RECLAIMED SOILS
Alkali soils, irrigation practices, India 323

RECONNAISSANCE STUDY
Asian water resources management, EAPI-EWC 701

RECREATION
Lakewater, navigation, India 16

RED FLAG CANAL
Irrigation, administrative level, water fee, China 259,790

REFORESTATION
Manual for forest management, Philippines 349

Multipurpose projects, soil conservation, watersheds, India 298

REGIONAL DEVELOPMENT
Spatial analysis, water management, Bicol River, Philippines 536

REGIONAL PLANNING
Drainage basin, Laguna de Bay, water quality, Philippines 80

REGULATED IRRIGATION
India 665

REGULATION
Prices, efficiency in irrigation water use 840

REINVESTMENT
Population, optimal, water use, Ganges Basin 517

REMOTE SENSING
Aerial photogrammetry, groundwater map, Sri Lanka 12

REPAYMENT OF LOAN
Irrigation pumps, irrigation associations, Philippines 771

RESEARCH
Irrigation command area factors, Bangladesh 134

Water management, Japan 83

Water resources, hydroelectric power and agricultural use, India, River Valley projects 103, 139,470

RESEARCH INTEGRATION
Irrigation systems research 466

RESEARCH METHODOLOGIES
Field research evaluation, improved irrigation systems, India 682,847

RESEARCH PRIORITIES
Irrigation system management, water distribution, India 711

RESEARCH PROJECTS
Directory, institutions, funding agency, Philippines 223

RESERVOIRS
Agricultural economic evaluation, Taiwan 528,539

Capacity estimates, sedimentation, India 19,317,524

Groundwater, sedimentation, integrated management, Japan 59,83,435

Projects, multipurpose development plans, Philipppines 46

Siltation and topographic problems, Indonesia 111

Water management, China 418

RESETTLEMENTS
Evaluation and impact on regional development, Sri Lanka 824

RESOURCE ALLOCATION
Agricultural production, Terai, Nepal 143

RESOURCE CONSERVATION
Hilly grassland, monsoon rain, run-off induced erosion 350

RESOURCE MOBILIZATION
Labor, subsidy effect, Indonesia 212

Local, irrigation rehabilitation, case study, Philippines 206

RESOURCE POLICY
Water planning, social assessment 65

RESOURCES FOR THE FUTURE, INC.
Agricultural development, Mekong River Basin, demand-supply study on physical and human resources, water management 110

RETURN FLOW
Pipe network rotation, water supply augmentation, rice cultivation, Japan 246

REVEGETATION (see REFORESTATION)

RICE CULTIVATION
Farm management, terai, tubewell irrigation, Nepal 176

Farm water management, irrigation requirements, Malaysia 602,631 632,686

HYV's, water availability, multiple cropping, India 172

Irrigation development 854

Irrigation management, Japan 246,548
641,649,830

Irrigation water use, yield improvement,
Indonesia 111,189,550

Philippines 37

Water balance 123

Water control 545

Water control, Taiwan 257,269,270
271,391,611

Water management, terminal irrigation
unity, Asia 659

Wet and dry seasons, irrigation management
practices, Sri Lanka 151

RICE PRODUCTION
Effective rainfall, least amount of irrigation,
Philippines 619

Farm level irrigation, water management, India 171

Irrigation economics, Malaysia 236

Land consolidation, water management, Thailand 215

RIPARIAN DISPUTES (see INTERNATIONAL RIVERS)

RISK AND UNCERTAINTY
Irrigation projects 578

Insurance, price supports, dry season crop
production, Thailand 196

Project appraisal, BCA, irrigation projects,
Muda scheme, Malaysia 504

RIVER BANK PROTECTION
Village level, watershed management, Nepal 309

RIVER BASIN DEVELOPMENT
Economic evaluation, Taiwan 258

Ex-post evaluation, Pakistan 479

Kitakami River Basin, water problems, Japan 268

RIVER BASINS
Abra river, development projects, Philippines 95

Abulog River, planning framework, Philippines 92

Agricultural econonomic evaluation, Taiwan 530

Cropping patterns 84

Flood control measures, urbanization, Japan 431

Hydropower program, energy projects, Nepal 105

Ilog-Hilabangan River Basin, development, Philippines 226

Integrated planning 472

Kala Oyga, Sri Lanka 543

Laoag River, planning framework, Philippines 91

Leyte, planning framework, Philippines 93

Lower Agno River, multipurpose projects, Philippines 88,89

Lower Cagayan planning framework, Philippines 94

Magat River, multipurpose projects, Philippines 87

Multipurpose projects, Han River, Nakdong River, Korea 57

Projects, statistics, irrigation, dams, Philippines 39,44 46,90

Serayu River basins, Indonesia 383

Upper Cagayan River Basin, Philippines 568

Water resources development, river systems, hydrology, projects, Nepal 11

RIVER CHANNELING
Siltation stabilization, watershed management, Himalayas 311

RIVER IMPOUNDMENTS
Human consequences, developing countries 275

RIVER VALLEY PROJECTS
Disputes, India 801

Organization, Taiwan 793

Water resources research, water use, India 103

Watershed management, India 295,301 304,342

ROADBUILDING
Environment, development, South Asia 341

Environmental and natural system effects, India 310

Land utilization, erosion and sedimentation 280

Landscape evaluation, Japan 455

ROTATION SYSTEM
Controlled irrigation system, centralized control, fixed rotation, India 165,169

Water distribution and control, efficiency, Philippines 197,219 242,243

ROTATIONAL CROPPING
Rice cultivation, irrigation practices, Malaysia 686

ROTATIONAL IRRIGATION (see ROTATIONAL WATER SUPPLY) 209

Taiwan 253

Water delivery, benefits, Malaysia 237

ROTATIONAL WATER SUPPLY
Comparison with continuous, water use efficiency, yield change and cost, Philippines 209

Fixed rotation (warabandi), controlled irrigation, India 169,186

ROYAL IRRIGATION DEPARTMENT
Thailand 191,192

RUNOFF
Erosion, hilly grassland, monsoon/rain 350

Mountainous watersheds, Japan 440,442

Water loss, groundwater, Nepal 26

Water loss, water supply, watersheds, water resources, India 8,312,314 325,334

RUNOFF ESTIMATION
Regression models, mountainous watersheds, India 329

Rice fields, distribution channels and drainage systems, Taiwan 391

Rocky watersheds, rainfall data, supplemental irrigation, India 316

Watersheds, simulation model, Philippines 538

RUNOFF UTILIZATION
Supplemental irrigation, rocky watersheds, India 316

RURAL COLLECTIVE SYSTEMS
Water conservancy, labor mobilization, China 798

RURAL DEVELOPMENT
Irrigation, agricultural production, India 173

RURAL ELECTRIFICATION
Groundwater development, Gangetic Plains, India 142

RURAL SANITATION (see also PUBLIC HEALTH)
Manpower development, appropriate technology, information dissemination, Indonesia 361

RURAL WATER SUPPLY
Design and implementation, case studies, allocation, pricing policies 73

RURAL WATERSHEDS (see WATERSHEDS)

SALINE SOILS
Irrigation practices, reclamation areas, India 323

SALINITY
Irrigation effects, waterlogging, large-scale development of groundwater projects, Pakistan 283,294 306,308

Irrigation practices, cropping pattern, water management, waterlogging 3

Seepage and waterlogging effects, India 290,321

SALINITY BARRIER
Design, dike and drainage, Bicol River, Philippines 348,355

SALINITY CONTROL AND RECLAMATION PROGRAM (SCARP), PAKISTAN 294

SALINITY INTRUSION (see also SALINIZATION)
Bicol River, coastal areas, elimination, Philippines 97

Effects on aquatic organizations, Lake Songkla, Thailand 382

SALINIZATION
Case study, waterlogging, food production, irrigation efficiency, Pakistan 333,345

Flood control, irrigation withdrawal water, Bicol River Basin, Philippines 348,355

Irrigation water quality, Chao Phya Basin, Thailand 388,410

World data, protective approaches, Asia 278

SANITARY SCHOOLS
Courses, water pollution control, rural sanitation, Indonesia 361

SANITATION (see also PUBLIC HEALTH) 2,114,124

SCHISTOSOMIASIS CONTROL
Philippines 224

SEA DIKES
Design and construction, protection of agricultural coastal lands, Malaysia 414

SEARCA
Social laboratory project, farmers associations, water management, Philippines 198

SECONDARY CANAL SYSTEMS
Cropping scheduling arrangement, time of irrigation intervals, Malaysia 651

SEDERHANA IRRIGATION
Simple irrigation program, irrigation structures, construction, coverage, Indonesia 204,827

SEDIMENT CONTROL
Efficiency, systems, suitability, India 317

Rivers and irrigation canals, Agno River, Philippines 398

Terracing and vegetative coverings, check dams, loess plateau, China 443

SEDIMENT DEPOSITION
Empirical prediction, reservoirs, Japan 435

SEDIMENT LOAD
Karnali Basin, data, watershed development, Nepal 315

Suspended and dissolved, drainage basins, Malaysia 366

SEDIMENT REMOVAL (see SEDIMENT CONTROL)

