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# **Publications Catalogue**

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## RESEARCH REPORTS

ISSN 1026-0862: Price, US\$5.00 (US\$2.50 for developing countries)

57. *Felix P. Amerasinghe, Flemming Konradsen, Wim van der Hoek, Priyanie H. Amerasinghe, J. P. W. Gunawardena, K. T. Fonseka and G. Jayasinghe*

**Small Irrigation Tanks as a Source of Malaria Mosquito Vectors: A Study in North Central Sri Lanka**

2001, 40pp., ISBN 92-9090-461-5

Malaria is a major cause of human mortality, morbidity and economic loss to rural communities in tropical countries. The disease is transmitted by *Anopheles* mosquitoes whose larvae occur in flowing or stagnant surface water habitats. Mosquitoes that transmit other diseases as well as nuisance mosquitoes may also breed in such habitats that are common in irrigation systems. A study done in 1994 in the Upper Yan Oya watershed in the north central dry zone of Sri Lanka showed the malariogenic potential of a small irrigation reservoir that forms part of a cascade irrigation system. The present study followed up on this finding, and investigated the mosquitoes breeding in nine small irrigation reservoirs (known locally as "tanks") in the same watershed during 1995-1997. The objectives were to determine a) whether important malaria vector mosquitoes breed in the tanks, b) tank characteristics that may enhance mosquito breeding, and c) rehabilitation and management measures that may help reduce mosquito breeding in these tanks.

*/ watersheds / tank irrigation / rehabilitation / malaria / waterborne diseases / vectors / data analysis / siltation / Sri Lanka / Huruluwewa /*

56. *David Molden, R. Sakthivadivel and Jack Keller*  
**Hydronomic Zones for Developing Basin Water Conservation Strategies**

2001, 40pp., ISBN 92-9090-463-1

The concept and procedures of hydronomic zones are introduced in this report. A set of six hydronomic zones are developed and defined based on key differences between reaches or areas of river basins. These are the water source

zone, natural recapture zone, regulated recapture zone, stagnation zone, final use zone, and environmentally sensitive zone. The zones are defined based on similar hydrological, geological and topographical conditions and the fate of water outflow from the zone. In addition, two conditions that influence how water is managed (whether or not there is appreciable salinity or pollution loading and whether or not groundwater is present that can be used for utilization or storage) are defined. Generic strategies for irrigation for four water management areas—the natural recapture, regulated recapture, final use, and stagnation zones—are presented. The water source zone and environmentally *sensitive zone* are discussed in terms of their overall significance in basin water use and management. Hydronomic zones allow the authors to define, characterize, and develop management strategies for areas with similar characteristics. The concept of zoning is demonstrated in four agricultural areas representing a wide variety of situations: the Kirindi Oya Basin in Sri Lanka, Egypt's Nile Basin, the Bhakra Command Area in Haryana, India, and the Gediz Basin in Turkey. The authors apply the zones within each basin and suggest water management strategies per zone. Hydronomic zones hold potential as a tool that helps to better understand complex water-interactions within river basins, to isolate similar areas within basins and to develop sets of water management strategies better tailored to different conditions within basins.

*/ water conservation / river basins / case studies / irrigation / water management / water use efficiency / Sri Lanka / India / Egypt / Turkey /*

55. *R. Sakthivadivel, Ronald Loeve, Upali A. Amarasinghe and Manju Hemakumara*

**Water Scarcity and Managing Seasonal Water Crisis:  
Lessons from Kirindi Oya Project in Sri Lanka**

2001, 40 pp., ISBN 92-9090-444-5

Coping with scarcity of water supply for managing irrigation under uncertain and inadequate conditions has become part and parcel of many irrigation systems in the semiarid tropics of Asia. Based on a case study of the Kirindi Oya Irrigation and Settlement Project (KOISP) in southern Sri Lanka, this report provides evidence of the uncertain and inadequate inflow into the reservoir and its impact on the seasonal planning.

*/ irrigation management / water management / irrigated farming / rain / crop production / crop yield / case studies / river basins / irrigation scheduling / water allocation / water use efficiency / water scarcity / water demand / reservoirs / flow / farmer participation / farmer-agency interactions / farmer associations / seasonal variation / Sri Lanka / Kirindi Oya /*

54. *Tushaar Shah*

**Wells and Welfare in the Ganga Basin: Public Policy and Private Initiative in Eastern Uttar Pradesh, India**

2001, 56 pp., ISBN 92-9090-446-1

This report analyzes the history of groundwater development in the eastern Uttar Pradesh region over the 1950-1990 period. Its main conclusion is that the story of groundwater-based livelihood creation in the Ganga Basin is one of failed public initiatives and successful adaptive responses by private agents. However, tube-well-induced agrarian dynamism in eastern Uttar Pradesh and north Bihar in recent years can spread to the entire basin if public policymakers learn correct lessons from the experience of these two subregions.

*/ groundwater management / public policy / poverty / pumps / tube wells / river basins / social aspects / flood water / water market / waterlogging / electricity supplies / desalination / energy / India /*

53. *Peter Droogers and Geoff Kite*

**Estimating Productivity of Water at Different Spatial Scales Using Simulation Modeling**

2001, 20pp., ISBN 92-9090-431-3

A clear understanding of the current water balance is required to explore options for water saving measures. However, measurement of all the terms in the water balance is infeasible in terms of spatial and temporal scale, but hydrological simulation models can fill the gap between measured and required data. For a basin in Western Turkey, simulation modeling at three different scales, field, irrigation scheme and basin scale, was performed to obtain all terms of the water balance. These water balance numbers were used to calculate the Productivity of Water at the three spatial levels distinguished to assess the performance of the systems.

*/ water resources / water scarcity / water supply / water balance / simulation models / performance indexes / indicators / river basins / cropping systems / crop yield / productivity / hydrology / economic analysis / Turkey /*

52. *C. J. Perry*

**Charging for Irrigation Water: The Issues and Options, with a Case Study from Iran**

2001, 28pp., ISBN 92-9090-427-5

In recent years, the evidence that water is a finite resource, and that the balance between supply and demand is precarious, has become widespread. In addition, particularly in the irrigation sector, infrastructure has deteriorated due to lack of proper funding for operation and maintenance. Together these two phenomena have generated interest in the potential role of water pricing, either as part of the broader treatment of water as an "economic good" as proposed at Dublin, or as a direct means of impacting on demand, as recommended at the recent Hague conference on water issues. The use of water charges to generate resources for maintenance and to reduce demand is widely advocated. Examples from other utilities, and from the domestic and industrial sectors of water supply suggest the approach could be effective.

*/ irrigation management / productivity / water allocation / water use efficiency / maintenance / operation / cost recovery / user charges / water pricing / water shortage / economic aspects / political aspects / case studies / salinity / Iran /*

51. *Mary E. Renwick*

**Valuing Water in Irrigated Agriculture and Reservoir Fisheries: A Multiple-Use Irrigation System in Sri Lanka**

2001, 44pp., ISBN 92-9090-439-9

Although irrigation water is often used for purposes like domestic use, fisheries, livestock, wildlife habitat and environmental enhancement, the importance of nonagricultural uses of water in relation to the economic development and quality of life for the rural poor has often been ignored. Failure to recognize the nonagricultural uses of water has important implications for irrigation project management, water rights and the economic appraisal of the irrigation projects themselves. Decision makers often lack information on the

relative economic contributions of water in irrigation and nonirrigation uses. This report addresses this problem. It examines the relative economic contributions of irrigated agriculture and reservoir fisheries in the Kirindi Oya irrigation system, located in southeastern Sri Lanka.

