

Articles List 3 - 2008

1. Enhancing water productivity at the irrigation system level: A geospatial hydrology application in the Yellow River Basin

S. Khan, M.M. Hafeez T. Rana, S. Mushtaq
Journal of Arid Environments

Abstract

This paper provides results of an application of a holistic systematic approach of water accounting using remote sensing and GIS coupled with groundwater modeling to evaluate water saving options by tracking non-beneficial evaporation in the Liuyuankou Irrigation System (LIS) of China. Groundwater rise is a major issue in the LIS, where groundwater levels have risen alarmingly close to the ground surface (within 1m) near the Yellow River. The lumped water balance analysis showed high fallow evaporation losses and which need to be reduced for improving water productivity. The seasonal actual evapotranspiration (ETs) was estimated by applying the SEBAL algorithm for 18 NOAA AVHRR-12 images over the year of 1990–1991 (April 1990–March 1991). This analysis was aided by the unsupervised land use classification applied to three Landsat 5 TM images of the study area. SEBAL results confirmed that a fair amount (116.7MCM) of water can be saved by reducing evaporation from fallow land which will result in improved water productivity at the irrigation system. The water accounting indicator (for the analysis period) shows that the process fraction per unit of depleted water (PF_{depleted}) is 0.52 for LIS, meaning that 52% of the depleted water is consumed by agricultural crops and 48% is lost through non-process depletion. Finally, the groundwater modeling was applied to simulate three land use and water management interventions to assess their effectiveness for both water savings and impact on the groundwater in LIS. MODFLOW's Zone Budget code calculates the groundwater budget of user-specified subregions, the exchange of flows between subregions and also calculates a volumetric water budget for the entire model at the end of each time step. The simulation results showed that fallow evaporation could be reduced between 14.2% (25.51MCM) and 45.3% (81.36MCM) by interventions such as canal lining and groundwater pumping. The reduction in non-beneficial ETs volumes would mean that more water would be available for other uses and it would allow the introduction of more surface water supplies in the area through improved water management strategies. This will ultimately lead to improved water productivity of the LIS system.

2. Water quality modelling for small river basins

Stefano Marsili-Libelli, Elisabetta Giusti
Environmental Modelling & Software

Abstract

Water quality modelling in small rivers is often considered unworthy from a practical and economic viewpoint. This paper shows instead that a simple model structure can be set up to describe the stationary water quality in small river basins in terms of carbon and nitrogen compounds, when the use of complex models is unfeasible. In short rivers point and nonpoint sources play a key role in shaping the model response, being as important as the self-purification dynamics. Further, the varying river characteristics, in terms of morphology, hydraulics and vegetation, require the introduction of variable parameters, thus complicating the originally simple model structure. To determine the identifiability of the resulting model an identifiability assessment was carried out, based on sensitivity analysis and optimal experiment design criteria. The identifiable subset was determined by ranking the parameters in terms of sensitivity and computing the associated Fisher Information Matrices. It was found that the inclusion of the nonpoint sources as piecewise constant parameters affected the identifiability to a considerable extent. However, the combined parameter resources calibration was made possible by the use of a robust estimation algorithm, which also provided estimation confidence limits. The calibrated model responses are in good agreement with the data and can be used as scenario generators in a general strategy to conserve or improve the water quality.

3. Indigenous knowledge as decision support tool in rainwater harvesting

B.P. Mbilinyi, S.D. Tumbo, H.F. Mahoo, E.M. Senkondo, N. Hatibu
Physics and Chemistry of the Earth 30 (2005) 792–798

Abstract

Rainfall patterns in semi-arid areas are typically highly variable, both spatially and temporally. As a result, people who rely completely on rainwater for their survival have over the centuries developed indigenous knowledge/techniques to harvest rainwater. These traditional water-harvesting systems have been sustainable for centuries. The reason for this is that they are compatible with local lifestyles, local institutional patterns and local social systems. In order to develop sustainable strategies, it is therefore important to take into account of, and learn from, what local people already know and do, and to build on this. This paper explores how indigenous knowledge is used by farmers in the Makanya catchment, Kilimanjaro region, Tanzania to identify potential sites for rainwater harvesting (RWH). The paper draws on participatory research methods including focus group discussions, key informant interviews, field visits and participatory workshops. Initial findings indicate that farmers do hold a substantial amount of knowledge about the resources around them. As there are spatially typical aspects to indigenous knowledge, it could be extrapolated over a wider geographic extent. From the preliminary findings, it is being recommended that geographic information system (GIS) could be an important tool to collect and upscale the utility of diverse indigenous knowledge in the decision-making process.