SEDIMENT TRANSPORT
Thickness of litter cover, Malaysia 379

SEDIMENTATION
Environmental and natural system studies, Rai and Chenab rivers, Pakistan 21

Forest clearings, land utilization, solutions 280

Irrigation structures, controlled grazing, water management, India 293,299 330,335

Karnali Basin, erosion problem, solutions, Nepal 315

Problems and solutions, Philippines 392

Reservoirs, trapping, watershed erosion, China 427

Sediment transport analysis, side flows, Thailand 412

SEDIMENTS
Simulation models, runoff and erosion, management schemes, construction sites 277

SEEPAGE
Development of saline and sodic soils, waterlogging, India 8,183,290

SELP-ENERGIZED IRRIGATION PUMP 499

SELF-HELP WORK
Labor utilization, local initiative, canal excavation, Bangladesh 153

SETTLING BASINS
Sedimentaton solution, Agno River, Philippines 392

SEWERAGE
Disposal, sanitation, water supply, projects, Philippines 107,114

SEWERAGE SYSTEMS
Urban, flood control, drainage, water quality, Philippines 354

SHALLOW TUBEWELLS
Comparative analysis, with deep tubewells and low lift pumps, Bangladesh 150,487

SHELTER
Problems, urban centers, water supply, sanitation, ESCAP region 4

SHELTERBELTS
Desertification, management approaches, China 418,456

SHIFTING CULTIVATION
Environmental deterioration, causes and effects, Himalayas 324

Erosion and sedimentation, long-term vs. short-term effects 280

Watersheds, India 326

SILTATION
Reservoirs, sedimentation, watershed management, program, India 299,302,330

Soil erosion, desertification, Nepal 337

Water storage, reservoirs, topography, Indonesia 111

Watershed management, Himalayas 311

SILTING (see SILTATION)

SIMPLE IRRIGATION PROGRAM
Construction and operation, Indonesia 819

SIMULATION
Cropping pattern and water management, Pakistan 187

SIMULATION ANALYSIS
Crop diversification, water management, Sri Lanka 527

SIMULATION MODELS
Flood control, Bicol River Basin, Philippines 347

Runoff estimation, watershed, Philippines 538

Sediment yields, watershed management, construction sites 277

Water deficits, irrigation planning 537

SIMULATION-OPTIMIZATION MODEL
Induced groundwater recharge, India 526

SIRIKIT DAM
Hydroelectric power, large-scale dam projects, Thailand 192,513

SLOPE CULTIVATION
Conservation measures, Taiwan 419,420

SMALL RESERVOIRS (see also PONDS)
Economics for irrigation, Thailand 490

SMALL-SCALE IRRIGATION
Alternative approaches, social organization 700

Communal gravity, NIA, Philippines 213,239

Comparative analysis, shallow tubewells, deep tubewells, low lift pumps, Bangladesh 150

Effectiveness 647

Pump irrigation, Indonesia 240

Pumps, tubewells, command areas, problems, Bangladesh 134,145

Traditional irrigation systems, localized approaches, India 180,181

SOCIAL ANALYSIS METHODOLOGY
Economic and social BCA, Chao Phya Irrigation Project, Thailand 481

SOCIAL ASSESSMENT
Water planning, resource policy 65

SOCIAL BENEFIT-COST ANALYSIS
Labor intensive techniques, irrigation and dam construction, India 178,503

SOCIAL CONSEQUENCES
Water areas, equalization, China 262

SOCIAL CUSTOM
Technical adoption of production, factors of adoption, social and traditional values, Philippines 207

SOCIAL IMPLICATIONS
Development programs, Kitakami River, Japan 601

SOCIAL LABORATORY PROJECT
Farmers association, irrigation water management problems and solutions, Philippines 198

SOCIAL ORGANIZATIONS
Honor (izzat), concept, coooperation and competition on water use, labor mobilization, Pakistan 103

Irrigation, Taiwan 796

Small-scale irrigation, production distribution 700

SOCIAL SCIENCES
Canal command area, India 470

SOCIOECONOMIC FACTORS
Water resources development, SEA 604

SOCIOECONOMIC INCENTIVES
Irrigation schemes, agricultural development 589

SOCIOECONOMIC SURVEYS (see also SURVEYS)
Irrigation project area, Thailand 590

SOCIOLOGY
Irrigation, Taiwan 264

SOIL CONSERVATION MODELS
People's participation, U.S. and Chinese models, watershed management, India 298

SOIL EROSION
Control, conservation trial, Malaysia 363,377

Control measures, Korea 453

Control measures, waters, loess plateau, China 433,437

Erosion, planning and implementation, tropics 273

Estimation of soil loss, slopelands, Japan 426,454

Factors, mountainous watersheds, Pakistan 322

Problems, components, impacts, tropics 273

Watershed management, River Valley projects, India 301

SOIL LOSS (see also SOIL EROSION)
Rainfall erosion, slopelands, Japan 426

SOIL-PLANT-WATER RELATIONSHIPS
Irrigation design and management, water stress, yields, Philippines 656

SOIL SALINITY (see SALINITY)

SOLO RIVER BASIN
Water development farm production possibilities, Indonesia 521,583

SPATIAL ANALYSIS
Regional development, Bicol River, Philippines 536

SPILLWAY
Feasibility studies, flood control, Manila 566

SPRINKLE IRRIGATION
Comparative analysis with surface system 147

STATE TUBEWELLS (see also TUBEWELLS)
Economic analysis, case study, India 170

STORAGE-DRAFT RATE
Gauged and ungauged rivers, estimation, Malaysia 549

STREAMFLOW
Gauging stations, locations, water resources, Philippines 49,51,108

STUDY TOURS
Water resources management, China 671

SUBAK (see also VILLAGE WATER ORGANIZATIONS)
Village irrigation system, Bali, Indonesia 112,205
756,758

SUBLATERAL CANALS
Water distribution, control, organization and operation, India 185

SUBSIDI DESA (see VILLAGE SUBSIDY PROGRAM)

SUBSIDIES
Irrigated dry season crop production, risk-bearing farm assets, Thailand 196

Subsidi desa, irrigation loans, effects, Indonesia 212

SUBWATERSHEDS
Development programs, problems, Nepal 309

SUN PUMPS
Irrigation, Pakistan 119

SUPPLEMENTAL IRRIGATION
Runoff from rocky catchments, crop utilization, India 316

SUPPLEMENTARY FACILITIES
Small projects, communes, work teams, water management, China 704

SUPPLEMENTARY IRRIGATION
Rice production, dry season, water shortage, Sri Lanka 160

SUPPORT PRICE
Rice self-sufficiency, irrigation projects, Korea 266

SUPPORT SERVICES
Credit, input supplies, pasture land development, watershed management, India 305

SURFACE DRAINAGE
Chao Phya irrigation, Thailand 227

SURFACE IRRIGATION
labor absorption, irrigated agriculture, India 155,628

SURFACE WATER
Irrigation and domestic use, assessment, estimation, Malaysia 40

Supply, quality, Bicol River Basin, irrigation development, Philippines 81,108

Utilization practices and problems, Chao Phya River, Thailand 38

Water resources development, Nepal 25

SURFACE WATER FLOW
Indus Basin, Pakistan 146

SURPLUS LABOR
Mobilization, communal irrigation, Philippines 230

SURVEYS
Groundwater, methods, Philippines 544

Socioeconomic, irrigation project area, Thailand 590

SUSPENDED SEDIMENT LOAD
Drainage basins, Malaysia 366

SWIDDEN CYCLES (see SHIFTING CULTIVATION)

SYSTEMS ANALYSIS
Design of water resource systems 468

Floods, flood control, Lower Ganges-Brahmaputra Basin, Bangladesh 471

Irrigation design, socioeconomic and engineering 459

River basin planning 472

Water management, developing countries 458

Water resources development, Ganges Basin, India 460, 514,524

TAIL-END FARMERS
Monitoring and evaluating administration, irrigation projects 689

TAIL-END SYNDROME
Water distribution, differential access, social and institutional factors, Philippines 200,201

TANK IRRIGATION
Action research, controlled water delivery, India 685

TANKS
Capacity estimates, India 19

Rehabilitation, traditions in irrigation development, local organizations, Sri Lanka 135,159, 160,174

TAUNGYA CULTIVATION (see also SHIFTING CULTIVATION)
Watershed management, forest conservation, Philippines 276

TAXES
Land, Indonesia 820

TECHNICAL CHANGE
Irrigation impact, production techniques adoption, rate, customs and traditions, Philippines 207

Muda Irrigation Project, Malaysia 211

TECHNICAL CRITERIA
Water distribution, rotation vs. continuous irrigation, UPRP, Philippines 242

TECHNICAL STUDIES
Urban water supply, 100-Cities Project, Philippines 101

TECHNOLOGICAL IMPROVEMENT
Comparative analysis, irrigation vs. no irrigation, adoption of production techniques, Philippines 207

TECHNOLOGIES
Agricultural development, water resources management, Mekong River Basin 110