*/ irrigation management / water management / water use efficiency / water allocation / domestic water / water quality / irrigated farming / paddy / fisheries / reservoirs / productivity / agricultural production / irrigation systems / Sri Lanka / Kirindi Oya /*

50. *Geoff Kite, Peter Droogers, Hammond Murray–Rust and Koos de Voogt*

**Modeling Scenarios for Water Allocation In the Gediz Basin, Turkey**

2001, 40pp., ISBN 92-9090-417-8

This report describes the use of a distributed hydrologic model to evaluate different data scenarios for the Gediz Basin in Turkey. The study attempted to answer questions such as: what will happen to the basin water resources if a) there is a change in climate, b) it is decided that more water must be retained in the river for environmental reasons, c) more water is extracted for urban and industrial use, or d) the timing and amounts of water used for irrigation are changed? The effects of such changes were evaluated in terms of their impacts on the yields of irrigated agriculture and on the volume of water discharged at the outlet of the basin.

*/ water management / water allocation / models/ river basins / hydrology / decision making / environmental protection / water use efficiency / climate / irrigation water / irrigated farming / streamflow / surface water / salt water intrusion / Turkey /*

49. *David Molden, R. Sakthivadivel and Zaigham Habib*  
**Basin-Level Use and Productivity of Water: Examples from South Asia**

2001, 36pp., ISBN 92-9090—425-9

Increasing water scarcity poses a threat to food security and safe domestic water supplies. Irrigated agriculture is a major driver in leading to water scarcity because of its high consumption of water resources. Obtaining more benefit from

each drop of water consumed, especially from each drop irrigated agriculture consumes, will be key to mitigating problems of scarcity. Means for improving productivity of water are not always immediately apparent due to the complex nature of water diversions and return flows within basins. The purpose of this report is to discuss and illustrate concepts for identifying ways of improving productivity of water within basins.

*/ water management / river basins / water use / productivity / case studies / irrigated farming / indicators/ water scarcity / South Asia/ India / Pakistan / Sri Lanka /*

48. *C. J. Jayatilaka, R. Sakthivadivel, Y. Shinogi, I.W. Makin and P. Witharana*

**Predicting Water Availability in Irrigation Tank Cascade Systems: The Cascade Water Balance Model**

2001, 48pp., ISBN 92-9090-422-4

Better water management in irrigation tank cascade systems is vital in achieving higher productive use of available water. To develop and implement management practices aimed at improving effective use of water, studies leading to the development of models that can predict available tank water in irrigation tank cascade systems are invaluable. This report presents a simple water balance model, *Cascade*, developed to predict tank water availability in the Thirappane tank cascade system in Anuradhapura, Sri Lanka. The report includes calibration of the model and its application to predict tank water availability for rice crops over a 10-year period.

*/ water management / irrigation systems/ tank irrigation / mathematical models/ calibration / water balance / water use efficiency / water availability / forecasting /runoff / indicators / agricultural production / Sri Lanka /*

47. *Wim van der Hoek, R. Sakthivadivel, Melanie Renshaw, John B. Silver, Martin H. Birley and Flemming Konradsen*

**Alternate Wet/Dry Irrigation in Rice Cultivation: A Practical Way to Save Water and Control Malaria and Japanese Encephalitis?**

2001, 40pp., ISBN 92-9090-418-6

A strategy and practice that is said to use water efficiently in irrigation schemes is the alternate wet/dry irrigation method (AWDI) of cultivating rice. It is increasingly used in parts of

Asia, especially in Japan, China, and India. AWDI implies that rice fields are not kept continuously submerged but are allowed to dry intermittently during the rice growing stage. This report reviews previous studies on AWDI with a focus on mosquito vector control, water saving, and rice yields. Examples are given from a number of countries and recommendations are provided for further studies.

*/ water management / water scarcity / water use efficiency / water conservation / irrigated farming / waterborne diseases / rice / malaria / disease vectors / productivity/ flood irrigation / environmental control / climate change / China/ East Africa / India / Indonesia / Japan / Philippines / Portugal / USA /*

46. *R. Sakthivadivel, Upali Amarasinghe and S. Thiruvengadachari*  
**Using Remote Sensing Techniques to Evaluate Lining Efficacy of Watercourses**

2001, 36pp., ISBN 92-9090-416-X

The cost of developing new irrigation potential is escalating. A low-cost alternative strategy of reducing seepage and increasing irrigated area is selective lining of watercourses. It is being increasingly adopted in the Indian subcontinent. In spite of huge investments being made in lining watercourses, studies on assessing the efficacy of such lining are limited in number and scope. Because they have depended mainly on a few sample watercourses supported by limited water measurement and agricultural data, their results are not conclusive. Satellite remote sensing is seen as a cost-effective evaluation tool in view of its large area of coverage, which is synoptic and repetitive.

*/ water management / water distribution / remote sensing / watercourses / canal linings / seepage loss / SRS data analysis / groundwater development / surface water / performance evaluation / equity / India /*

45. *Tushaar Shah, M. Alam, M. Dinesh Kumar, R. K. Nagar and Mahendra Singh*

**Pedaling out of Poverty: Social Impact of a Manual Irrigation Technology in South Asia**

2000, 44pp., ISBN 92-9090-421-6

Treadle pump technology can be a powerful tool for poverty reduction in this region. It self-selects the poor and it puts to

productive use the region's vast surplus of family labor. This report offers an assessment of the social impact of treadle pump technology for manual irrigation in eastern India, the Nepal Terai and Bangladesh, South Asia's so-called "poverty square." This region where 500 million of Asia's 900 million poor live is underlain by one of the world's best groundwater resources at a depth of 1.5 to 3.5 meters. It is claimed that the treadle pump could raise the annual net household income by US\$100, on the average. This report reviews evidence from a variety of studies—including our own—designed to test these claims.

*/ Irrigation management / treadle pump / treadle pump technology / technology transfer / pumps / aquifers / poverty / irrigated farming / social impact / marketing / South Asia / India / Bangladesh / Nepal /*

44. *Intizar Hussain, Fuard Marikar and Waqar Jehangir*

**Productivity and Performance of Irrigated Wheat Farms across Canal Commands in the Lower Indus Basin**

2000, 36pp., ISBN 92-9090-415-1

Enormous differences in agricultural productivity exist across farms and regions in Pakistan. Farm-level data from Sindh, for example, indicate that irrigated wheat output per hectare varies from 0.5 to 5.4 tons across farms. Improving and sustaining productivity, narrowing the existing productivity gaps and enhancing resource use efficiencies, to meet food requirements of a rapidly growing population, are now a central goal of agricultural policy in the country. This report attempts to enhance the understanding of the factors that determine differences in agricultural productivity.

*/ irrigation programs / water management / irrigation water / irrigation supply / agriculture / productivity / performance evaluation / irrigated farming / wheat / data analysis / Pakistan /*

43. Geoff Kite and Peter Droogers

**Integrated Basin Modeling**

2000, 40pp., ISBN 92-9090-411-9

Hydrological modeling simulates the conversion of precipitation to runoff through all of the natural processes involved, such as evaporation, infiltration, transpiration, percolation, surface flow, interflow and groundwater flow.

Hydrological models must be able to simulate those anthropogenic activities, which affect the flow of water from source to sink, such as dams, reservoirs, diversions and irrigation schemes. This report describes multi-scale modeling using, as an example, the Gediz Basin in western Turkey. This basin contains large reservoirs, diversions and irrigation schemes and has industrial and urban water consumptions. Two models, at field, irrigation-scheme and basin scales, were combined to study both water productivity at these three different scales and what the impacts of changing water availability, management practice, and climate might be on irrigation productivity and on the other water users within the basin.