4. Bulawayo water supplies: Sustainable alternatives for the next decade

Noel Mkandla, Pieter Van der Zaag, Peter Sibanda
Physics and Chemistry of the Earth 30 (2005) 935–942

Abstract

Bulawayo is the second largest city in Zimbabwe with a population of nearly one million people. It is located on the watershed of Umzingwane and Gwayi catchments. The former is part of the Limpopo basin, while the latter drains into the Zambezi basin. Bulawayo has a good potential of economic development but has been stymied by lack of sufficient water. The city currently relies on five surface sources in the Umzingwane catchment where it has to compete with evaporation. The well field from the Nyamandlovu aquifer in the Gwayi catchment, which was constructed as an emergency measure during the 1992 drought, is currently not operational. Alternative water supply sources are far and expensive. A multilinear regression model was developed to analyse and quantify the factors affecting water consumption. It was found that per capita water consumption is very low, indicating suppressed demand. Water rationing, tariffs, rainfall, population growth and gross domestic product are the main factors influencing water consumption in Bulawayo. Assuming that these factors will continue to be influential, future water consumption was projected for intensive, regular and slack water demand management. Future water consumption was then compared with the current water supply capacity in order to determine the date by which the next water supply source is required. With slack demand management, the Nyamandlovu well field should have been operational by 2003, while by the year 2007 an additional source of water is required. With intensive demand management and assuming low population growth, current capacities may suffice to satisfy the suppressed demand until the year 2015, by which time Nyamandlovu wells should be operational again. The additional water supply sources that are currently being considered for Bulawayo (namely the Zambezi water pipeline; Gwayi Shangani dam; Mtshabezi dam; Lower Tuli dam; and Glass block dam) were then compared with an alternative water source not yet contemplated, namely drawing groundwater from Umguza, part of the Nyamandlovu aquifer. The paper then provides details of the Umguza alternative, which was designed at pre-feasibility level by Mkandla [Mkandla, N., 2003. Bulawayo water supplies: Umguza well field as a sustainable alternative for the next decade. Unpublished M.Sc. WREM dissertation. University of Zimbabwe, Harare]. All alternative additional water supply sources were compared in terms of their Net Present Values. It was found that Umguza well field is the least-cost alternative to meet additional water demand. The Umguza alternative will be able to satisfy water demand for a period of six to ten years. Thereafter, the second least-cost alternative, namely Gwayi Shangani dam, must be on stream.

5. Can Local People also Gain from Benefit Sharing in Water Resources Development? Experiences from Dam Development in the Orange-Senqu River Basin

Palesa Selloane Mokorosi, Pieter van der Zaag

Physics and Chemistry of the Earth

Abstract

The concept of sharing benefits derived from beneficial uses of water is increasingly embraced in numerous international discourses in place of sharing water in volumes among nations riparian to common water bodies. Many benefit-sharing efforts involve building of dams and inter-basin transfer schemes. These infrastructures have been blamed to be posing environmental and social costs and directly affecting local people (Gupta and Van der Zaag, 2007). This paper attempts to find attributes that lead towards recognising the rights of affected people and the mechanisms that may ensure access of direct benefits to them. Four theoretical factors are identified as key in recognising the rights of the affected people and were adopted as the analytical framework: a. Appropriate legal and policy framework, b. Public participation, c. Sustainable compensation measures, and d. Equitable access of derived benefits. In order to complement these theoretical factors, the study compared two large water development projects in the Orange-Senqu river basin: the Orange River Development Project and the Lesotho Highlands Water Project. In both projects several large dams were constructed and water was transferred from one river into another: The following are the findings of the paper: a) the political environment through the legal and institutional framework plays a major role in protecting or marginalizing the affected people; b) compensation measures for lost properties left many affected people destitute and food insecure; c) affected people mainly benefited from the indirect benefits of the projects instead of direct benefits. In order to ensure access to direct benefits for the affected people it is recommended that a) the national legislation must support the concept, b) mechanisms for allocating benefits to the affected people must be defined at project planning stage and should aim at long-term development goals, and c) local authorities must have sufficient capacity to ensure smooth operation.

6. Innovative land and water management approaches in Asia: productivity impacts, adoption prospects and poverty Outreach

Regassa E. Namara, Intizar Hussain, Deborah Bossio and Shilp Verma

Irrig. and Drain. 56: 335–348 (2007)

Abstract

There are no unanimous views regarding the real water-saving effects of land and water management innovations. Some claim that the innovations merely change the prevailing water allocation. However, there is no dispute regarding their land and water productivity impacts. The water productivity improvement ranged from 30% for zero tillage technology to 648% for micro-irrigation technology for beetroot. The land productivity improvement ranged from 4% for bed planting technology to 88% for micro-irrigation technology for watermelon. Aerobic rice varieties are inferior to lowland rice varieties in terms of land productivity but superior in water productivity. In addition, some of the innovations reduce cost of production, improve the quality of produce and entail positive environmental externalities. However, the current level of adoption of these innovations is not satisfactory due to insufficient labour and organic fertilizer availability problems, uncertain irrigation water supply, crop specificity and complexity, lack of capital, high knowledge and technical skill requirements. To realize the potential benefits of these innovations to the poor the following actions are suggested: (1) provision of subsidies; (2) targeted training opportunities; (3) encouragement of private participation in the supply chain of inputs; (4) focus on short pay-back period technologies; (5) strengthening of public research on the systems.