Rice cultivation, piped water, water management, Japan 246

Water resources development, irrigation projects, India 168,173

TECHNOLOGY TRANSFER
Irrigation planning, arid lands 78

TERAI (NEPAL)
Agricultural production, resource allocation 143

Forest development, water supplies 291

Groundwater, legal and organizational aspect of groundwater development 26

Irrigation development, groundwater 96

TERMINAL FACILITIES
Farm level water management, water delivery, rotation units, Malaysia 237

TERMINAL IRRIGATION
Water management, rice cultivation, APO survey, Asia 659

TERMINAL-LEVEL IRRIGATION
Organizations, Nong Wai Project, Thailand 769

TERMINAL SYSTEMS
Infrastructure and management, policy issues 636

TERRACE
Management, soil erosion, Nepal 337

TERRACES
Loess Plateau soil conservation, China 424

TERRACING
Erosion control, Loess Plateau, China 443

Watershed development, local labor mobilization, India 344

TERTIARY CANALS
Cropping scheduling, secondary canals, Malaysia 651

TERTIARY CANALS DEVELOPMENT
Sederhana irrigation programs, farmers' responsibility, Indonesia 204,205

TERTIARY LEVEL
Conveyance losses, irrigation scheduling, Indus Basin, Pakistan 146

TERTIARY SUBSYSTEMS
Irrigation efficiency, conveyance efficiency, Pakistan 144

THANA IRRIGATION PROJECT
Cooperatives, pump irrigation, bureaucratic arrangements, Bangladesh 712

THEORETICAL FORMULATION
Benefit-cost analysis, minor irrigation projects 483

TIDAL LANDS
Management and reclamation problems, Indonesia 357

TORRENTS (see FLOODS)

TOXICITY
Industrial waste water, water pollution, crop growth, Taiwan 423

TRADITIONAL CUSTOMS
Water management, small irrigation reservoirs, Korea 792

TRADITIONAL IRRIGATION SYSTEMS
Indonesia 208

Japan 260

Water distribution, mountain tribes, water-use rights, Philippines 193

Water management, Bangladesh 831

TRADITIONS
Irrigation development, customs, local organizations, Sri Lanka 174

TRAINING CENTERS
Dryland research, conservation techniques, action programs, India 296

TRAINING PROGRAMS
Irrigation, farmer participation, institutional development 70

TREE PLANTING (see AGROFORESTRY) 280

TRIBAL DEVELOPMENT
Watershed management program, people's participation, India 305

TUBEWELL IRRIGATION (see also TUBEWELLS)
Diagnostic surveys, plan, USAID 67

Economic evaluation, India 494

TUBEWELLS
Bamboo, irrigation alternatives, costs, Bangladesh 128,474

Causes or effects of late operations, Thailand 615

Determination of costs, economic rents, canal irrigation, Pakistan 839

Groundwater use, development, Gangetic Plains, India 140,142

Local innovation, India 137,478

Pump irrigation, command areas, small-scale irrigation, Bangladesh 134

State tubewells, economic analysis, India 137,170

Water fee, overirrigation, local participation, India 704,727

TURNOUTS
Density, farm ditches, water use efficiency, Philippines 243,655

Water control parameter, lowland irrigation water management, Philippines 219

UBOLRATANA RESERVOIR
Water quality, Nam Pong Project, Thailand 369

ULU-ULU (see DITCHTENDERS)

UN DEVELOPMENT DECADE
Water resources development projects, food production, Asia 76

UN DEVELOPMENT PROGRAM
Budget allocation to water resources project in Asia 857

Comprehensive survey, Mahaweli River, water resources development, Sri Lanka 162

Cotabato-Agusan River Basin Development Project, funding, Philippines 228

Technical assistance, NWRC establishments, Philippines 833

Watershed management, FAO, Philippines 389

Water resource study, FAO, WB, Harvard, Bangladesh 17

UN-ECAFE
Glossary, hydrologic terms, water resources projects 77

Water resources development, programs and policies, Asia 856

UN WATER CONFERENCE
Mar del Plata, Argentina, water management development and supply 1,71

Water resources, administration, projects, Thailand 53

UNDER-IRRIGATION
Soil salinity, water management design, Pakistan 308

UNDERSLUICE TECHNIQUE
Sedimentation solution, Bonga River, Philippines 392

UNESCO
Natural resource development, humid tropical Asia 6

UPLAND CROPS
Irrigation management, crop production efficiency, Sri Lanka 623

UPLAND CULTIVATION
Rice terraces, mountain tribes, water distribution, Philippines 193

Water use efficiency, yield improvement, Thailand 194

UPLAND HYDROECOLOGY RESEARCH
Programs, policy recommendations, Philippines 415

UPLAND IRRIGATION
Farm management, Japan 648

Model, methods, moisture stress, Malaysia 365,519

UPPER PAMPANGA RIVER PROJECT (UPRP), PHILIPPINES
Computerized diversion control 532

Irrigation water pricing, case study 507,842

Multipurpose projects, water management plans 39,197

Water distribution, rotational vs. continuous irrigation 209,242

Water technologists training program, NIA 817

Watershed problems 387

UPSTREAM WATER CONTROL
Village tanks, irrigation canal systems, Sri Lanka 135

URBAN EXPANSION
Manila growth center, Laguna Lake development, Philippines 85,86

URBAN WATER SUPPLY
Bangkok, Thailand 841

100-Cities Project, improvement, groundwater, Philippines 101,554

Water diversion, pumping station, Chao Phya River, Thailand 346

URBANIZATION
Effects on water yields, Malaysia 413

Flood control measures, urban rivers, Japan 431

Water resource activities, Taiwan 245

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)
Asia Bureau, public health, water supply, health problems, case studies 124

Evaluation project, hydrology, crop diversification, Bicol River Basin, Philippines 416

Field research, water management, CSU, Pakistan 684

Irrigation and reclamation program financing, Indonesia 204

Irrigation investment for Asia, research and planning approaches for Asian irrigation 70

Shallow tubewells financing, economic evaluation, Bangladesh 487

US BUREAU OF RECLAMATION
Physical surveys, Cotabato-Agusan River Basin Development Project, Philippines 228

USAID WATER MANAGEMENT SYNTHESIS PROJECT
Irrigation development and investment, model irrigation management system, tubewell irrigation, India 67

VILLAGE DITCHTENDERS (see DITCHTENDERS)

VILLAGE IRRIGATION SYSTEM (see also IRRIGATION SYSTEMS)
Subak water distribution system, Indonesia 756

VILLAGE LEVEL WATER MANAGEMENT
China 249

Local participation, India 716

Management, organizational arrangements 125

VILLAGE SUBSIDY PROGRAM
Irrigation loans, administration financial requirements, subsidi desa, Indonesia 212

VILLAGE TANKS (see TANKS)

VILLAGE WATER ORGANIZATIONS
Water distributions, Dharma Tirta, Subak, water management, Indonesia 205

Water distribution, traditional system, mountain tribes, water-case rights, Philippines 193

Water management decision making, Pakistan 729

WARABANDI (INDIA)
Fixed rotation water supply controlled irrigation 169,186

Management approach, implementation 721,737

WARPING
Sandy soil improvement, erosion and sediment control, China 443

WATER ABSORPTION
Physical effects, soil and reclaimed sea land, Japan 441

WATER ACCESS (see also DIFFERENTIAL ACCESS)
Differential access, social and institutional factors, tail-end syndrome, Philippines 200,201

Social consequences, equalization, China 262

WATER ALLOCATION (see also WATER DISTRIBUTION)
Institutional and technical aspects, India 691,737

Organizational and institutional issues 695

Rural water supply, pricing policies, case studies 73

WATER AND POWER DEVELOPMENT AUTHORITY (WAPDA)
Administrative structures, water resources management, Pakistan 732

WATER AUGMENTATION
Economic impacts in farm, India 500

WATER BALANCE
Agricultural production, Java, Indonesia 229

Climate, India 24,533

Maps, climate 5,7

Study for the Bicol River Basin, Philippines 570

Water losses, lowland rice irrigation 123,373

Watershed, dipterocarp forest, Philippines 352

WATER CHARGES (see also PRICING [WATER], WATER PRICING)
Conflicts in water use, collection, CAD, India 742

Economic rent in canal irrigation, tubewell water cost, Pakistan 839

Farmers' income and government revenue, Philippines 842,848

Financing irrigations services, operation and maintenance cost, collection, Indonesia 510

Irrigation, development and management, ADB 816

WATER CODE
Implementing rules and regulations, Philippines 807,811

WATER CONSERVATION
Forestry development, forest cover maintenance, Nepal 291, 309,320

Rural collective systems, labor mobilization, China 789

Watershed management, river valley projects, India 301,320

WATER CONTROL
Computer program, irrigation delivery schedule, UPRP, Philippines 219,531

Economic evaluation, Chao Phya Project, Thailand 505

Environmental and natural system effects, planning and evaluation, India 180, 310,320

Organizations, projects, flood control, China 59

Rice cultivation 545

Rice cultivation, Taiwan 269

River basin development, comprehensive approach, Japan 247,268

Water guards, Philippines 748

WATER DEFICIENCY
Crop response, underirrigation, waterlogging and salinity, Pakistan 308

WATER DEFICITS
Irrigation planning, simulation models 537

WATER DELIVERY (see also WATER DISTRIBUTION)
Computerized schedule, UPRP, Philippines 531