*/ water balance / irrigation management / groundwater / river basins / hydrology / flow / simulation models / evapotranspiration / precipitation / soils / Turkey / Gediz Basin /*

42. *Geoff Kite and Peter Droogers*

**Comparing Estimates of Actual Evapotranspiration from Satellites, Hydrological Models, and Field Data: A Case Study from Western Turkey**

2000, 42pp., ISBN 92-9090—412-7

This report provides an overview of the results of an experiment in which eight different methods of estimating actual evaporation and transpiration were compared using a common database. Methods based on field data, hydrological models, and satellite data were used and the objectives were to compare results and to assess the utility of each method for various applications. The rationale for this experiment was to see the extent to which newly developed techniques provide data, how these data compare with the data from more traditional methods that rely either on field measurements or that merely calculate evaporation and transpiration as a residual of a water balance. To make the comparison as rigorous as possible, the methods were tested using a common dataset provided from two sites in western Turkey. Most comparisons are based on data for 2 days of satellite overpasses, but some methods were able to provide results for longer periods and larger areas.

*/ estimation / field tests / measurement / productivity / remote sensing / crops / water requirements / water balance / irrigation management / river basins / hydrology / models / evapotranspiration / Turkey /*

41. *Christopher A. Scott, J. Antonio Zarazúa and Gilbert Levine*  
**Urban-Wastewater Reuse for Crop Production in the Water-Short Guanajuato River Basin, Mexico**  
2000, 42pp., ISBN 92-9090—404-6

As is the case with most water management practices, there are significant trade-offs associated with irrigation using untreated urban sewage. From a river-basin perspective, wastewater irrigation is an important form of water and nutrient reuse; however, there are important water quality, environmental and public-health considerations. This report explores the advantages and risks of urban wastewater reuse for crop production in the water-short Guanajuato river basin in west-central Mexico. Through a selective literature review, the authors demonstrate how common this practice is throughout the world and in Mexico specifically, and apply and validate the Interactive River Aquifer Simulation (IRAS) model, developed by Cornell University and Resource Planning Associates, to evaluate the outcomes of several alternative water management scenarios for water and soil quality in the study area.

*/ wastewater management / water quality / irrigation management / water shortage / legislation / river basins / environmental degradation / crop production / public health / water reuse / recycling / simulation models / field tests / Mexico /*

40. *Martin Lacroix, Geoff Kite and Peter Droogers*  
**Using Datasets from the Internet for Hydrological Modeling: An Example from the Küçük Menderes Basin, Turkey**

2000, 40pp., ISBN 92-9090-398-8

Public domain datasets have become increasingly available on the Internet. These data are free, easy to obtain and often more up-to-date than those from local sources. These data can be used as inputs into hydrological models. Increased competition for water among water users will be amongst the most important issues of the next few decades. As a result, water scarcity for agriculture and the resulting problem of food security must be addressed. Hydrological modeling can be used to assess basin water resources and to study alternative water allocations among competing demands. Such modeling endeavors usually require a large amount of data. The SLURP (Semi-Distributed Land-Use Runoff Process) hydrological

model has been designed to take advantage of such data sources. This report describes the application of the model to the Küçük Menderes Basin in western Turkey using public domain data from the Internet for topography, land use, seasonal variation in leaf area index (for transpiration) and climate data— all without calibration of parameters.

*/ river basin development / water resources / data collection / models / hydrology / land classification / water management / water scarcity / water allocation / streamflow / water demand / Turkey /*

39. *Andrew Keller, R. Sakthivadivel and David Seckler*  
**Water Scarcity and the Role of Storage in Development**  
 2000, 28pp., ISBN 92-9090-399-6

One-third of the developing world will face severe water shortages in the twenty-first century even though large amounts of water will continue to annually flood out to the sea from water-scarce regions. The problem is that the sporadic, spatial and temporal distribution of precipitation rarely coincides with demand. Whether the demand is for natural processes or human needs, the only way water supply can match demand is through storage. In this report, the authors concentrate on the three kinds of technologies that store water for periods of months, in small reservoirs, or years, in aquifers and large reservoirs. These three technologies are compared from the hydrological, operational and economic standpoints. Some of the environmental aspects of these options are also mentioned, but these aspects are very location-specific and are not discussed in detail.

*/ groundwater resources / water storage / water scarcity / reservoir storage / costs / aquifers / conjunctive use / river basins / surface water / dams / India / China / USA /*

38. *Douglas L. Vermillion, Madar Samad, Suprodjo Puspoutardjo, Sigit S. Arif and Saiful Rochdyanto*  
**An Assessment of the Small-Scale Irrigation Management Turnover Program in Indonesia**  
 2000, 48 pp., ISBN 92-9090-392-9

This study assesses the results of the Small-Scale Irrigation Turnover Program in Indonesia. In 1987, the Government of Indonesia adopted a policy to turn over to water user

associations the management of all public irrigation systems—from the intake to drainage facilities—in the country that are 500 hectares or less in service area. The primary interest of the government in the turnover policy is to lighten its cost burden for the irrigation subsector while enabling farmers to sustain and even improve the productivity of irrigated agriculture through the mobilization of their own local resources. This report examines to what extent these aspirations of the government and the farmers were realized through the turnover program. It analyzes the impacts of management turnover on irrigation management and irrigated agriculture in selected small-scale systems in West and Central Java.

*/ irrigation management / privatization / small-scale systems / irrigation systems / water distribution / performance / operation / maintenance / productivity / crop yield / economic impact / costs / Indonesia /*

37. Charles L. Abernethy, Hilmy Sally, Kurt Lonsway and Chegou Maman

**Farmer-Based Financing of Operations in the Niger Valley Irrigation Schemes**

2000, 44pp., ISBN 92-9090-397-X

This report presents the results of case studies of the functioning of four pump-based irrigation systems in the Niger River valley. The objectives and performance of these schemes and their prospects for sustainability are analyzed, especially in light of the government's policy of promoting irrigators organizations to take over responsibilities for operating and maintaining the irrigation facilities. Lessons and recommendations for future organizational and institutional design, with particular emphasis on the reduction of constraints to physical and organizational performance and on enhancing sustainability, are suggested.

*/ irrigation management / irrigation systems / river basin development / sustainability/ water resources development / low-lift irrigation / low-lift pumps / farmer-managed irrigation systems / farmers' associations / institution building / privatization / performance evaluation / constraints / case studies / financing / costs / climate / food production / Niger /*

36. *D. J. Bandaragoda*

**Institutional Change and Shared Management of Water Resources in Large Canal Systems: Results of an Action Research Program in Pakistan**

1999, 40pp., ISBN 92-9090-387-2

Organizing water users at the secondary level of Pakistan's contiguous canal irrigation system is socially feasible. This conclusion is the result of an action research program conducted at four pilot sites in Pakistan and is contrary to the popular beliefs that exist both within and outside Pakistan. The popular notions, which are related to constraints of an integrated socio-technical system, illiterate farmers, social pressure from big landowners and obstacles caused by the hierarchical society, were proven to be invalid under conditions of a participatory process of social organization.