7. Does groundwater irrigation reduce rural poverty? Evidence from Indian states

A. Narayanamoorthy

Irrig. and Drain. 56: 349–362 (2007)

Abstract

Groundwater irrigation has become a dominant source of irrigation in Indian agriculture today. Besides increasing the cropping intensity and productivity of crops, the intensive cultivation of crops due to timely access to groundwater irrigation increases the demand for agricultural labourers and hence wage rates for those who mostly live below the poverty line. Both increased affordability of foodgrain and wage rates help the rural poor to cross the poverty barriers. However, the importance of groundwater has not been recognized by studies focusing on rural poverty in India. Since groundwater irrigation is proved to be prominent in increasing the production of crops, it is likely that the impact of it on rural poverty would also be significant. In this study, therefore, an attempt has been made to examine the nexus between groundwater irrigation and rural poverty using state-wise cross-section data covering five time points: 1973–74, 1977–78, 1983, 1987–88 and 1993–94. The study shows that there is a significant inverse relationship between the availability of groundwater irrigation and the percentage of rural poverty at all five time points. The results suggest that public policy should focus more on developing groundwater irrigation, without harming the environment, through a strong rural electrification and institutional credit support wherever possible to reduce rural poverty in a sustained manner.

8. Valuing natural resources and the implications for land and water management

David Pearce

Resources Policy December 1987

Abstract

New models of sustainable development stress the importance of the efficient management of resources, including labour, capital equipment and natural resources. Overuse of the resource base today will lead to shortages tomorrow; yet it can be a difficult task persuading politicians and planners in developing countries of the importance of resource management. This paper suggests methodologies for doing so and argues the urgency of the task.

9. An integrated water resource management tool for the Himalayan region

H.G. Rees, M.G.R. Holmes, M.J. Fry, A.R. Young, D.G. Pitson, S.R. Kansakar

Environmental Modelling & Software 21 (2006)

Abstract

The Himalayan region of Nepal and northern India experiences hydrological extremes from monsoonal floods during July -September to periods of very low flows during the dry season (December-February). While flooding causes significant damage to local populations and infrastructure, the lack of water during the dry season impacts people's agriculturally based livelihoods. Furthermore, competition for water for irrigation, domestic supply, industrial uses and hydropower is at a maximum during the dry season. Successful management of water resources is dependant on an ability to balance the natural availability of water with the pressures exerted by water-users. A software system has been developed to assist water resource practitioners in the region to meet these goals. The software incorporates regression-based hydrological models that enable long-term average monthly recession flows to be estimated in ungauged catchments. Recessions are the periods of successively decreasing flows that occur during the dry season. Users are able to compare predicted flows with observed flows recorded at gauging stations. The impact of existing and future water use scenarios on dry season flows can be simulated by characterisation of seasonal water use at points within the catchment. The user-friendly interface is Geographical Information System based, providing the ability to add contextual spatial data to enhance the application of the conceptual model. Standard display and output formats provide a consistent set of reporting tools. This paper describes the components of the system and presents a case study implementation in the West Rapti catchment (Nepal).

10. Rainwater management for increased productivity among small-holder farmers in drought prone environments

Johan Rockström, Jennie Barron, Patrick Fox

Physics and Chemistry of the Earth 27 (2002) 949–959

Abstract

A critical analysis of conventional water resources assessments and re-visiting the on-farm water balance suggests large scopes for water productivity improvements in small-holder rainfed farming systems in drought prone environments of Eastern and Southern Africa. The paper addresses key management challenges in trying to upgrade rainfed agriculture, and presents a set of field experiences on system options for increased water productivity in small-holder farming. Implications for watershed management are discussed, and the links between water productivity for food and securing of water flow to sustain ecosystem services are briefly analysed. Focus is on sub-Saharan Africa hosting the largest food deficit and water scarcity challenges. The paper shows that there are no agro-hydrological limitations to doubling on-farm staple food yields even in drought prone environments, by producing more “crop per drop” of rain. Field evidence is presented suggesting that meteorological dry spells are an important cause for low yield levels and it is hypothesised that this may constitute a core driver behind farmers risk aversion strategies. The dry spell induced risk perceptions contribute amongst others to soil nutrient mining due to insignificant investments in fertilisation. For many small-holder farmers in the semi-arid tropics it is simply not worth investing in fertilisation (and other external inputs) as long as the risk for crop failure remains a reality every fifth year with risk of yield reductions every second year, due to periodic water scarcity during the growing season (i.e., not necessarily cumulative water scarcity). Results are presented from field research on small-holder system innovations in the field of water harvesting and conservation tillage. Upgrading rainfed production systems through supplemental irrigation during short dry-spells is shown to dramatically increase water productivity. Downstream implications of increased upstream withdrawals of water for upgrading of rainfed food production are discussed.