Conflict resolution, water rights, Pakistan 644,798

Flexibility, institutional development, irrigation water management 70

Gravity canal irrigation, canal position, differential access 690

Institutional arrangements, irrigation techniques, Bangladesh 717

On-farm and off-farm irrigation, case study, Taiwan 254

Problems, control 149

Types of management, government regulation, India 726

WATER DEMAND
Irrigation, Indian subcontract 12

Projections, population growth, water supply and sanitation, Philippines 41,114

WATER DISTRIBUTION
Diffferential access, social and institutional factors, tail-end syndrome, Philippines 200,201 234,676

Historical development, water resource development, Japan 272,658

Legal and institutional arrangements, international linkages, Sri Lanka 29

Main canal, research priorities, irrigation linkages, India 185 711,743

Rotation system, intervals, efficiency, Philippines 193,197 209,242

Rural water supply, plans and implementation, Thailand 33

Terminal system, irrigation design, rotation units, Malaysia 237

Tertiary units, rotational system, village organizations, Indonesia 205

Water rights, water guards, irrigation cooperatives, Japan 700

Weirs, numerical proportions, special device, Sri Lanka 159

Zangjeras, water-use rights, irrigation societies, Philippines 218,242

WATER DIVERSION
Chao Phya River, hydraulic model, drinking water, Thailand 346

WATER FEE (see also WATER CHARGES)
Additional yield, irrigation, rice production 127

Irrigation districts, amount, farms, China 790

Water losses, overirrigate, water use efficiency, India 727

WATER GUARDS
Water control, Philippines 748

Water distribution, irrigation cooperatives, Japan 780

WATER HARVESTING STRUCTURES
Irrigation ponds, watershed management, India 344

WATER IMPOUNDING PROJECT
Feasibility studies, multipurpose project, Philippines 552

WATER LIFTING DEVICES (see PUMPING DEVICES)

WATER LOSS
Evapotranspiration, subsurface flow, groundwater, Sri Lanka 12,160

Groundwater, runoff, Nepal 26

Infiltration, water course, improvement, 156
earthen structure, Pakistan 307,689

Lowland rice irrigation 373

Seepage, evaporation, low irrigation, 8
India 183,727

Surface water, estimation, Malaysia 40

WATER MANAGEMENT
Comprehensive planning, Bicol River Basin, Philippines 97

Economic study, India 158

Environmental and economic points of view, Taiwan 61,113

Han River Basin, salinity problems, River Basins, Korea 57

History, cultural evolution, China 55

Irrigation, cropping pattern, water pricing, waterlogging, salinity 3

Needs and problems approaches, policy options, Sri Lanka 29

On-farm institutional factors, legal factors, irrigation projects, Nepal 797

Pakistan 664

Population growth Five-Year Development Plan, structure and pattern, Indonesia 104

Problem areas, Asia 66

WATER OPERATIONS SYSTEM
Chao Phya Basin, Thailand 586,618

WATER PLANNING (see also PLANNING)
Social assessment, resource policy 65

WATER POLLUTION
Control, course offerings, sanitary schools, Indonesia 361

Control, local technologies, China 439

Control, Pasig River, Laguna Lake, control structure, Philippines 397

Crop growth, industrial waste water, Taiwan 423

Detailed study of sources, control measures, Chao Phya River, Thailand 404,411

Environmental problems, industrial and agricultural activities, India 327,328

Industrialization, Japan 448

Technical measures, socioeconomic considerations 286

WATER PRICING
BCA, development projects, Taiwan 508

Irrigation, case study, UPRP, Philippines 507,650

On-farm development, water management, agricultural extension, Chambal Project, India 129

WATER PROJECTS (see also IRRIGATION PROJECTS, MULTIPURPOSE PROJECTS)
Irrigation, flood control, and water supply, investments, Philippines 74

WATER PUMP
Hand-operated, rural water supply, local manufacture, Philippines 582

WATER QUALITY
Control, technological advances, RPF, agricultural development, Mekong River Basin 110,369

Estimation, groundwater, wells and aquifers, urban areas, Philippines 102,354 395,559

Forest change, degradations, forest management strategies 281

Hand pumps, rural drinking water, surveillance, WHO, India 343

Irrigation, salinization, Asia 278

Laguna de Bay, government projects, Philippines 80,417

Seasonal conditions, village ponds, inadequate water supplies, Thailand 372

WATER RELATIONS
Assessment, uses, and projections, India 8,9,18,19 23,31,43

Development policies, multipurpose projects, demand, Philippines 49,813

East Indonesia 50

Inventory, rainfall, evapotranspiration, Malaysia 36,52

WATER RESOURCE ACTIVITIES
Taiwan 245

WATER RESOURCES DEVELOPMENT
Groundwater, river basin, projects, hydrology, Nepal 11,25

Indus River, irrigation, Pakistan 21

Major rivers, Indus Water Treaty, environmental problems, Pakistan 306

Master plan, proposed projects, Bangladesh (east Pakistan) 152

WATER RESOURCES PROJECTS
Current activities and plans, India 14,15,585

Operation and maintenance, modern management techniques 286

WATER RIGHTS
Disputes, land improvement, canal irrigation, Japan 802

Water delivery system, customs, conflicts, Pakistan 798

WATER RIVALRY (see CONFLICTS)

WATER ROTATION
Canal irrigation, institutional arrangements, warabandi, India 737

WATER SCHEDULING
Delivery policies, water management, Chambal Valley Development Program, India 129

Diversion irrigation systems, area estimation to be irrigated, Philippines 674

Institutional alternatives, irrigation management, Pakistan 723

WATER-SHARING (see WATER DISTRIBUTION)

WATER SHORTAGE
Location of laterals, moisture stress, water supply, Philippines 234

Overapplication, tanks, rice production, Sri Lanka 160

Rice cultivation, irrigation, Taiwan 257

WATER STORAGE (see also RESERVOIRS)
Dipterocarp forest watershed, water balance and use, Philippines 352

Reservoirs, topographic and siltation problems, Indonesia 111

RID development of river systems, dams, Thailand 192

WATER STRESS (see also MOISTURE STRESS)
Crop yields, Sri Lanka 177

Soil-plant-water relationships, HYU's, rice yields, Philippines 656,687

WATER SUPPLY
Asia Bureau (USAID), health care improvements, case studies 124

Bicol River, irrigation planning, Philippines 41,81

Crop pattern, irrigation, economic study, Taiwan 256

Design problems, Nepal and Bhutan 547

Groundwater, aquifer, freshwater storage, Metro Manila 45

Groundwater, industrial needs, urban areas, Japan 432

Groundwater rights and regulation, India 8,741

Large-scale projects, Philippines 107

Sanitation, urban center, delivery systems, pollution surfaces, sources, deep tubewells, piped water, ESCAP region 4

Sanitation, waste disposal, proposed projects, Philippines 114,486

WATER TABLE
Rice irrigation system, Taiwan 270

WATER TAX (see WATER CHARGES)

WATER TRADING AND SALE
Water delivery control 149

WATER USE EFFICIENCY (see also IRRIGATION EFFICIENCY) 194
Alternative approaches, farm level, Thailand 457

Dry season, turnout density, farm ditches, Philippines 655

Farmers organization, case study, India 292,714

WATER-USE RIGHTS
Village organizations, mountain tribes, water distribution, Philippines 193

WATER USERS' ASSOCIATIONS
Constraints and benefits, participatory approach, Philippines 763,772

History, operation, Thailand 757

Operation, functional relation with the government 808

Organizational setup, Indonesia 775

Social organizations and management, Pakistan 730,734

Water distribution, collective management, India 743

WATER UTILIZATION 595
Conflicts between irrigation and urban use, Japan 580

Domestic, agricultural, industrial, Philippines 41

Dry season, profitability, risks, Thailand 196

Efficiency, reuse, estimates, India 9,30,166

Historical development, western technologies, China 250

Hydroelectric, supplementary uses, Nepal 100

Irrigation, proposals, development plans, Indonesia 112

Research, India 139

Supply and demand for surface and groundwater, water development, administration, water projects, Thailand 53

Watershed, water balance, water storage, Philippines 352

WATER YIELDS
Land-use changes, effects, Malaysia 413

Watershed management, agricultural water supply, Philippines 407

WATERCOURSE IMPROVEMENT
Concrete and masonry living, earthen banks, Pakistan 307

WATERLOGGING
Effects of irrigation, large-scale development 283
of groundwater projects, Pakistan 294,345

Irrigation practices, cropping pattern, salinity 3

Planning, evaluation, environmental effects, India 290,310

Salinity, underirrigation, crop responses, Pakistan 306,308

WATERMASTER (see DITCHTENDERS)

WATERSHEDS
Conservation, sedimentation control, Philippines 107,359

Critical watershed, problems, Ambuklao and Binga, Philippines 406

Design flood estimation, procedures and limitation, Malaysia 384

Design flood frequency, watersheds, Thailand 370

Development and management, soil and water conservation 279

Erosion control, experimental watersheds, runoff, sediment, India 300,302

Erosion control, forest conservation, taungya 276

Factors on soil losses, Pakistan 322

Forest conservation, hydrological problems, agricultural development, Malaysia 356,375

