Externality Effects of Irrigation Development

Efficiency in Irrigation: The Conjunctive Use of Surface and Groundwater Resources. Edited by Gerald T O'Mara. Washington, DC: A World Bank Symposium, The World Bank, March 1988, 196 pages, $19.95

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In many developing countries, the creation or extension of irrigation agriculture has led to numerous deleterious side effects, commonly known as externality effects. Some of these effects, such as salt accumulations in the soils, depletion of aquifers, and disruption of natural drainage systems, are the focus of this book. The book grew from a 1983 World Bank conference in Washington, DC, that discussed the physical and economic effects that result when farmers rely on surface irrigation and certain common aquifer systems.

The papers in this book have developed important information on the nature of externalities associated with certain irrigation regions of the world. Irrigation experts will find the analyses especially useful as they become increasingly aware of the potential for conjunctive use of water.

O'Mara's introductory chapter suggests that innovative approaches, such as farmer participation in the planning and management of water resources through careful scheduling of water distribution, will reduce inefficiency in irrigation practices. Providing the heart of the book is the discussion of three regional models of irrigation development which resolve the effects of externalities in California (Coe), Pakistan's Indus Basin (Johnson), and the North China Plain (Ronghan and Lingen). In each case, the solution varies. In California, the overmining of ground water was resolved in part by importing surface supplies developed through the Feather River Canyon Project. In the Indus Basin, tube wells removed salt accumulation by lowering the ground water tables. In the North China Plain, the conjunctive use of underground aquifer water to supplement the diversion of sediment-laden water from the Yellow River was the top priority. These papers show sound empirical analyses based on extensive fieldwork.

On other issues, Randall argues for the replacement of such well-known concepts as "common property resources," "public good," "natural monopoly," and "externalities" by alternative concepts as nonexclusiveness and nonrivalry. Randall says the new terms are more useful than the old ones, which do not define the sources of market failures properly because they are interpreted in a variety of ways by different people. The reasoning and conclusions are somewhat abstract and would be difficult to apply in practice.

Radosevich illustrates the role of water laws including policies and institutions that have evolved in various regions of the world to guide water development. The discussion is incisive and will prove influential in the long run for developing water resources through innovative legal institutions. Radosevich claims that "the law may be inappropriate to the present problems or may not provide the proper guidance." He cites water pricing as an example where the present laws fail to provide an efficient use of water resources. He contends that laws should permit water-user fees to be charged by volume to encourage more efficient use of water.

The last part of the book revolves around the main analytical methods applied to analyze water resource management models. Gorelick reviews ground-water management models for efficient allocation of groundwater resources. However, lack of physical measurements on aquifer processes makes these models less practical in analyses. Rogers, Harrington, and Fiering also discuss new approaches to using mathematical programming for resource allocation. The authors attempt to link a sequence of linear programming formulations, each representing a different stage of development in an integrated system, resulting in enormously large matrices of the constraining set, which lead to needless computational difficulties.

In another discussion of the Indus Basin, O'Mara and Duloy divide the area into agroclimatic zones to identify the differences in soils and climate as they are reflected in the region's cropping patterns. The entire Indus Basin is partitioned into 53 irrigated regions known as polygons. Each polygon is essentially homogeneous with respect to ground water and preserves boundaries that are significant to ground-water aquifer systems. Each polygon also receives surface water on a monthly basis from the control points of the surface water delivery system. Thus, interdepend-

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ence is built into the water development measures of the Indus Basin system O'Mara and Duloy convincingly establish that externalities are really the crux of water resource management and that progress in internalizing these externalities is an urgent challenge for development

Zapata develops a model using the existing institutional arrangements for water allocation (except for the optimal pumping tax) in the case of ground-water uses in western Argentina This model, however, neglects dynamic optimization issues such as the optimum level of storage in the aquifer, and ignores other environmental effects, such as the mixing of fresh water with saline ground water

In contrast to Zapata's analysis, Bredehoeft and Young address the efficient conjunctive use of water from ground and surface sources along a reach of the South Platte River in Colorado The authors skillfully display technical ingenuity in simulating the physical interdependence among different water supply sources in a relatively dry environment where the surface water supply is limited As more wells are installed, the variation in farm net income tends to be reduced, and the net income increases

Thomas evaluates policy choices for two arid countries, Qatar and Libya The recent tapping of new petroleum reserves in both countries has opened up some innovative options for water development (including the use of cheap petroleum energy in desalting sea water for agricultural purposes) which were not previously available Thomas points out that, in the long run, the development of ground water in desert aquifers will be costly to maintain because of falling water tables and rising energy costs The goal of achieving self-sufficiency in food production, though politically attractive as long as oil supplies and revenues are available, may not be economically feasible in the long run

Basu and Ljung describe a ground-water scheduling sequence strategy in India to maximize crop yields by minimizing plant stress conditions at crucial stages of crop growth The authors discuss yields from additional ground-water use for wheat, mustard, and castor They treat externalities as inefficiencies in irrigated agricultural systems prevalent in many parts of India, seeing possible compensation for inefficiencies arising from seepage losses by means of extracting the "lost" water and using it for productive purposes The authors do mention that the pumping of ground water should be limited to the recoverable recharge, but fail to specify the size of recoverable recharge and the duration of the possible recharge period The strength of this paper lies in developing an appropriate irrigation schedule for conjunctive use that is primarily based on a water demand schedule

In my view, these papers are worth reading, and O'Mara should be commended for providing us these analyses in a book form where one could use this information as an aid in understanding various aspects of irrigation development

The papers include (1) "The Efficient Use of Surface Water and Groundwater in Irrigation An Overview of the Issues" by Gerald T O'Mara

Part I: ***Theoretical Issues,*** (2) "Market Failure and the Efficiency of Irrigated Agriculture" by Alan Randall, (3) "Legal Considerations for Coping with Externalities in Irrigated Agriculture" by George Radosevich

Part II: ***Case Studies of Conjunctive Use,*** (4) "Responses to Some of the Adverse External Effects of Groundwater Withdrawals in California" by Jack J Coe, (5) "Large-Scale Irrigation and Drainage Schemes in Pakistan" by Sam H Johnson III, (6) "Development of Groundwater for Agriculture in the Lower Yellow River Alluvial Basin" by Huang Ronghan

Part III: ***Analytical Methods and Applications,*** (7) "A Review of Groundwater Management Models" by Steven M Gorelick, (8) "New Approaches to Using Mathematical Programming for Resource Allocation" by Peter P Rogers, Joseph J Harrington, and Myron B Fiering, (9) "Modeling Efficient Conjunctive Use of Water in the Indus Basin" by Gerald T O'Mara and John H Duloy, (10) "Estimating the Externalities of Groundwater Use in Western Argentina" by Juan Antonio Zapata, (11) "Risk Aversion in Conjunctive Water Use" by John D Bredehoeft and Robert A Young, (12) "Groundwater as a Constraint to Irrigation" by Robert G Thomas, (13) "Irrigation Management and Scheduling Study on an Irrigation System in India" by D N Basu and Per Ljung