Finally it is argued that some of the most exciting opportunities for water productivity enhancements in rainfed agriculture are found in the realm of integrating components of irrigation management within the context of rainfed farming, e.g., supplemental or micro irrigation for dry spell mitigation. Combining such practices with management strategies that enhance soil infiltration, improve water holding capacity and plant water uptake potential, can have strong impact on agricultural water productivity. This suggests that it is probably time to abandon the largely obsolete distinction between irrigated and rainfed agriculture, and instead focus on integrated rainwater management.

11. Catchment Management Agencies for poverty eradication in South Africa

Barbara Schreiner, Barbara Van Koppen

Physics and Chemistry of the Earth 27 (2002) 969–976

Abstract

This paper discusses the changes in water law in South Africa since the new dispensation. The focus is on the poverty dimensions of the early experiences of implementation of one of the components of the National Water Act: the establishment of Catchment Management Agencies (CMAs). From a diversity of recent experiences in decentralizing integrated water resources management, key areas emerge where future actions by the government are crucial to establish pro-poor, developmental CMAs.

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

David Seckler, Upali Amarasinghe, David Molden, Radhika de Silva and Randolph Barker
Research Report 19
International Water Management Institute

Abstract

It is widely recognized that many countries are entering an era of severe water shortage. The International Water Management Institute (IWMI) has a long-term research program to determine the extent and depth of this problem, its consequences to individual countries, and what can be done about it. This study is the first step in that program. We hope that water resource experts from around the world will help us by contributing their comments on this report and sharing their knowledge and data with the research program. The study began as what we thought would be a rather straightforward exercise of projecting water demand and supply for the major countries in the world over the 1990 to 2025 period. But as the study progressed, we discovered increasingly severe data problems and conceptual and methodological issues in this field. We therefore created a simulation model that is based on a conceptual and methodological structure that we believe is valid and on various estimates and assumptions about key parameters when data are either missing or subject to a high degree of error and misinterpretation. The model is in a spreadsheet format and is made as simple and transparent as possible so that others can use it to test their own ideas and data (and we would like to see the results). One of the strengths of this model is that it includes a submodel on the irrigation sector that is much more thorough than any used to date in this context. Since irrigation uses over 70 percent of the world's supplies of developed water, getting this component right is extremely important. The full model, with a guide, can be downloaded on IWMI's home page (<http://www.cgiar.org/iimi>).....

13. Governance, agricultural productivity and poverty reduction in Africa, Asia and Latin America

Colin Thirtle and Jenifer Piesse
Irrig. and Drain. 56: 165-177 (2007)

Abstract

Twenty per cent of the world's population or 1.2 billion live on less than US\$1 per day; 70% of these are rural and 90% in Asia and sub-Saharan Africa. Research-led technological change in agriculture generates sufficient productivity growth to give high rates of return in Africa and Asia and has a substantial impact on poverty, currently reducing this number by 27 million per annum, whereas productivity growth in industry and services has no impact. The annual per capita "cost" of poverty reduction by means of agricultural research expenditures in Africa is US\$144 and in Asia US\$180 or 50 cents per day, but this is covered by output growth. By contrast, the annual per capita cost for the richer countries of Latin America is over US\$11 000. This paper extends this model by including measures of governance developed by Kaufmann et al. (1999). The rationale is simple, since the "government effectiveness" cluster provides an index of government ability to provide public goods. Hence, countries that score poorly are unlikely to be able to generate improved agricultural technologies. We show that government effectiveness is significant in explaining research effort, yields and gross domestic product (GDP) per capita.

14. Issues in Poverty Reduction and Natural Resource Management

This publication was produced for review by the United States Agency for International Development (USAID). It was prepared by the Natural Resources Information Clearinghouse, an operation of Chemonics International. 2006

Introduction

Poverty is a global problem that affects citizens around the world. About 1.1 billion people earn less than one dollar per day, and they face daily risks and hardships that determine their very survival. The development community, including government agencies, banks, and nongovernmental organizations (NGOs), seeks to improve the livelihoods of impoverished citizens through poverty reduction strategies

that address the root causes of poverty and its crippling effect on people trapped in adverse situations. But after years of implementing programs to solve these issues, poverty remains a multi-dimensional problem with many faces.

Issues in Poverty Reduction and Natural Resource Management defines the links between poverty reduction and natural resources. About three in four poor people live in rural areas, where they depend on natural resources for their livelihoods, and about 90 per-cent of them depend on forests for at least some part of their income. This report explores the connection between poverty reduction and natural resources management (NRM)—it describes how the world's poorest citizens depend on forests, fisheries, water, land, and other natural resources for their livelihoods; examines the governance, economic, and social factors that determine this vital relationship; and shows how wise use of these resources can serve as the basis for effective poverty reduction strategies. The report also examines the relationships among resource management—or mismanagement—and global trade, human migrations, and regional conflicts.....