Forest influences, bibliography 288

German Foundation, forest rehabilitation and management, Philippines 362,407

Infiltration studies, L. leucocephola, Philippines 353

Kandi Watershed Project, forestry components, India 338

Laguna Lake, land use, urban expansion, Philippines 85,86

Land use, water use, river valley projects, planning, India 301,330,331 339,342,344,523

Management, rehabilitation, development agencies, Pakistan 289

Parametric models, runoff estimation, India 312,325

Problems, Upper Pampanga River Basin, Philippines 387

Projects, management, multipurpose projects, India 298 299,314

Rehabilitation, Gliricidia sepicum 282

Runoff estimation, simulation model, Philippines 352,538

Runoff, Japan 440,442

Soil erosion control measures, Loess Plateau, China 437

Trisuli Project, Nepal 297

Water resources planning, economic situation, Taiwan 68

WATERSHED MANAGEMENT
Comprehensive, subwatershed, Nepal 309,311

Constraints on implementation, programs, India 330,336

Demonstration and training, FAO, UNDP, Philippines 389,407

Farmers' participation, construction projects, India 305 326,338

Flood prediction, China 421

Integrated, rural development, Drought Prone Areas, India 295,303 304,722

Past and present land use, remedial measures, Pakistan 318

Programs, erosion problems, Nepal 315

Windbreaks, forestry to support agriculture, Indonesia 376

WATERSHED PLANNING
Water resources region, drainage systems, India 313,331

WASTE WATER
Industrial, water pollution, crop growth, Taiwan 423

WEIRS (see also DIVERSION WEIRS)
Water distribution, numerical proportions, special device, Sri Lanka 159

WELLS
Aquifers, groundwater supply and quality, hydrology, urban areas, Philippines 51 102,114

Cost comparison with water diversion from streams, Thailand 194

WET-RICE CULTIVATION (see also RICE CULTIVATION)
Topographic conditions, irrigation design, canals, Malaysia 381

WILDFIRES
Major forest alteration, effects on water quality 281

WILDLIFE
Multipurpose project, river basins, Philippines 226

WINDBREAKS
Watershed management, forestry and agriculture, Indonesia 376

WORK TEAMS
Water management people's communes, China 704

WORLD BANK (see also IBRD)
Budget allocation to water resources project in Asia 857

Irrigation and drainage, Indian subcontinent 13

Study mission, Nong Wai Project, financing, Thailand 202

Watershed development project, people's participation, local labor mobilization, India 344

WORLD HEALTH ORGANIZATION (WHO)
Environment and Health Division, world water, statistics, water-borne diseases, ASPAC countries 2

Rural water quality, drinking water, surveillance, India 343

WORLD WATER
WHO, International Drinking Water Supply and Sanitation Directory, water-borne diseases, statistics, ASPAC countries 2

YANGTZE RIVER
Water transfer proposal, China 250

YELLOW RIVER
Erosion control, loess plateau, China 427,437,443

YELLOW RIVER BASIN
Water management, capital intensive multipurpose dams, labor mobilization, China 250

YODO RIVER BASIN
Integrated water management, Japan 83

ZANGJERA (see also IRRIGATION SOCIETY) 201,218

COUNTRY INDEX

GENERAL.....1, 2, 3, 4, 5, 6, 7, 13, 34, 62, 65, 66, 70, 71,
(cross-country) 73, 76, 77, 78, 84, 98, 99, 110, 115, 116, 117,
118, 119, 120, 121, 122, 123, 124, 125, 127,
127, 147, 273, 274, 275, 276, 277, 278, 279,
280, 281, 282, 283, 284, 285, 286, 287, 288,
341, 350, 373, 458, 459, 463, 464, 465, 466,
468, 469, 472, 475, 480, 483, 489, 492, 493,
499, 506, 509, 536, 545, 574, 575, 577, 578,
589, 595, 601, 604, 616, 624, 626, 636, 643,
645, 646, 647, 654, 659, 660, 666, 677, 678,
681, 688, 689, 690, 692, 693, 694, 695, 696,
699, 700, 701, 702, 705, 706, 744, 803, 804,
808, 815, 816, 826, 832, 835, 837, 840, 852,
854, 855, 856

BANGLADESH.....3, 4, 17, 128, 130, 133, 134, 145, 150, 152,
153, 154, 471, 474, 487, 498, 535, 591, 605,
613, 615, 622, 668, 708, 712, 717, 719, 822, 831

BHUTAN.....311, 547

BURMA.....4, 195

CAMBODIA.....34

CHINA.....55, 59, 249, 250, 259, 261, 262, 276, 418, 421,
422, 424, 427, 433, 437, 439, 443, 450, 456,
573, 652, 669, 671, 704, 789, 790, 791

INDIA.....3, 4, 8, 10, 14, 15, 16, 18, 19, 22, 23, 24, 30, 31, 64, 67, 75, 79, 103, 106, 119, 129, 132, 136, 137, 139, 140, 141, 142, 149, 155, 157, 158, 164, 165, 166, 167, 168, 169, 170, 173, 175, 178, 179, 180, 181, 182, 183, 184, 185, 186, 221, 290, 292, 293, 295, 296, 298, 299, 300, 301, 302, 303, 304, 305, 310, 311, 312, 313, 314, 316, 317, 319, 320, 321, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 334, 335, 337, 338, 339, 342, 343, 344, 460, 462, 467, 470, 476, 477, 478, 484, 485, 494, 496, 500, 501, 502, 503, 512, 514, 515, 517, 522, 523, 524, 525, 526, 531, 533, 534, 569, 584, 585, 587, 588, 592, 594, 627, 628, 630, 635, 637, 639, 653, 665, 672, 682, 685, 691, 703, 704, 709, 710, 711, 714, 716, 718, 721, 722, 726, 727, 733, 736, 737, 739, 740, 741, 742, 743, 799, 800, 801, 814, 818, 825, 828, 844, 847, 853

INDONESIA.....3, 4, 32, 50, 104, 11, 112, 189, 204, 205, 208, 212, 214, 222, 229, 240, 357, 361, 376, 408, 510, 521, 550, 583, 598, 599, 608, 621, 756, 758, 761, 767, 775, 812, 819, 820, 827, 861

JAPAN.....56, 58, 83, 246, 247, 251, 252, 260, 265, 267, 268, 272, 425, 426, 428, 429, 430, 431, 432, 434, 435, 436, 440, 441, 442, 444, 445, 448, 449, 451, 454, 455, 548, 580, 596, 600, 607, 641, 648, 649, 658, 780, 786, 793, 802, 810, 830

LAOS.....34

MALAYSIA.....36, 40, 52, 60, 190, 210, 211, 236, 237, 356, 358, 360, 363, 364, 365, 366, 375, 384, 377, 379, 380, 381, 385, 386, 400, 402, 405, 409, 413, 414, 504, 511, 519, 549, 602, 625, 631, 632, 633, 651, 670, 686, 755, 767, 821, 838, 845, 846

NEPAL.....4, 11, 20, 25, 26, 27, 28, 96, 100, 143, 176, 291, 297, 309, 311, 315, 337, 340, 482, 547, 797

PAKISTAN.....3, 21, 69, 119, 138, 144, 146, 149, 156, 161, 163, 187, 289, 294, 306, 307, 308, 318, 322, 333, 345, 467, 473, 479, 516, 518, 644, 664, 680, 684, 713, 715, 723, 724, 728, 729, 730, 732, 734, 735, 798, 809, 839

PHILIPPINES.....3, 35, 37, 39, 42, 43, 44, 45, 46, 47, 48, 49, 51, 54, 74, 80, 81, 82, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 97, 101, 102, 107, 108, 114, 119, 127, 193, 197, 198, 199, 200, 201, 203, 206, 207, 209, 213, 218, 219, 223, 224, 225, 226, 228, 230, 232, 234, 239, 241, 242, 243, 276, 347, 348, 349, 352, 353, 354, 355, 359, 362, 370, 387, 389, 392, 393, 394, 395, 396, 397, 398, 399, 406, 407, 415, 416, 417, 461, 486, 488, 495, 507, 520, 531, 536, 538, 544, 551, 554, 552, 553, 554, 555, 556, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 570, 571, 572, 576, 581, 582, 603, 606, 612, 619, 640, 650, 655, 656, 657, 674, 676, 679, 683, 687, 697, 698, 745, 746, 747, 748, 749, 750, 751, 752, 759, 760, 762, 763, 764, 765, 768, 770, 771, 772, 773, 776, 806, 807, 811, 813, 817, 833, 842, 843, 848, 850, 851

SOUTH KOREA.....3, 57, 248, 255, 266, 438, 453, 597, 792, 858, 859

SRI LANKA.....3, 4, 12, 29, 135, 148, 151, 159, 160, 174, 177, 188, 491, 527, 543, 546, 579, 623, 634, 691, 725, 805, 824

TAIWAN.....60, 61, 68, 113, 244, 245, 253, 254, 256, 257, 258, 260, 264, 269, 270, 271, 391, 419, 420, 423, 446, 447, 452, 497, 508, 528, 529, 530, 539, 540, 541, 593, 610, 611, 673, 779, 781, 782, 783, 784, 785, 787, 788, 793, 795, 849, 860