*/ water resources management / irrigation canals / property rights / social organization / social participation / leadership / landownership / farmer associations / water user associations / equity / farmer-agency interactions / Pakistan /*

35. *D. Renault and I.W. Makin*

**Modernizing Irrigation Operations: Spatially Differentiated Resources Allocations**

1999, 32pp., ISBN 9209090-386-4

Irrigation modernization is increasingly recognized as a fundamental transformation in the management of water resources within agricultural areas. This report discusses how modernization provides an opportunity to redefine and update operational procedures within irrigation schemes. By incorporating broader perspectives and taking more consideration of the spatial distribution of significant variables, this report defines new approaches for the allocation of operational resources

*/ modernization / irrigation systems/ operating policies / water use / irrigation canals / sensitivity analysis/ case studies / models / resources allocation / Sri Lanka / Kirindi Oya /*

34. *M. Samad and Douglas Vermillion*

**Assessment of Participatory Management of Irrigation Schemes in Sri Lanka: Partial Reforms, Partial Benefits**

1999, 40pp., ISBN 92-9090-384-8

This report presents the results of a study to assess the impact of reforms in the management of government-owned irrigation schemes in Sri Lanka. This study was undertaken with the objectives of empirically validating the methodology developed by IWMI to assess the impacts of management devolution and documenting the effects of the participatory irrigation management program on the performance of irrigation schemes in Sri Lanka.

*/ privatization/ policy / performance evaluation / indicators / operating costs / irrigation management / economic aspects / returns / participatory management / farmer participation / government-managed irrigation systems / small-scale systems / large-scale systems / regression analysis models / Sri Lanka / Nachchaduwa / Hakwatuna Oya /*

33. *R. Sakthivadivel, S. Thiruvengadachari and Upali A.*

*Amarasinghe*

**Modernization Using the Structures System Design of the Bhadra Reservoir Project, India: An Intervention Analysis**

1999, 32pp., ISBN 92-9090-385-6

The structured system design is central to the World Bank-funded National Water Management Project (NWMP) that covered about 80 schemes in 11 States in India during 1988–95. This report attempts to evaluate the Bhadra Reservoir Project (BRP) in the Karnataka State, which was one of the earliest projects to adopt the structured system design under the NWMP. The main objective of this report is to carry out a comparative analysis of the BRP before, during and after the NWMP intervention. While the main focus is on water distribution and agricultural productivity, the analysis also briefly covers other relevant issues such as farmer participation, monitoring and evaluation and training. The lessons learnt could be of use for future implementation of such projects.

*/ performance evaluation/irrigation programs / modernization / participatory management /farmer participation/ farmer-agency interactions / farmer attitudes / remote sensing / rice / irrigated farming / water distribution / water supply / productivity / India/ Bhadra Project /*

32. *Upali A. Amarasinghe, Lal Mutuwatta and R. Sakthivadivel*  
**Water Scarcity Variations Within a Country: A Case Study of Sri Lanka**

1999, 40pp., ISBN 92-9090-383-X

Sri Lanka is a country with vast spatial and seasonal variations of water supply and demand. Statistics in the form of aggregated information at national level sometimes mask issues of local water scarcity. But when the same indicators are used at subunit level, a substantial area of the country comes under severe water-scarce conditions. A knowledge of subunit level water scarcities is very important because most of the food requirement of the country at present comes from water-scarce regions and projected additional requirements are also to be met by the same regions.

*/ water scarcity / case studies / irrigated farming / rice / indicators / water resources / water supply / demand / runoff / river basins / irrigation requirements / Sri Lanka /*

31. *Elena P. Bastidas*  
**Gender Issues and Women's Participation in Irrigated Agriculture: The Case of Two Private Irrigation Canals in Carchi, Ecuador**

1999, 32pp., ISBN 92-9090-382-1

Although women play an important role in water management, there is a lack of research on specific roles, tasks and functions of women in irrigated agriculture, especially in Latin America. By considering women as a heterogeneous group among the different water user groups, this report seeks to understand the factors that influence the involvement of mestizo women in irrigated agriculture in two private irrigation canals in the province of Carchi, Ecuador.

*/ women in irrigation / gender / irrigated farming / case studies / irrigation canals / water user associations / participatory management / Latin America / Ecuador /*

30. *S. A. Prathapar and Asad S. Qureshi*  
**Mechanically Reclaiming Abandoned Saline Soils: A Numerical Evaluation**

1999, 32pp., ISBN 92-9090-202-7

In arid and semiarid regions, large tracts of land developed for irrigation are being abandoned each year due to secondary salinization from saline water tables. The objective of this report

is to test the hypothesis that timely surface cultivation and monsoonal or winter rains in semiarid and arid areas will assist reclamation of abandoned saline soils.

*/ water quality / groundwater / simulation models / water table / water balance / hydraulics / soil reclamation / soil water / soil properties / salinity / calibrations / flow / Pakistan / Punjab / Sindh /*

29. *D. Renault and G. G. A. Godaliyadda*

**Generic Typology for Irrigation Systems Operation**

1999, 32pp., ISBN 92-9090-372-4

This report presents a methodology for identifying the main characteristic features (constraints and opportunities) of gravity-fed irrigation systems, which influence management and operation of the system for the purpose of water delivery. It presents the development of a generic typology for improving irrigation system operations. A case study of 64 irrigation systems in Sri Lanka is presented illustrating the practical application of the proposed typology.

*/ irrigation management / irrigation systems / water use efficiency / canals / operations / water delivery / irrigation effects / hydraulics / gravity flow / resource management / typology / case studies / constraints / water supply / networks / Sri Lanka /*

28. *R. Sakthivadivel, S. Thiruvengadachari, Upali Amerasinghe, W. G. M. Bastiaanssen and David Molden*

**Performance Evaluation of the Bhakra Irrigation System, India, Using Remote Sensing and GIS Techniques**

1999, 32pp., ISBN 92-9090-375-9

In this study, satellite remote sensing and geographic information system (GIS) techniques were used to analyze the agricultural performance and sustainability of the Bhakra Irrigation System in India. The results demonstrate the synergy possible from applying satellite remote sensing and GIS to evaluate trends in rising water tables and salinity, which are two important threats to the sustainability of irrigation systems and the cost-effectiveness of these techniques as diagnostic tools for irrigation system improvement.

*/ irrigation systems / irrigation scheduling / performance evaluation / remote sensing / GIS / irrigated farming / satellite surveys / agricultural sustainability / productivity / groundwater*

*/ salinity / crop yield / rice / food production / surface irrigation / India / Bhakra irrigation system /*

27. *W. G. M. Bastiaanssen, D. J. Molden, S. Thiruvengadachari, A. A. M. F. R. Smit, L. Mutuwatte and G. Jayasinghe*  
**Remote Sensing and Hydrologic Models for Performance Assessment in Sirsa Irrigation Circle, India**  
1999, 36pp., ISBN 92-9090-374-0

Studies of irrigation system performance are often restricted by practical limitations on the amount of data that can be collected in the field. Consequently, researchers tend to focus in detail on parts of an irrigated area or to make a less-detailed investigation of a whole system. Advanced information technologies support the analysis of irrigation performance by facilitating in-depth studies of large irrigated areas. This report describes the results of an irrigation performance evaluation using remote sensing techniques, GIS procedures and hydrologic modeling at a regional scale. The study area was the Sirsa Irrigation Circle within the Bhakra Irrigation System in northwest India.

*/ irrigation management / irrigation systems / irrigation canals / performance evaluation / remote sensing / GIS / models / irrigated farming / hydrology / satellite surveys / irrigation scheduling / evapotranspiration / India /*

26. *W. K. B. Elkaduwa and R. Sakthivadivel*  
**Use of Historical Data as a Decision Support Tool in Watershed Management: A Case Study of the Upper Nilwala Basin in Sri Lanka**  
1999, 44pp., ISBN 92-9090-377-5

Watershed analysis provides a framework for ecosystem management, which is currently the best option for conservation and management of natural resources. The current methods of assessing hydrologic impacts of land use transformation at the watershed scale, particularly in the tropics, are impaired by technical, financial and time constraints. This study provides an alternative approach to ascertain the actual changes in hydrologic response of a particular watershed to land use transformations made in the past.