15. Irrigation management reforms in the Yellow River basin: Implications for water saving and poverty

Jinxia Wang, Jikun Huang, Zhigang Xu, Scott Rozelle, Intizar Hussain and Eric Biltonen
Irrig. and Drain. 56: 247-259 (2007)

Abstract

The overall goal of this paper is to better understand irrigation management reforms in the Yellow River Basin, especially focusing on the effect that it will have on water use and poverty. Based on a random sample of 51 villages and 189 farmers in four large irrigation districts in Ningxia and Henan provinces, both provinces in China's Yellow River Basin, the results show that two of the major types of irrigation management institutions, water user associations and contracting, have begun to systematically replace traditional types of collective management. The impact analysis demonstrates that it is not the nominal implementation of the reforms that matters, but rather it is the creation of new management institutions that offer managers incentives to save water. Specifically, when managers in reformed organizations are provided with incentives, they save water. Importantly, given China's concerns about poverty alleviation, the reductions in water have little effect on higher incidences of poverty.

16. World Development Report 2008: Agriculture for Development

THE WORLD BANK Available in BlueDocs:

17. Livestock farming as a factor of environmental, social and economic stability with special reference to research

J. Boyazoglu

Livestock Production Science 57 (1998) 1-14

Abstract

Scientific advances and the present methods of technology for food production, preservation, processing, transport and marketing are forcing rapid change, throughout the developing and marginal regions of the world. Only time will show whether the present pace of change will, on balance, have an overall positive or negative effect on the future state of affairs. This change should be managed to prevent devastating effects not only on traditional animal production but also on the environment as a whole allowing for a planned evolutionary process so that humans and the livestock and domestic animals they care for can adopt the new socio-economic conditions, they both must face. Livestock-related development projects are required to be efficient and economically sustainable, but also diversified, clean, of high biological added value, and integrated in a healthy, dynamic and renewed agricultural and environmental context. The need for a more multidisciplinary systemic research and wider choice of subjects is strongly recommended. On the topic of sustainable growth, without promoting less progressive approaches and uneconomical environmental policies, we run the risk today of over hastily accepting and applying new alternatives that might neglect the fundamental

factors of adaptability and time; this could be a destructive experience for livestock production especially in marginal areas.

18. The economic linkages between rural poverty and land degradation: some evidence from Africa

Edward B. Barbier

Agriculture, Ecosystems and Environment 82 (2000) 355–370

Abstract

This paper focuses on the potential role of policy in influencing the poverty and land degradation problems facing Africa. This is done through exploring a few case studies, chosen from a broad spectrum of African countries — Sudan, Malawi, Nigeria, Ghana and Kenya. The first case study examines the comparative returns to the gum arabic agroforestry system cultivated by poor farmers in Northern Sudan, and the role of policies in influencing these returns. The second explores how erratic agricultural pricing policies in Malawi during the 1980s may have distorted the incentives of poor smallholders to adopt less-erosive crops in their farming systems. The third case study illustrates how inappropriate policies and investments can cause displacement of poorer rural groups from their traditional farming and grazing lands, by examining the loss of a major floodplain due to dam building in northern Nigeria. The final two case studies are concerned with policy 'lessons learned'. The first looks at the impact of a macro-economic adjustment policy — in this case trade liberalization — on farmers' decisions to expand cultivated area rather than intensify crop production in western Ghana. The final case study examines the role of policy in land management success story in Africa, the Machakos District, Kenya, and explores the critical question of whether this success can be replicated elsewhere in Africa. These case studies serve two important functions. First, they demonstrate how policy analysis can be effective in highlighting key dimensions of the poverty–environment linkages underlying land degradation. Second, they illustrate how both 'good' and 'bad' policies can affect the economic incentives determining poor rural household's decisions to conserve or degrade their land.

19. Climate change impacts on irrigation water requirements: Effects of mitigation, 1990–2080

Günther Fischer, Francesco N. Tubiello, Harrij van Velthuizen, David A. Wiberg

Technological Forecasting & Social Change 74 (2007) 1083–1107

Abstract

Potential changes in global and regional agricultural water demand for irrigation were investigated within a new socio-economic scenario, A2r, developed at the International Institute for Applied Systems Analysis (IIASA) with and without climate change, with and without mitigation of greenhouse gas emissions. Water deficits of crops were developed with the Food and Agriculture Organization (FAO)–IIASA Agro-ecological Zone model, based on daily water balances at 0.5° latitude×0.5° longitude and then aggregated to regions and the globe. Future regional and global irrigation water requirements were computed as a function of both projected irrigated land and climate change and simulations were performed from 1990 to 2080. Future trends for extents of irrigated land, irrigation water use, and withdrawals were computed, with specific attention given to the implications of climate change mitigation. Renewable water-resource availability was estimated under current and future climate conditions. Results suggest that mitigation of climate change may have significant positive effects compared with unmitigated climate change. Specifically, mitigation reduced the impacts of climate change on agricultural water requirements by about 40%, or 125–160billionm³ (Gm³) compared with unmitigated climate. Simple estimates of future changes in irrigation efficiency and water costs suggest that by 2080 mitigation may translate into annual cost reductions of about 10billion US\$.