THAILAND.....3, 4, 33, 34, 38, 53, 63, 191, 192, 194, 196, 202, 215, 216, 217, 231, 220, 227, 232, 235, 238, 346, 367, 368, 369, 370, 372, 274, 378, 382, 388, 390, 400, 403, 404, 410, 411, 412, 457, 481, 490, 505, 513, 542, 586, 590, 609, 614, 617, 618, 620, 629, 642, 661, 663, 707, 753, 754, 757, 769, 774, 777, 778, 823, 829, 836, 841

VIETNAM.....34, 707

AUTHOR INDEX

Aart, R. van, with H.L.M. van der Hoff, 189

Abel, M.E., 779

Academia Sinica, 418

Ackermann, N.L., 542; with T. Tingsangchali and V.A. Sahagun, 348; with others, 346, 347

Adams, M.E., 812

Adan, B.L., with E.W. Lee, 80

Agarwal, M.C., 190

Aglibut, A.P., 612

Agpaoa, A., et al., 349

Agrawal, N.K., 797

Alam, M., 613

Aleem, A., 289

Alejandrino, A.A., 813

Ali, S.H., 62, 814

Alton, C.T., 614

Ambasht, R.S., with K.N. Misra, 350

Ambegaonkar, L.V., 815

American Society of Agronomy and Soil Science Society of America, 273

Andreou, P., 708

Angeles, H.L., 674

Arbhabhirama, A., et al., 81

Arif, M.T., 128

Arulpragasam, L.C., 589

Arumugam, S., 543

Asia Society, 100

Asian and Pacific Development Institute, 274

Asian Development Bank, 744, 816

Asian Institute of Technology, 351

Asian Productivity Commission, 115

Asian Productivity Organization, 659, 660

Asopa, V.N., et al., 129

Assen, J.H., 590

Attanato, C., 63, 457

Atthayodhin, C., 191, 192, 661

Bacdayan, A.S., 193

Bach, K.W., 194

Baconguis, S.R., 352; with C.S. Rondilla, 353

Bagadion, B., with F.F. Korten, 745; with F.F. Korten and D. Korten, 746; with others, 817

Bahdrapur, T.G., with T.S. Rao, 290

Bajracharya, K.M., 291

Banerji, S., with V.B. Lal, 292

Bangladesh Agricultural University, 591

Bangladesh Government, 130

Bangladesh Institute of Development Studies, 474

Bari, F., 615

Barnard, R.E., 131

Barrow, C.J., 275

Basu, D.N., 132; with C. Gopinath and G. Karady, 475; with S.B. Mukherjee, 592

Beardsley, R.K., with J.W. Hall and R.E. Ward, 780

Bhargana, B.S., 709

Bhaskaran, P., 710

Bhatia, R., 476, 477, 818; with M. Mehta, 478

Bhatty, K.M., 798

Bhuiyan, S., 675

Bhuiyan, S.J., 662; with C.A. Khan and I. Islam, 133

Bikashamaiah, G., with B. Subramanian, 293

Biswas, A.K., 1, 458

Biswas, M.R., et al., 134

Boedidarmo, B., 819

Bokhari, S.M.H., 294, 479

Bolle-Jones, E.W., 195

Bonatan-Dura, F.M., 354

Boonlu, J., 663

Booth, A., 32, 820

Bottomley, A., 480

Bottrall, A.F., 676, 688, 689, 781

Bower, B.T., with M.M. Hufschmidt, 64

Brannon, R.H., with C.T. Alton and J.T. Davis, 196

Briones, N.D., 276

Bromley, D.W., with D.C. Taylor and D.E. Parker, 690

Bruce, C.M.F., with Y.H. Kimaro, 481

Buddhasa, S.V.A., 135

Burke, J.T., 593

Cablayan, O.M., with R.S. Gamboa, 747

Caldwell, J.M., 355

Camp Dresser and McKee International, Inc., 101

Caprihan, S.P., 136

Carruthers, I.D., with N. Mountstephens, 459

Cerdan, T.A., 197

Chadha, O.P., 711, 799; with B.K. Uppal, 65

Chainarong, L., 33

Chambers, R., 691; with R. Lenton, 677

Chan, C.C., 419, 420

Chandrasheklar, A.K., 800

Chang, K.T., with T.Y. Tsai and S.T. Hsu, 244

Changming, L., with W. Guangte, 421

Chaturvedi, A.C., 295

Chaturvedi, M.C., 8, 460; with P. Rogers, 514; with V.K. Srivastava, 526

Chen, C.L., 782

Cheng, C.S., et al., 783

Cheong, C.L., 821

Chin, L.T., 692, 784

Chinese Academy of Sciences, 422

Choksi, C.K., 801

Chou, C.H., et al., 423

Chowdry, K.R., 296

Chung-Yue, F., 245

Clark, R., 693

Clay, E., 137

Cohon, J.L., with D.H. Marks, 574

College of Agricultural Engineering, Tamil Nadu Agricultural University, 678

Colorado State University, 616

Committee for Co-ordination of Investigations of the Lower Mekong River, 34

Conlin, S., 482

Corey, G.L., with W. Clyma, 138

Cotabato-Agusan River Basin Development Project, 82

Coward, E.W., Jr., 116, 694, 695, 696, 748, 749; with B. Ahmed, 712

Cowley, J.E., with D. Jarasvathana, 617; with B.I. McClennan and C. Swatotirurk, 618