*/ watershed management / hydrology / land use / flow / catchment areas / water balance / case studies / runoff / water*

*yield / rainfall-runoff relationships / forestry / decision support systems / data collection / Sri Lanka / Nilwala Basin /*

25. *D. Vermillion and Carlos Garcés-Restrepo*  
**Impacts of Colombia's Current Irrigation Management Transfer Program**  
1998, 43pp., ISBN 92-9090-364-3  
This report deals with the results of a study conducted by the International Water Management Institute in collaboration with the National Institute for Land Development (INAT) to assess the impacts of the current national irrigation management transfer program in Colombia. The report examines the context of transfer, the basic transfer strategy, the impacts of transfer and the powers and functions devolved in the transferred districts. The need to use the transfer process to create local management self-reliance is also stressed.  
*/ privatization / irrigation management / irrigated farming / policy / costs / economic aspects / operation / maintenance / agricultural production / Colombia /*
24. *C. J. Perry and S. G. Narayanamurthy*  
**Farmer Response to Rationed and Uncertain Irrigation Supplies**  
1998, 28pp., ISBN 92-9090-362-7  
Managing irrigation systems for maximum productivity under conditions of shortage and uncertainty is a critically important challenge to irrigated agriculture. This report explores the theoretical and actual responses of farmers faced with irrigation supplies that are limited in relation to available land and labor resources and where the actual schedule and available volume for delivery are uncertain.  
*/ water resources management / water use efficiency / evapotranspiration / agricultural production / irrigated farming / irrigation scheduling / water allocation / water supply / water scarcity / water delivery / reservoirs / uncertainty / yield / India / Haryana /*

23. *G. Levine, A Cruz Galvan, D. Garcia, C. Garcés-Restrepo and S. Johnson III*

**Performance of Two Transferred Modules in the Lagunera Region: Water Relations**

1998, 24pp., ISBN 92-9090-357-0

The study of the performance of transferred system is an important research program of the International Water Management Institute. This report evaluates the degree of success of water users in managing water allocations and deliveries in two irrigation district modules in the Lagunera Region of Mexico where O&M responsibilities were transferred to the users in 1993.

*/ water policy/ performance / privatization / irrigation systems/ operation/ maintenance / irrigation / efficiency / water user association / water rights / water allocation / water supply / Mexico /*

22. *Wim H. Kloezen and Carlos Garcés-Restrepo*

**Assessing Irrigation Performance with Comparative Indicators: The Case of the Alto Rio Lerma Irrigation District, Mexico**

1998, 52pp., ISBN 92-9090-359-7

This report describes and evaluates the application of IWMI's minimum set of comparative performance indicators to the Alto Rio Lerma Irrigation District (ARLID), located in the Mexican State of Guanajuato and compares this with the application of a small set of process performance indicators.

*/ irrigated management / irrigation scheduling / water allocation / water distribution / case studies / institutional constraints / operation / monitoring / indicators / performance indexes / water rights/ economic aspects / data collections / environmental effects / performance evaluation / water use efficiency / Mexico /*

21. *D. J. Bandaragoda*

**Need for Institutional Impact Assessment in Planning Irrigation System Modernization**

1998, 28pp., ISBN 92-9090-201-9

This report cites a case study of the institutional implications of remodeling an old irrigation system in northern Pakistan and draws the attention of donors and project planners to the institutional implications of current project preparation methods and concludes that the institutional constraints in modernizing old irrigation system can be foreseen at the planning and design stages.

*/ irrigated management/ irrigation systems / water allocation / rehabilitation / modernization / case studies / institutional constraints / operation / maintenance / irrigation canals / irrigation effects /Pakistan /*

20. David J. Molden, R. Sakthivadivel, Christopher J. Perry, Charlotte de Fraiture and Wim H. Kloezen

**Indicators for Comparing Performance of Irrigated Agricultural Systems**

1998, 36pp., ISBN - 92-9090-356-2

This report presents IWMI's external and other comparative performance indicators that will allow for comparative analysis of irrigation performance across irrigation systems. It also presents the experience with their use, based on application across several irrigation systems. At this stage, it is hypothesized that through the use of these indicators, we are able to document and compare key performance attributes of irrigation systems. If so, then it should be possible to compare performance across irrigation systems in a number of settings to understand where we presently stand with respect to productive utilization of land and water, to compare relative performance of systems and to identify where performance can be improved.

*/ irrigated farming / irrigation systems / indicators/ performance indexes / land / water / financing/ crop production /*

19. David Seckler, Upali Amarasinghe, David Molden, Radhika de Silva and Randolph Barker

**World Water Demand and Supply, 1990 to 2025: Scenarios and Issues**

1998, 52pp., ISBN 92-9090-354-6

Appropriate policies and projects need to be implemented to deal with severe water shortages that are expected to affect many countries. The International Water Management Institute has launched a long-term research program to improve the conceptual and empirical basis for analysis of water in major countries of the world. This study is the first step in this country research program.

*/ irrigation management /water balance / river basins / basin irrigation / water use efficiency / water supply / water requirements / domestic water / water scarcity / water demand / water shortage / irrigated farming / productivity / food security / recycling / rice /*

18. *Upali A. Amarasinghe, R. Sakthivadivel and Hammond Murray-Rust*  
**Impact Assessment of Rehabilitation Intervention in the Gal Oya Left Bank**  
 1998, 32pp., ISBN 92-9090-348-1  
 This report presents the results of an impact assessment of rehabilitation interventions on irrigation system performance in the Left Bank of the Gal Oya irrigation system in Sri Lanka. The method of analysis was based on time series intervention analysis. The irrigation system performance indicators used as dependent variables in the analysis are irrigated area, irrigation supply per unit area, total irrigation supply, productivity per unit of land and productivity per unit of irrigation supply.  
 / irrigation management / water management / irrigation systems / productivity / rehabilitation / models / project evaluation / rain / reservoir storage / Sri Lanka / Gal Oya Project /
17. *D. J. Bandaragoda*  
**Design and Practice of Water Allocation Rules: Lessons from Warabandi in Pakistan's Punjab**  
 1998, 36pp., ISBN 92-9090-200-0  
 Warabandi, an irrigation water allocation method, has been practiced in Pakistan and northern India for more than 125 years and covers an area of about 24 million hectares of irrigated land in the two countries. This report, which is based on intensive field work, focuses on the existing gap between the traditional design concepts of warabandi and its actual practice. Within this focus, it also outlines some institutional implications of the present practice of warabandi and identifies further research and policy needs.  
 / water management / irrigation management / water allocation / watercourse / water distribution / design / irrigation scheduling / social aspects/ economics aspects / water users / distributary canals / Pakistan / Punjab /
16. *Sam H. Johnson III*  
**Irrigation Management Transfer in Mexico: A Strategy to Achieve Irrigation District Sustainability**  
 1997, 40pp., ISBN 92-9090-347-3  
 This report details the process of transfer of public irrigation districts in Mexico from public ownership to joint management, where responsibility for irrigation O&M is shared between the

public irrigation agency and the water user associations. The case of Mexico is very important as the country has demonstrated that it is possible to quickly transfer large public irrigation systems to groups of users. The success of the Mexico transfer program and its reputation have attracted visiting study tour groups from all over the world.