20. Facing Climate Change by Securing Water for Food, Livelihoods and Ecosystems

Available in BlueDocs

C de Fraiture, V Smakhtin, D Bossio, P McCornick, C Hoanh, A Noble, D Molden, F Gichuki, M Giordano, M Finlayson and H Turrall

SAT eJournal | ejournal.icrisat.org December 2007 | Volume 4 | Issue 1

Abstract

Future changes in water availability due to climate change (CC) are of paramount importance for food security of millions of rural people worldwide. Many recent extremes of water shortage followed by devastating floods reflect some of the climate change predictions, which are gradually becoming more certain and alarming. Appropriate measures in agricultural water management can greatly reduce poor people's vulnerability to CC by reducing water related risks and creating buffers against often unforeseen changes in precipitation and water availability. An appropriate water research agenda is essential to improve our knowledge of the linkages between water, food and CC and guide the right investments aimed at improving resilience of farming communities and food security. This agenda includes understanding the adaptation and mitigation roles of agricultural practices and water resources management options, characterization of climate change impacts at different scales, and evaluation of water implications of direct climate change mitigation interventions. This agenda will result in strategies that contribute to reduced risk and enhanced resilience of agricultural systems. Building on its research capital in the water, food and livelihood nexus, IWMI is in a good position to help formulate and implement this agenda.

21. Water and carbon fluxes from savanna ecosystems of the Volta River watershed, West Africa

Heiko Freitag, Paul R. Ferguson, Kristal Dubois, Ebenezer Kofi Hayford, Vincent von Vordzogbe and Ján Veizer

Global and Planetary Change 61 (2008) 3–14

Abstract

The fluxes of water and carbon from terrestrial ecosystems are coupled via the process of photosynthesis. Constraining the annual water cycle therefore allows first order estimates of annual photosynthetic carbon flux, providing that the components of evapotranspiration can be separated. In this study, an isotope mass-balance equation is utilized to constrain annual evaporation flux, which in turn, is used to determine the amount of water transferred to the atmosphere by plant transpiration. The Volta River watershed in West Africa is dominated by woodland and savanna ecosystems with a significant proportion of C_4 vegetation. Annually, the Volta watershed receives ~ 380 km³ of rainfall, $\sim 50\%$ of which is returned to the atmosphere via transpiration. An annual photosynthetic carbon flux of $\sim 170 \times 10^{12}$ g C yr⁻¹ or ~ 428 g C m⁻² was estimated to be associated with this water vapor flux. Independent estimates of heterotrophic soil respiration slightly exceeded the NPP estimate from this study, implying that the exchange of carbon between the Volta River watershed and the atmosphere was close to being in balance or that terrestrial ecosystems were a small annual source of CO₂ to the atmosphere. In addition to terrestrial carbon flux, the balance of photosynthesis and respiration in Volta Lake was also examined. The lake was found to evade carbon dioxide to the atmosphere although the magnitude of the flux was much smaller than that of the terrestrial ecosystems.

22. Innovations in Climate Risk Management: Protecting and Building Rural Livelihoods in a Variable and Changing Climate. Available in BlueDocs

James W Hansen, Walter Baethgen, Dan Osgood, Pietro Ceccato, Robinson Kinuthia Ngugi
SAT eJournal ejournal.icrisat.org 2007, 4(1)

Abstract

We argue that more effective management of climate risk must be part of the response of the international agriculture community to the double crisis of persistent poverty and a changing climate. The most promising opportunities to adapt to climate change involve action on shorter time scales that also contributes to immediate development challenges. Climate risk management (CRM) combines systematic use of climate information, and technology that reduces vulnerability and policy that transfers risk. The cost of climate risk comes both through damaging extreme events and through forfeited opportunity in climatically-favorable years. Effective CRM therefore involves managing the full range of variability, balancing hazard management with efforts to capitalize on opportunity. We discuss several innovations for managing climate risk in agriculture, which have not yet been fully

mainstreamed in international agricultural research-for-development. First, effective rural climate information services enable farmers to adopt technology, intensify production, and invest in more profitable livelihoods when conditions are favorable; and to protect families and farms against the long-term consequences of adverse extremes. Second, information and decision support systems synthesize historic, monitored and forecast climate information into forms that are directly relevant to institutional decisions (planning, trade, food crisis response) that impact farmer livelihoods. Third, innovations in index-based insurance and credit overcome some of the limitations of traditional insurance, and are being applied to pre-financing food crisis response, and to removing credit constraints to adopting improved technology. We present a typology of CRM interventions around the concept of dynamic poverty traps.

23. Payments for environmental services in watersheds: Insights from a comparative study of three cases in Central America

Nicolas Kosoy, Miguel Martinez-Tuna, Roldan Muradian, Joan Martinez-Alier
Ecological Economics 61(2007): 445-455

Abstract

We have compared three cases of payments for water-related environmental services (PES) in Central America, in terms of socioeconomic background, opportunity costs of forest conservation and stakeholders' perceptions of the conditions of water resources and other issues. We found that, in general, the opportunity costs are larger than the amounts paid, which apparently contradicts the economic foundation of PES schemes and suggests that the role of "intangibles" is important in inducing participation. The results also show that trade-offs between different environmental and social goals are likely to emerge in PES schemes, posing some doubts as to their ability to be multipurpose instruments for environmental improvement and rural development. We also found that PES schemes may work as a conflict-resolution instrument, facilitating downstream-upstream problem solving, though at the same time they might introduce changes in social perceptions of property rights.