Crow, B., 822

Cruz, D.A., with B.R. Realuyo, 750

Cruz, F.A., 198

Cruz, H.A., 199, 697

Cruz, M.C., 200, 201

Curtin, G., 544

Dakshinamurti, C., with A.M. Michael and S. Mohan, 9

Daneke, G.A., with J.D. Priscoli, 66

Daniel, J.G., with A. Kulasingham, 356

Das, K.B., 483

Dastane, N.G., 139

David, W.P., 202

Degushi, K., 246

De Los Reyes, R., et al., 203, 751, 752

De Luna, E., with H.P. Quiazon, 35

Demaine, G., with C.J. Dixon, 823

Deshmukh, O.A., 10

Devendra, T., 824

De Vera, M.R., 619

Devitt, J.G., 297

De Wolf, J., 545

Dhawan, B.D., 140, 141, 142, 484

Dhillon, G.S., with T.C. Paul, 298

Dillaka, T.A., III, with D.B. Beasley and L.F. Huggins, 277

Division of Agricultural Economics, Indian Agricultural Institute, 594

Dixon, J.A., 143

Djojoadinato, D., 204

Djunaedi, S., 205

Dozina, G., Jr., with M. Kikuchi and Y. Hayami, 206

Duncan, S., 753, 754

Dutch National Committee, ICID, 620

Dwyer, D.J., 207

Early, A.C., 144, 461, 515; with B.U. Bagadion, 679, 698; with others, 516, 713

Easter, K.W., 117, 485

Eckert, J., with N. Dimick and W. Clyma, 664

Edwards, C., with S. Biggs and J. Griffith, 145

Eelart, L.J. van den, 357

El-Swaify, S.A., et al., 278

Elumalai, G., 714

Evett, W.W., 11

Eyre, J.D., 247

Faisal, K., 755

Fang, Z.S., et al., 424

Federation of Malaya, 358

Fernando, A.D.N., 12

Fok, Y.S., 2

Food and Agriculture Organization, 36, 248, 359

Foss, P., et al., 715

Framji, K.K., with I.K. Mahajan, 13

Fricke, T.J., with K.V. Lewis, 360

Fujimoto, S., with S. Takasu, 425

Fujioka, Y., 595

Fukuda, H., 596

Gallin, B., 249

Gandi, P.C., 665

Ganguly, S.S., 299

Garcia-Yangas, R., 486

Gasser, W.R., 3

Gavan, J.D., with P. Rogers, 517

Gearheart, R.A., 361

Gebalier, D.M.E., 699

Geertz, C., 208, 756

Gerards, J.L.M.H., 621

German Foundation for Developing Countries, 362

Ghosh, R.C., with B.K. Subba Rao, 300

Gil, N., 279

Gill, M.A., with A.C. Early, 146

Gillespie, V.A., 757

Giron, O., et al., 209

Gittinger, J.P., 210, 597

Goel, A.C., with B.N. Rao, 147

Goldman, R.H., with L. Squire, 211

Gomez, G.E.M., 148, 527

Goonasekere, K., 622; with T. Wickham, 623

Gopalakrishnayya, K., 462

Gopinath, C., 825

Government of Karnataka Planning Division, 716

Greer, C., 250

Gunawardana, R.A.L.H., 546

Gupta, G.P., 301

Gustafson, E.W., with R.B. Reidinger, 146

Hafid, A., with Y. Hayami, 212

Hakanglu, E., 518

Hamid, M.A., et al., 717

Hanam, Z., 102

Haniff, M., 302

Hanumantha Rao, K., with K.M. Rao, 826

Hanumantha Rao, T., 303

Haque, F., 150, 487

Harriss, J., 666

Hatate, I., 802

Hatch, T., 363

Hayton, R.D., 803

Heider, T.D., with C.H. Hong, 364

Heiler, T., 365

Hiames, Y.V., with W.A. Hall and H. Freedman, 575

Hock, P.D., 366

Holloran, S., et al., 827

Holmes, D.W., with R. Wooldridge, 151

Hosain, A., 152

Hosoyamada, K., 426

Hossain, M.A., 153

Howard, P.M., 427

Howes, M., 700

Hsieh, S.C., 785

Hsu, Y.P., 624

Huang, Y., 625

Huelgas, R.R., with R.D. Torres, 488

Hufschmidt, M.M., with B.T. Bower, 701

Husein, Z., 598

Hutapea, R., with P. Dirjasanyata and N.G.S. Nordholt, 758

Ienaga, Y., 37, 626

Illo, J.F.I., 213; with R. De Los Reyes and N.S. Felix, 759

Imamura, N., 428

India, Central Board of Irrigation and Power, 103, 627, 718

India, Ministry of Agriculture and Irrigation, 14, 15

Indian Institute of Science, 828

Indian National Committee for IHP, 304

Indian National Science Academy, 16

Indonesia, Ministry of Public Works and Electric Power, 104, 599

Ingersoll, J., 463

Inos, P.I., 760

Institute of Science, Tribhuwan University, 105

Institut Pertanian Bogor, 761; and Proyek Irrigasi IDA, 214

Interim Committee for the Coordination of Investigations of the Lower Mekong Basin, 367, 368, 369

International Affairs Commission of the Japanese Society of Irrigation, Drainage and Reclamation Engineering, 429

International Bank for Reconstruction and Development, 17

International Commission on Irrigation and Drainage, 215

International Rice Research Institute, 118

Irrigation (Special Issue), 119

Islam, T.R., 719

Isles, C.D., 762

James, L.D., 489

Jansen, E.G., 154

Japan, Aichi Irrigation Public Corp., 251

Japan Cultural Science Society, 600

Japan Government, with FAO, 601

Japan International Cooperation Agency, 370, 576

Japan, Ministry of Construction, 430, 431

Japan, Ministry of International Trade and Industry, 432

Japan, Yodo River Dams Control office, 83

Japanese National Committee, ICID, 252

Japanese Society of Irrigation, 56

Jaraswathana, D., 38; with S. Pinkayan, 371

Jayaraman, T.K., 155, 305, 628, 720, 721, 722

Jian, D.Q., with L.D. Qi and J.H. Tan, 433

Jindarojana, J., 372

Johnson, C.R., 547

Johnson, B.L.C., 306

Johnson, S.H., III, 490; with A.C. Early and M.K. Lowdermilk, 156; with W.D. Kemper and M.K. Lowdermilk, 307

Joint Commission on Rural Reconstruction, 120, 253

Jones, G.N., 723; with R.L. Anderson, 308; with others, 724

Joshi, M.D., 309

Julian, S.I., 39

Kadomura, H., 434

Kambhu, M., 829

Kampen, J., 373

Kanazawa, N., 548, 786, 830

Kanchanaphol, L., 629

Kandiah, A., 491

Kang, N., 374

Kannan, K.P., 310

Kanshik, C.R., with A.C. Gangwar, 157

Kapon, K.N., 311

Karuanayake, M.M., 725

Kathpalia, G.N., 726

Kaufman, H.K., 216

Keat, T.S., with D.C. Still and P. Scarf, 40

Kedah, H., 375

Keller, J., et al., 67

Kemper, W.D., with M. Haq and A. Saeed, 727; with others, 680

Khan, H.R., with J. Romm, 831

Knrisha, J.H., 312

Kikuchi, M., 492

Kim, K.H., 57

Kira, H., with K. Ohta, 435

Kislali, A., with C. Sevin, 313

Ko, N.C., 254

Kodaira, T., with R. Hamada, 436

Korea (Republic), Ministry of Agriculture and Fishery, 255

Korten, F.F., 763

Kudo, H., with K. Ishizaki, 58

Kumar, P., 158, 630

Kung, P., 121, 217

Kung, S.Y., with T.C. Chiang, 437

Kunkle, S.H., 376; with A.J. Dye, 280

Kwi, S.N., 377

Lahiri, S., 106

Lakshminarayana, C., with S.P. Rajagopalan, 84

Land Use Study Project, University of London, 378

Langford, K.J., with P.J. O'Shaughnessy, 281

Lazaro, R., with D. Taylor and T. Wickham, 832

Leach, E.R., 159

Lee, C., 438

Lee, C.Y., with S.T. Hsu, 528; with K.M. Lee, 256; with Y.J. Yang, 787, 788; with Y.J. Yang and S.T. Shyu, 529

Lee, S.C., with C.Y. Lee and Y.J. Yang, 68, 258, 530; with C.Y. Lee, Y.J. Yang and K.M. Lee, 257

Leeds, H., with Jewett, Inc., 833

Leigh, C.H., 379; with K.S. Low, 380

LeMarquand, D.G., 804

Lenton, R.L., 464, 465, 681, 834

Leuterio, M., 764

Levine, G., 122, 466, 577; with E.W. Coward, Jr., 835; with H.C. Hart, 702

Lewis, H.T., 218

Lewis, J.A., 160

Lieftinck, P., with A.R. Sadove and T.C. Creyke, 69

Lim, C.C., 381, 602, 631, 632

Limpadanai, D., with P. Brahmanonda, 382

Lin, M., 259

Linden, P. van der, 383

Livingstone, I., with A. Hazelwood, 578

Llorente, R.R., 765

Lowdermilk, M.K., with W. Clyma and A.C. Early, 161; with A.C. Early and D.M. Freeman, 467; with M. Svendsen, 70

Maass, A., et al., 468

Macpherson, G., 703

Mageed, Y.A., 71

Maheswaran, A., 469; with G.J.P. Gunawardane, 805

Major, D.C., 493

Malabanan, I.P., 806

Malaysia, Ministry of Agriculture, 384, 385, 519, 549, 633

Malaysia, Ministry of Agriculture and Fisheries, 386

Malhotra, G.P., 314

Malla, K.B., 315

Mana, H.S., et al., 316

Maruyana, E., 123

Mathur, P.D., 470

Mathur, R.N., with A.K. Tosin, 18

McGarry, M.G., with J. Stainforth, 439

Megino, R.P., with J.C. Sta. Inglesia, 603

Mehta, R.S., 4

Mendis, M.W.J.G., 162

Mendoza, V.B., 387

Merrey, D.J., 163, 728

Merriman, J.L., 634

Miao, C.T., 260

Minami, I., 388

Mines, N.H., with M.Y. Golour, 389

Miranda, S.M., with G. Levine, 219

Mirza, A.H., 729; with D.J. Merrey, 730

Mohamed, K.H., 766

Mohanakrishnan, A., 166

Mohan Rao, J.S.R., 164, 165, 319, 320

Mohan, S., 767

Mohite, A.V., with A.K. Shingte, 321

Mohsin, N., 667

Moore, M., 579

Moroto, K., with S. Watanabe, 440

Motooka, T., 604, 836, 837

Muda Agricultural Development Authority, 838

Muda Irrigation Scheme, 72

Muhammad, A.C., 839

Mukerji, S.P., 635

Murshed, S., with M. Hossain, 605

Murthy, Y.K., 731

Nachappan, K.M., with R.K. Sivanappan and G. Balashbramanian, 167

Nag, B.S., with G.N. Kathpalia, 19

Nagahori, K., with N. Haccho, 441

Nagata, K., 261

Namba, S., 322

Narayana, V.V.D., with N.K. Tyagi, 323

Narayanmurthy, S.G., with R. Revelle, 531

Neghazzi, H.M., with J.A. Seagraves, 840

Negi, S.S., 324

Nelson, M.L., et al., 390

Nepal Ministry of Water and Power, 20

Nickum, J.E., 59, 789, 790, 791

Niwas, S.R., with R.A. Rastogi and S. Ram, 325

Noranitipadungkarn, C., 841

Notodihardjo, M., with R.C. Amster, F. Putuhena, and G. Wardoyo, 550

Ogata, H., 580

Ogawa, S., with N. Ebisu and K. Mizutani, 442

Oh, H.S., 792

Omar, A.H., 636

Ongkongko, P.S., 768, 842

Pacheco, E.S., et al., 532

Padhye, M.G., 168

Pai, A.A., 169; with S.K. Hukkeri, 637

Pakistan Academy of Sciences, 21

Pakistan Planning Commission, 732

Pal, P.K., 326

Pal, S.P., 170, 494

Palanisami, K., with D.S. Thornton, 682

Palosoot, P., with M. van Dis, 638

Pande, H.K., 171, 172

Pandey, M.P., 173

Pandyahibya, B., 220

Pant, M.C., et al., 327

Pant, N., 221, 733

Paranakian, K., 769

Parikh, J.K., 328

Pasandaran, E., 222

Pasternak, B., 262, 263, 264

Patel, S.M., et al., 639

Patri, S., with S. Chandra and E.K. Subba Rao, 329

Patten, R.H., with A.H. Khan, 668

Pemberton, E.L., 392

People's Republic of China, Bureau of Water Conservancy and Electric Power, 669

Perino, J.M., 282

Pescod, M.B., 73

Philippine Council for Agricuture and Resources Research, 223

Philippines (Republic), Bicol River Basin Development Program, 393

Philippines (Republic), Department of Public Works, Transportation, and Communications, 394, 396, 551