*/ irrigation management / privatization / participatory management / agricultural production / sustainability / private sector / public sector / economic aspects / water user associations / investment / agricultural policy / irrigated farming / water law / user charges / landownership / Mexico /*

15. *Wim H. Kloezen, Carlos Garcés-Restrepo and Sam H. Johnson III*

**Impact Assessment of Irrigation Management Transfer in the Alto Rio Lerma Irrigation District, Mexico**

1997, 44pp., ISBN 92-9090-350-3

The economic crisis of Mexico in the 1980s led to radical and extensive reforms in its agriculture sector. Among the most significant institutional reforms was the program to transfer irrigation management responsibilities for large-scale irrigation districts from the sole control of the public sector irrigation agency to a joint management arrangement with newly created water user associations (WUAs). This study reports on the findings of a 2-year field research study started by IIMI late in 1995 in the 112,772-hectare Alto Rio Lerma Irrigation District (ARLID) in Mexico.

*/ irrigation management / privatization / economic aspects / legal aspects / data collection / water rights / water allocation / water distribution / groundwater / financing/ maintenance / operation / agricultural production / water user associations / farmer participation / Mexico /*

14. *C. J. Perry, Michael Rock and D. Seckler*

**Water as an Economic Good: A Solution, or a Problem?**

1997, 20 pp., ISBN 92-9090-351-1

Water serves many different objectives and has properties that make it both a private and a public good. The appropriate blend of values and facts in proper policy formulation for water requires a much more sophisticated form of analysis than that allowed by the simpleminded dogmatism of proponents, either of basic needs or of free markets. Water

policy must be formulated in terms of multi-objective decision making, recognizing that the relevance and importance of various values and facts will vary substantially over different conditions of time and place.

*/ water resource management / water as an economic good / economic aspects / economic analysis / irrigated farming / water rights / pricing / privatization / marginal analysis / water market / water policy /*

13. *R. Sakthivadivel, Nihal Fernando and Jeffrey D. Brewer*  
**Rehabilitation Planning for Small Tanks in Cascades: A Methodology Based on Rapid Assessment**

1997, 42pp., ISBN 92-9090-345-0

This report presents a methodology for planning the rehabilitation and improvement of small-scale irrigation systems within the context of the water basin when information on hydrology and water use is inadequate. It was developed for planning the rehabilitation and improvement of small tank systems in the dry zone of Sri Lanka. The methodology is useful to those undertaking irrigation rehabilitation projects in similar circumstances and it may also be extended to water resources planning in many other circumstances.

*/ irrigation system / rehabilitation / tank irrigation / small-scale systems / reservoirs / conflict / farmer participation / river basin development / water resources development / Sri Lanka /*

12. *Jeffrey D. Brewer, R. Sakthivadivel and K.V. Raju*  
**Water Distribution Rules and Water Distribution Performance: A Case Study in the Tambraparani Irrigation System**

1997, 44pp., ISBN 92-909-343-0

The relationship of water distribution rules to water distribution performance is explored in the Tambraparani Irrigation System. The report argues that if the water distribution rules define a pattern of water delivery that does not match technically feasible goals desired by the users, then the users subvert the rules to provide the water deliveries they require. This adversely affects water distribution performance and equity and raises the cost of irrigation. It is proposed that a periodic review of the distribution rules should be made but the process involved in changing the rules should make it sufficiently difficult to ensure that only the necessary changes are made.

*/ irrigation management / irrigation systems / performance / operation / water distribution / water allocation / water delivery / water users' associations / legislation / large-scale systems / bananas / India / Tamil Nadu /*

11. *Douglas L. Vermillion*

**Impacts of Irrigation Management Transfer: A Review of the Evidence**

1997, 44pp., ISBN 92-9090-340-5

Data from 29 different studies on irrigation management transfer are drawn together and evaluated to assess the impacts of transfer on various aspects of irrigation system management. Twelve guiding principles to ensure a more systematic approach to research on the impacts of management transfer are proposed and a number of key research propositions identified on the conditions which should prevail if management transfer programs are to succeed.

*/ irrigation management / irrigation systems / policy / privatization / case studies / performance evaluation / irrigated farming / economic aspects / financing / operation / environmental sustainability /*

10. *Margreet Zwarteveen*

**A Plot of One's Own: Gender Relations and Irrigated Land Allocation Policies in Burkina Faso**

1997, 20pp., ISBN 92-9090-338-4

In the Dakiri irrigation system of Burkina Faso, the effects of allocation of plots on productivity, labor contributions and intra-household distribution of income derived from agricultural activities are compared when men are the sole owners of plots and when both men and women within the same household own irrigated plots. In households where both men and women own plots, land and labor productivity are higher, the income received by women increases sharply and the proportion of labor contributed by women to the plots owned by men remains unchanged.

*/ irrigation management / land management / policy / gender / women / agricultural production / irrigation systems / case studies / households / income distribution / labor allocation / West Africa / Burkina Faso /*

9. *S. Thiruvengadachari and R. Sakthivadivel*  
**Satellite Remote Sensing Techniques to Aid Irrigation System Performance Assessment: A Case Study in India**  
1997, 32pp., ISBN 92-9090-337-6  
Satellite remote sensing (SRS) and geographic information system (GIS) techniques are applied to a rice irrigation system in the Bhadra project, India, to obtain information on primary agricultural productivity and irrigation system performance under disaggregated conditions. This study demonstrates the potential and cost-effectiveness of SRS techniques for making inventories and monitoring agricultural productivity in a large rice irrigation system in India. Effective integration of GIS with SRS techniques is shown to enhance diagnostic analysis and performance evaluation of irrigation systems.  
*/ irrigation management / irrigated farming / agricultural production / irrigation systems / food production / rice / cropping systems / crop yield / remote sensing / GIS / models / policy / case studies / satellite surveys / performance evaluation / India / Bhadra Project /*
8. *Douglas J. Merrey*  
**Institutional Design Principles for Accountability in Large Irrigation Systems**  
1997, 36pp., ISBN 92-9090-335-X  
This report argues that single irrigation systems managed by autonomous system-specific organizations accountable to their customers perform better and are more sustainable than those managed by agencies dependent on the government, or by agencies responsible for multiple systems. Selected cases are reviewed and the plausibility of this hypothesis established. Several suggestions are made for further research, but it is suggested that the arguments are sufficiently persuasive to be used by policymakers in the design of reform programs.  
*/ irrigation management / government-managed irrigation systems / large-scale systems / organizational design / water users' associations / water users / farmers' associations / farmer participation / sustainability / water rights / performance evaluation / performance indexes / participatory management / privatization / policy / research methods / case studies /*

7. *Margreet Zwarteveen and Nita Neupane*  
**Free-Riders or Victims: Women's Nonparticipation in Irrigation Management in Nepal's Chhattis Mauja Irrigation Scheme**

1996, 32pp., ISBN 92-9090-334-1

The Chhattis Mauja irrigation scheme is considered from a gender perspective—making an empirical analysis of the livelihood strategies of farm households, documenting the level and nature of participation of women and men in the water users' organizations, analyzing women's access to irrigation services and examining the need and desirability of increasing the participation of women in the scheme organization. The findings are discussed in terms of schemes performance and the responsiveness of the users' organization to the irrigation needs of women.