24. Using tropical forest ecosystem goods and services for planning climate change adaptation with implications for food security and poverty reduction

Nkem, J.; Santoso, H.; Murdiyarso, D.; Brockhaus, M.; Kanninen, M.
Center for International Forestry Research (CIFOR)

Abstract

Tropical forest ecosystems represent a common heritage with livelihood portfolios shared by a great majority of people especially in developing countries but are now threatened by climate change. In spite of their contribution to poverty alleviation and food security, and also for climate change responses (adaptation and mitigation especially through the market-incentive schemes (CDM) of the Kyoto Protocol) forests are still hardly integrated into national planning processes aimed at addressing any of these national development challenges. This is evident in some of the national documents of some developing countries such as the Poverty Reduction Strategy Paper (PRSP) to the World Bank, and the First National Communication to UNFCCC. This paper presents some preliminary outcomes of the Tropical Forests and Climate Change Adaptation (TroFCCA) project of the Center for International Forestry Research (CIFOR) whose overall mission is to underscore the importance of tropical forests for livelihood adaptation to climate change and mainstreaming adaptation into national development processes. The paper also highlights TroFCCA's approach in engaging stakeholders from the onset in setting the agenda with the identification and prioritization of forest-based sectors as the entry point in the process of assessing the vulnerability to climate change and developing adaptation strategies for these selected development sectors.

26. Multiple-criteria decision analysis for integrated catchment management

Tony Prato, Gamini Herath
Ecological Economics 63: 627-632

Abstract

Implementation of integrated catchment management (ICM) is hampered by the lack of a conceptual framework for explaining how landowners select farming systems for their properties. Benefit-cost analysis (a procedure that estimates the costs and benefits of alternative actions or policies) has limitations in this regard, which might be overcome by using multiple-criteria decision analysis (MCDA). MCDA evaluates and ranks alternatives based on a landowner's preferences (weights) for multiple-criteria and the values of those criteria. A MCDA approach to ICM is superior to benefit-cost analysis which focuses only on the monetary benefits and costs, because it: 1) recognizes that human activities within a catchment are motivated by multiple and often competing criteria and/or constraints; 2) does not require monetary valuation of criteria; 3) allows trade-offs between criteria to be measured and evaluated; 4) explicitly considers how the spatial configuration of farming systems in a catchment influences the values of criteria; 5) is comprehensive, knowledge based, and stakeholder oriented which greatly increases the likelihood of resolving catchment problems; and 6) allows consideration of the fairness and sustainability of land and water resource management decisions. A MCDA based on an additive, multiple criteria utility function containing five economic and environmental criteria was used to score and rank five farming systems. The rankings were based on the average criteria weights for a sample of 20 farmers in a US catchment. The most profitable farming system was the lowest-ranked farming system. Three possible reasons for this result are evaluated. First, the MCDA method might cause respondents to express socially acceptable attitudes towards environmental criteria even when they are not important from a personal viewpoint. Second, the MCDA method could inflate the ranks of less profitable farming systems for the simple reason that it allows the respondent to assign non-zero weights to non-economic criteria. Third, the MCDA might provide a better framework for evaluating a landowner's selection of farming systems than the profit maximization model.

27. Poverty and Conservation: The New Century's "Peasant Question?"

Steven Sanderson

World Development Vol. 33, No. 2, pp. 323-332, 2005

Abstract

By issuing its Millennium Development Goals, the United Nations has declared its intention to alleviate poverty and hunger at a global scale over the next decade. But, the perspectives and policies to achieve those goals have not addressed the failures of previous development efforts of this kind. Nor have the plans to meet the Millennium Development Goals paid sufficient attention to the costs of rural development for wild nature. This paper points up the absence of a new analytical framework for sustainability and an action program in favor of a poverty- and conservation-oriented rural development program to ensure that the benefits of multilateral development plans accrue to the truly poor and to the future of wild nature.

28. Climate change mitigation through afforestation/reforestation: A global analysis of hydrologic impacts with four case studies

Antonio Trabucco, Robert J. Zomer, Deborah A. Bossio, Oliver van Straaten, Louis V. Verchot
Agriculture, Ecosystems and Environment