Philippines (Republic), Development Academy of the Philippines, 41

Philippines (Republic), Farm Systems Development Corporation, 552

Philippines (Republic), Laguna Lake Development Authority, 85, 86

Philippines (Republic), Local Water Utilities Administration, 395, 495, 553, 554, 555, 556, 557, 558, 559, 683

Philippines (Republic), Ministry of Public Works and Highways, 560

Philippines (Republic), National Economic and Development Authority, 74, 87, 107, 843

Philippines (Republic), National Hydraulic Research Center, 42, 397, 561, 562

Philippines (Republic), National Irrigation Administration, 398, 563, 581, 640

Philippines (Republic), National Power Corporation, 399, 520, 564, 565

Philippines (Republic), National Water Resources Council, 43, 44, 45, 47, 48, 49, 90, 91, 92, 93, 94, 95, 226, 566, 567, 568, 606, 770, 807

Pinkayan, S., with V.A. Sahagun, 400

Pohjakas, K., 401; with E. Livingston and Y.M. Lubis, 50

Poolsup, M., 227

Potts, P.W., with R. Knight and Y. Sternberg, 582

Prabowo, D., 521, 583

Pradhan, B.K., 96

Prasad, P.H., 496

Prasad, T., 75, 522

Prasad, V.N., 228

Purushottam, J., 330

Pushparajah, E., 402

Rada, E.L., with T.H. Lee, 497

Radosevich, G.E., 734, 808; with C. Kirkwood, 735

Rana, M.M., with B.B. Shresta, 109

Rao, A.A., with V. Ramesan, 22

Rao, K.L., 23

Rao, K.N., 24, 533

Rao, P.K., 534

Rao, P.S., 584

Rao, V.K.R.V., 844

Rao, V.R., 331

Rege, N.D., 585

Reidinger, R.B., 736, 737

Resosudarmo, S., 229

Resources for the Future, Inc., 110

Reuss, J.O., 684

Ritchie, J.C., et al., 586

Roberts, M., 174

Robinson, A.R., 443

Robinson, D.M., 771, 772

Rogers, P., 332, 333, 471, 498; with M.C. Chaturvedi, 587; with C. Hurst, 499; with P.S. Rao and S. Ramasheshan, 588; with D. Smith, 535

Rondinelli, D.A., 536

Rouysungnern, S., 403

Ruangdej, S., 404

Rubin, H., 773

Rydzewski, J.R., with S. Nairizi, 537

Saburo, K., 265

Saito, H., 607

Sakamoto, I., 641

Samad, M.A., 809

Sanders, W., 230

Sandoval, M., with F.B. Mamaril, Jr., 51

Sastary, G., with P.N. Bhatt, 334

Satoh, M., 444

Schramm, G., 472

Scott, W.J., with F.M. Riberny and T.J. Fricke, 405

Seang, T.T., 670

Sears, T.W., 406

Seckler, D., with D. Joshi, 335

Sektheera, R., with A. Cornavich, 774

Selvalingam, S., with S. Phonopraphan, 642

Selverajan, S., with S.R. Subramanian, 500

Seng, G.K., 52

Shah, S.L., 336

Shakya, K.M., 337

Shankar, K., 25

Sharma, A.C., with B.R. Garg, 338

Sharma, A.K., with V. Kumar, 339

Sharma, C.K., 26

Sharma, R.K., 501

Sheik, M.I., 473

Shepherd, A.W., 175

Sherman, L., 97

Shibuya, K., 445

Shimkhada, D., 340

Shimura, H., 643

Short, D.E., 845; with J.C. Jackson, 846

Shrestha, M.M., 176

Shristha, H.O., 27

Sigurdson, J., 704

Sims, B.D., with M.L. Bonita, 407

Sing, L.M., 446

Singh, A.J., 341

Singh, J., 847

Singh, K., with K.M.B. Rahim, 523

Singhal, M.K., 502, 524

Sinha, B., with R. Bhatia, 503

Sivanappan, R.K., with M. Koteswaran and A.A.N. Bright, 342; with O.P. Kumari, 569; with K. Palanisami, 685

Sivanayagan, T., 117

Skogerboe, G.V., with W.D. Kemper and J.D. Reuss, 644; with J.D. Reuss and W.D. Kemper, 645

Slade, R.H., 504

Small, L.E., 506, 646

Soelistyo, 608

Soenarjo, G., 775

Soerjani, N., 408

Soo, T.T., 409

Southeast Asia Development Advisory Group, 28

Spencer, T., 647

Spooner, B., 283

Sri Lanka, Ministry of Irrigation, Power and Highways, 29

Srivardhana, R., 232, 410

Srivastava, K.B., 738

Stansby, I., with S. Stisen, 233

Steinberg, D.I., with R.B. Morrow, I. Palmer, and K. Dong-Il, 266

Subramanian, R., et al., 739

Sugarawa, M., 98

Sumayao, C.R., 538

Sun, P.C., 447

Sundar, A., with P.S. Rao, 740

Suwarnarat, K., 411

Suzuki, I., 648

Tabbal, D.F., with T.H. Wickham, 234

Tagarino, R.N., 848; with R.D. Torres, 507

Taiwan Provincial Water Conservancy Bureau, 60, 508, 539, 540, 541, 849

Takagi, A., et al., 810

Takahashi, A., 776

Takase, K., 850, 851

Takeda, K., 99

Tamaki, A., 267, 649

Tantigate, K., 235

Tariq, M.N., et al., 343

Taylor, D.C., 236, 509, 510, 852; with K. Tantigate, 511

Thailand, International Land Development Consultants, 777

Thailand, Ministry of Agriculture and Cooperative, 53

Thailand, Royal Irrigation Department, 778

Thamoldaran, R., with S. Bide and E.O. Heady, 512

Thavaraj, S.H., 237, 705

Theppachoncherin, P., 238

Thimakorn, P., et al., 412

Thomson, J.F., 124

Thormann, P.H., 178

Thornwaite, C.W., et al., 5

Tillson, D., with J.V. Sinogba, Jr., 54

Tingsanchali, T., et al., 570

Toebes, C., with G.K. Seng, 413

Tolba, M.K., 284

Tomosugi, T., 609

Torres, R.D., 650

Trehan, N.C., with I.D. Mirchandani, 344

Trelease, F.J., 811

Tripathy, R.N., 853

Trung, N.Q., 513

Tsuchida, A., with T. Murota, 448

Tsuchimochi, M., with K. Ezaki and S. Yashima, 651

Tsuchiya, A., 449

Tsuchiya, H., 793

Tsutsui, H., 854

Ueda, M., 414

United Kingdom, University of Sussex, Institute of Development Studies, 855

United Nations, 345, 571

United Nations Development Programme, 671

United Nations Economic and Social Commission for Asia and the Pacific, 287, 652, 856

United Nations Economic Commission for Asia and the Far East, 76, 77, 179, 268, 285, 286

United Nations, Educational, Scientific, and Cultural Organization, 6

United Nations, Report of the Secretary General, 857

United Nations Secretariat, 706

Unson, D.C.D., 239

Upland Hydroecology Research Program, 415

Vaidya, G.M., 180

Van, T.K., 686

Van Aart, R., 181, 653; with H.L.M. van der Hoff, 240

Vander Velde, E.J., 182, 183

Vandermeer, C., 269, 270

Varma, C.V.J., 30

Vedula, S., 525

Veeman, T.S., 741

Venkataraman, A., 184

Verma, R.D., 78

Vermeer, E.B., 450

Vohra, B.B., 79

Wade, R., 185, 672, 742, 743, 858, 859; with R. Chambers, 654

Wagner, W.K., 572

Walker, H.H., with P. Kampe, 186

Walker, S.H., et al., 111, 112

Walker, S.R., 187

Wang, C.C., 61

Wang, J.K., et al., 416

Wang, S.H., with R. Apthorpe, 271

Wang, Y.T., 113, 860

Wardoyo, I.R., 861

Watanabe, K., with T. Oshima, 451

Water Resources Planning Commission, 794

Watt, S., 707; with J. Collett, 573

Wattanavitukul, S., with M.C. Cruz, 125

Wells, K.S., 188

Wen, L.J., 673

Wickham, G.Y., 241; with T. Wickham, 242

Wickham, T.H., 126, 127, 655, 656; with R.D. Reyes, 687; with K. Takase, 657; with A. Valera, 243

Williams, D.A., 31

Williams, J.A., with L.S. Hamilton, 288

Williams, J.F., 452

Woo, B.M., 453

World Health Organization, 114, 417

Wu, C.H., 795

Wu, W.C.H., 610

Yabashi, S., et al., 454

Yang, Y.J., 611

Yoshida, H., 455

Yoshino, M.S., 7

Young, F.W., with T.C. Huang, 796

Yukawa, K., 272, 658

Zhu, Z.S., 456