*/ irrigation management / farmer-managed irrigation systems / irrigation programs / water users' associations / irrigated farming / irrigation canals / water delivery / water allocation / water distribution / maintenance / gender / women in development / farmers / female labor / agricultural manpower / households / family labor / living standards / social aspects / agricultural production / villages / social organization / performance evaluation / Chhattis Mauja irrigation scheme / Nepal /*

6. *Jacob W. Kijne*  
**Water and Salinity Balances for Irrigated Agriculture in Pakistan**

1996, 28pp., ISBN 92-9090-330-9

Analysis of water and salinity balances of an irrigation system can yield useful information about the potential impact of current irrigation practices on the sustainability of irrigated agriculture in the system. Such an analysis was conducted in three different areas of Pakistan afflicted by salinity. The results indicated that in each of the three areas the current irrigation and agronomic practices are not sustainable. Several corrective measures are presented.

*irrigation management / irrigated farming / water balance / salinity / sensitivity analysis / groundwater management / watercourses / irrigation systems / water table / waterlogging / soil degradation / Pakistan / North-West Frontier Province / Punjab /*

5. *C. J. Perry*  
**The IIMI Water Balance Framework: A Model for Project Level Analysis**  
1996, 28pp., ISBN 92-9090-331-7  
Understanding the water balance at project or command level is a prerequisite to the analysis of the operation of an irrigation system and its performance. Consequently, the IIMI Water Balance Framework—which identifies sources, uses and reuses of water—will be of interest to those involved in the design of irrigation projects and in the formulation of improvements to existing infrastructure of operational rules. Managers of irrigation projects will also find it useful for interpreting water use efficiency, or for identifying interventions to improve the efficiency and sustainability of their projects.  
*/ irrigation management / irrigation programs / surface irrigation / analysis / water use efficiency / water balance / water loss / seepage / groundwater / pumping / models /*
  
4. *Douglas. L. Vermillion and Carlos Garcés-Restrepo*  
**Results of Management Turnover in Two Irrigation Districts in Colombia**  
1996, 36pp., ISBN 92-9090-329-5  
In 1976, the government turned over the management of two irrigation districts in Colombia—Coello and Saldaña—to the water users' associations. A study was conducted from 1993 to 1995 by IIMI to assess the extent to which the turnover program had made an impact on the cost of irrigation to farmers and the government, the quality of water distribution, the sustainability of irrigation, the productivity of agriculture and farmer income.  
*/ irrigation management / irrigated farming / privatization / farmer participation / farmers' associations / farmer-agency interactions / farmer-managed irrigation systems / social aspects / economic aspects / operation / maintenance / agricultural production / sustainability / water distribution / Colombia / Coello / Saldaña /*
  
3. *Andrew Keller, Jack Keller and David Seckler*  
**Integrated Water Resource Systems: Theory and Policy Implications**  
1996, 24pp., ISBN 92-9090-326-0  
Over the past several years, researchers have been developing a concept of integrated water resources systems (IWS) that

has substantially changed their own views on this subject. This report attempts to present the concept of IWS as clearly and simply as possible. It focuses on the irrigation sector, which is by far the largest and most complex user of water in the world.  
 / *water resource management / water policy / irrigation efficiency / water demand / leaching / water use efficiency / water supply / evapotranspiration / models /*

2. *C. J. Perry*

**Alternative Approaches to Cost Sharing for Water Service to Agriculture in Egypt**

1996, 24pp., ISBN 92-9090-321-X

Charging users for water and water services is a sensitive issue in Egypt, as it is in many countries, involving political, historical, social, religious and economic factors. This report combines and interprets results from a number of studies that were designed to help the Egyptian government formulate a rational approach to sharing the costs of water services among the beneficiaries—agriculture and other users—and the government.

*/ agricultural development / water management / water delivery / benefits / cost recovery / operating costs / maintenance costs / policy / water allocations / user charges / water use efficiency / water shortage / water resource development / Egypt /*

1. *David Seckler*

**The New Era of Water Resources Management: From “Dry” to “Wet” Water Savings**

1996, 28pp., ISBN 92-9090-325-2

This report addresses recent developments in the field of water resources that have practical implications for water policies, programs and projects. Procuring additional freshwater supplies is highly problematical. As a result, attention has naturally turned to “demand management.” Proponents of demand management contends that physical water use efficiency can be increased by using less water per unit of output. Similarly, economic efficiency can be increased by reallocating water from lower-valued to higher-valued users.

*/ water resources management / water policy / water use efficiency / water demand / water supply / irrigated agriculture / irrigation efficiency /*

## SPANISH RESEARCH REPORTS

*Elena P. Bastidas*

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*Douglas L. Vermillion y Carlos Garcés Restrepo*

**25-Es Informe de Investigación**

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*G. Levine, A. Cruz Galván, D. García, C. Garcés Restrepo, y S. Johnson III.*

**23-Es Informe de Investigacion**

**Desempeño de dos módulos transferidos en la región Lagunera: Relaciones del agua.**

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*Wim H. Kloezen y Carlos Garcés-Restrepo*

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1998, 52pp., ISBN 92-9090-359-7.

*Sam H. Johnson III*

**16 –Es Informe de Investigación**

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*Wim H. Kloezen and Carlos Garcés-Restrepo y Sam H. Johnson III*

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**WORKING PAPERS**

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## GENERAL PUBLICATIONS

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this book reviews the current state of knowledge on the management of Vertisols in Africa, with comparative chapters covering other parts of the world such as India, Australia and the US state of Texas.

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This paper presents a conceptual framework for water accounting and provides generic terminologies and procedures to describe the status of water resource use and consequences of water-resources-related actions. The framework applies to water resources use at three levels of analysis: a use level such as an irrigated field or household, a service level such as an irrigation or water supply system, and a water-basin level that may include several uses. Water accounting terminology and performance indicators are developed and presented with examples at all the three levels. Concepts and terminologies presented are developed to be supportive in a number of activities including: identification of opportunities for water savings and increasing water productivity; developing a better understanding of present patterns of water use and impacts of interventions, improving communication among professionals and communications to non-water professionals; and improving the rationale for allocation of water among uses. It is expected that with further application, these water accounting concepts will evolve into a robust, supporting methodology for water basin analysis.

*/ water management/ irrigation management / water supply / terminology / performance indexes / water use/ water allocation / productivity /*

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#### **How to Manage Salinity in Irrigated Lands: A Selective Review with Particular Reference to Irrigation in Developing Countries**

1997, 42pp., ISBN 92-9090-353-8

<sup>1</sup> System-Wide Initiative on Water Management

This paper reviews the causes of irrigation-induced salinity, particularly in developing countries. It describes the underlying chemical and physical processes involved in soil and water degradation due to irrigation. The present state of knowledge and the contributions made by modeling these processes are presented. Areas of uncertainty in our current understanding are identified. The paper discusses several remedial management actions, categorized as engineering, agronomic, policy-level and system-level interventions. Special attention is given to the regional management of saline effluent from irrigation systems, including options for its disposal.

*/ irrigation management/ irrigable land / soil salinity / sodic soils/ developing countries/ soil-water-plant relationships / water use efficiency / soil degradation / irrigated farming / policymaking /*

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This paper reviews perceived notions of the relationships between catchment land use and hydrology, and explores whether much of the widely disseminated folklore, so often inextricably linked with issues of land use, are based on myth or reality. Gaps in our knowledge of the underlying processes in relation to land use and hydrology are identified. Our ability to apply this knowledge at different scales, ranging from the plot to the catchment and regional scales, are discussed and specific examples are drawn from Indian and African case studies. Methods for linking spatially distributed land-use hydrological models with economics and ecology through decision support systems are outlined and proposed as a framework for the integrated management of land and water developments at the catchment scale.

*/ water resource management / water use / case studies / catchment areas / land use /hydrology / models / evaporation / soil moisture / GIS / decision support systems / water use / runoff / flow / forestry / deforestation / erosion control / rain / Africa / India /*

4. *Charles Batchelor, Jeremy Cain, Frank Farquharson and John Roberts*

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The central theme of the System-Wide Initiative on Water Management (SWIM) is "enhancing the productivity of water and agriculture in an environment of growing scarcity and competition." This paper has been prepared as part of the process of planning research that is to be undertaken to improve water utilization in a watershed perspective. The paper includes a historical review of research that has involved the use of catchment experiments and a discussion on hydrological modeling techniques. Options for improving water utilization at the catchment and farm scales are identified and recommendations are made for research that might be undertaken by SWIM. The case is argued for interdisciplinary catchment studies that involve the participation of local communities and other stakeholders.

*/ water management / water scarcity / water use efficiency / catchment areas / calibrations / hydrology / models / river basins / water resources management / participatory management / water balance / case studies / Asia / Africa / South Africa / Zimbabwe /*

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This paper reviews the literature on irrigation efficiency and on the potential for increasing the productivity of water in rice-based systems. It stresses the continuing confusion over the concepts of irrigation efficiency and water productivity. It identifies the reasons for the wide gap between water requirement and actual water input (both irrigation diversions and rainfall) in irrigated rice production systems and discusses potential opportunities for increasing water productivity both on-farm and at the system level. The paper emphasizes the need to measure the productivity of water at farm, system, and basin levels, and to understand how the productivity at one level relates to the productivity at another. Without water balance studies to measure productivity at these different scales, it is not possible to identify the potential economic benefits of alternative interventions and the most appropriate strategies for increasing irrigation water productivity in rice-based systems.

*/ irrigation management / water use efficiency / crop production / water requirements / water balance / rice / water distribution / irrigated farming / productivity / on-farm research / irrigation scheduling / groundwater / conjunctive use / rehabilitation / modernization / farmer participation / farming systems / irrigation systems / crop-based irrigation / Asia / the Philippines /*

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The world faces severe and growing challenges in maintaining water quality and meeting the rapidly growing demand for water resources. In addition, water used for irrigation, the largest use of water in most developing countries, will likely have to be diverted increasingly to meet the needs of urban areas and industry whilst remaining a prime engine of agricultural growth. Finally, environmental and other in-stream water demands become more important as economies develop. The river basin has been acknowledged to be the appropriate unit of analysis to address these challenges facing water resources management; and modeling at this scale can provide essential information for policy-makers in their decisions on allocation of resources. This paper reviews the state of the art of modeling approaches to integrated water resources management at the river basin scale, with particular focus on the potential of coupled economic-hydrologic models, and concludes with directions for future modeling exercises.

*/ water quality / water resources development / agricultural production / river basin development / mathematical models / simulation models / water allocation / policy / economic aspects / hydrology / reservoir operation / groundwater management / drainage / conjunctive use / surface water / GIS / decision support systems / optimization methods / water supply /*

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1999, 52pp., ISBN 92-9090-378-3

The countries in West Asia and North Africa (WANA) will soon be diverting water from irrigation to supply their domestic and industrial needs, unless, they obtain substantial amounts of water from additional, untapped water resources. Some of these countries are already doing it, and hence agriculture is left each year with less water. The renewable water resource per capita in the WANA region is about one-sixth of the worldwide average. The chance, therefore, of reversing the trend of diminishing

supplies to agriculture is extremely small. If agricultural production and livelihoods are to be sustained at current levels, the water available to agriculture will have to be used more productively. The productivity of land and water in rain-fed areas can still be greatly enhanced through water harvesting and supplemental irrigation. Marginal lands with annual rainfall of less than 300 mm can be cultivated if controlled but limited additional water is made available. In many instances, such an incremental water supply can be provided through appropriate water harvesting techniques. However, the past experience with the introduction of water harvesting techniques into semiarid and arid countries has not been very promising. This paper aims to elucidate the likely reasons for these disappointments. The paper reviews the state of the art of both water harvesting and supplemental irrigation technologies in the temperate and subtropical dry lands with a Mediterranean-type climate.

*/ productivity / water harvesting / water scarcity / agricultural production / poverty / water use efficiency / arid lands / water resources development / rain-fed farming / West Asia / North Africa / India /*

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**Multiple Uses of Water in Irrigated Areas: A Case Study from Sri Lanka**

1999, 56pp., ISBN 92-9090-380-5

Water is being transferred out of agriculture to meet the growing demand in other areas, often without an agreement of or compensation to farmers with irrigated land and water rights. Furthermore, there is a failure to recognize that irrigation systems supply water not only for the main fields, but also for domestic uses, home gardens, trees and other permanent vegetation, and livestock. Other productive uses include fishing, harvesting of aquatic plants and animals, and a variety of other enterprises such as brick making. In addition, irrigation systems can have a positive or negative effect on wildlife habitats. Thus, the withdrawal of water affects the rural household, rural economy, and the environment in a number of ways. This paper argues that to ensure efficient, equitable, and sustainable water use, to reduce poverty and improve the well-being of the community, irrigation and water resources policies need to take into account all uses and users of water within the irrigation system. The multiple uses of water

in the Kirindi Oya irrigation system are examined in this paper. An interdisciplinary group of scientists have investigated a number of areas including water accounting, water quality, household water use, the valuing of water for alternative uses, and the complementarities, competition, and conflicts among uses and users.

*/ water management / water allocation / water use efficiency / irrigated farming / water resources development / water policy / water quality / domestic water / water user associations / water rights / gender / case studies / households / pricing / water costs / Sri Lanka / Kirindi Oya /*

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## DIALOGUE PUBLICATIONS

The Dialogue on Water Food and Environment is an initiative of ten of the primary international actors in the fields of water resources management, water resources research, environmental conservation and health:

- Food and Agriculture Organization (FAO)
- Global Water Partnership (GWP)
- International Commission on Irrigation and Drainage (ICID)
- International Federation of Agricultural Producers (IFAP)
- International Water Management Institute (IWMI)
- United Nations Environmental Program (UNEP)
- World Conservation Union (IUCN)
- World Health Organization (WHO)
- World Water Council (WWC)
- World Wide Fund for Nature (WWF)

### Dialogue Objectives:

- Improve water resources management for food security and environmental sustainability with special focus on the reduction of poverty and hunger and the improvement of human health.
- Build bridges between agricultural and environmental communities by improving linkages between sectoral approaches that dominate policymaking and implementation, particularly at the national level.
- Establish a viable dialogue, primarily at national and local levels, and draw together, maintain and improve the required knowledge base for the Dialogue.

- **Dialogue on Water, Food and Environment: Summary Report, Planning and Design Meeting, Colombo, December 2000**
- **Dialogue on Water, Food and Environment: Proposal**

## DIALOGUE WORKING PAPERS

1. *David Molden, Frank Rijsberman, Yutaka Matsuno and U. A. Amerasinghe*  
**Increasing Productivity of Water: A Requirement for Food and Environmental Security**
2. *H. Galbraith, K. Strzepek and David Yates*  
**Moving beyond the Vision: The Importance of Case Studies in Reconciling Water for Nature and for Agriculture**
3. *K. Strzepek, D. Molden and H. Galbraith*  
**Comprehensive Global Assessment of Costs, Benefits and Future Directions of Irrigated Agriculture.**
4. *Constantina Safiliou-Rothschild*  
**Food Security and Poverty: Definitions and Measurement Issues.**

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