Abstract

The implicit hydrologic dimensions of international efforts to mitigate climate change, specifically potential impacts of the Clean Development Mechanism-Afforestation/Reforestation (CDM-AR) provisions of the Kyoto Protocol (KP) on global, regional and local water cycles, are examined. The global impact of the redistribution of water use driven by agriculture and land use change, of which CDM-AR can be a contributing factor, is a major component of ongoing global change and climate change processes. If converted to forest, large areas deemed suitable for CDM-AR would exhibit increases in actual evapotranspiration (AET) and/or decreases in runoff. Almost 20% (144 Mha) of all suitable land showed little or no impact on runoff and another 28% (210 Mha) showed only moderate impact. About 27% (200 Mha) was in the highest impact class, exhibiting an 80-100% decrease in runoff, and prevalent in drier areas (based on Aridity Index (AI)), the semi-arid

tropics, and in conversion from grasslands and subsistence agriculture. Significant impacts on local hydrologic cycles were evident, however large impacts were not predicted at regional or global scale due primarily to the current limit on carbon offset projects under the Kyoto Protocol. Predicted decreases in runoff ranged from 54% in drier areas to less than 15% in more humid areas, based on four case studies located across a range of biophysical conditions and project scenarios in Ecuador and Bolivia. Factors other than climate, e.g. upstream/downstream position, were shown to be important in evaluating off-site impacts. This study demonstrates that it will become increasingly important to consider implications on local to regional water resources, and how the hydrologic dimension of CDM-AR impacts on issues of sustainability, local communities, and food security.

29. The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa

J.K. Turpie, C. Marais, J.N. Blignaut
Ecological Economics

Abstract

A payments for ecosystem services (PES) system came about in South Africa with the establishment of the government-funded Working for Water (WfW) programme that clears mountain catchments and riparian zones of invasive alien plants to restore natural fire regimes, the productive potential of land, biodiversity, and hydrological functioning. The success of the programme is largely attributed to it being mainly funded as a poverty-relief initiative, although water users also contribute through their water fees. Nevertheless, as the hydrological benefits have become apparent, water utilities and municipalities have begun to contract WfW to restore catchments that affect their water supplies. This emerging PES system differs from others in that the service providers are previously unemployed individuals that tender for contracts to restore public or private lands, rather than the landowners themselves. The model has since expanded into other types of ecosystem restoration and these have the potential to merge into a general programme of ecosystem service provision with in a broader public works programme. There is a strong case for concentrating on the most valuable services provided by ecosystems, such as water supply, carbon sequestration, and fire protection, and using these as 'umbrella services' to achieve a range of conservation goals. The future prospects for expansion of PES for hydrological services are further strengthened by the legal requirement that Catchment Management Agencies be established. These authorities will have an incentive to purchase hydrological services through organisations such as WfW so as to be able to supply more water to their users.

30. Integrated water and economic modelling of the impacts of water market instruments on the South African economy

Jan H. van Heerden, James Blignaut, Mark Horridge,
Ecological Economics

Abstract

A static computable general equilibrium model of South Africa is adapted to compare new taxes on water demand by two industries, namely forestry, and irrigated field crops. Comparisons are made with respect to both the short and the long run, in terms of three target variables, namely (i) the environment; (ii) the economy; and (iii) equity. Since the taxes on the two industries do not raise the same amount of revenue, the target variables are calculated per unit of real government revenue raised by the new taxes (also referred to as the marginal excess burdens of the taxes). The model results are robust for moderate values of the water elasticity of demand in the two industries, in both the long and the short run. The tax on irrigated field crops performs better in terms of all three the target variables in the short run. In the long run the tax on irrigated field crops is better in terms of water saving, but reduces real GDP and the consumption by poor households.

31. Substitution between water and other agricultural inputs: Implications for water conservation in a River Basin context

Ximing Cai., Claudia Ringler, Jiing-Yun You

Ecological Economics

Abstract

Substitution of irrigation water with other agricultural inputs could be an important means to conserve water in the face of growing pressures on water resources from both nonagricultural water demands and environmental water requirements. This paper discusses the potential of such substitution through an empirical analysis based on a multiple-input crop production function at the field and farm scales complemented with a numerical modeling exercise at the basin scale. Results from the crop production function analysis show that under both crop yield and net profit maximization, water is a substitute to other crop inputs for high-value crops, and is a complement to water for low-valued crops. At the basin scale, an integrated economic-hydrologic river basin model is used to analyze the role of other factors in crop input substitution, including the spatial connections among water sources and demands, hydro-agronomic conditions, and institutional settings for water allocation. Results show that in the case study area, the Maipo River basin in Chile, where water is very scarce, moving from the current, input-constrained, situation to full optimization of water resources leads to an increase in all crop inputs, including water. In that case, 301 million m³ of additional water use results in additional net profits of USD 11 million. However, if the water fee is raised by a factor of eight while overall basin irrigation profits are maintained at the original, baseline level, a reduction of water withdrawals by 326 million m³ is traded off with costs of USD 43.2 million for other inputs. Irrigation districts with a high share of low-value crops have a low potential for substituting water with other crop inputs. Therefore, investments for water substitution should also be kept low in these areas.

32. Editorial: Integrated Water Resources Management in Latin America

Asit K. Biswas,

Water Resources Development, Vol. 24, No. 1, 1-4, March 2008

33 Integrated Water Resources Management: Is It Working?

Asit K. Biswas

Water Resources Development, Vol. 24, No. 1, 5-22, March 2008

Abstract

Integrated water resources management is not a new concept: it has been around for some two generations. In the early 1990s it was 'rediscovered' by some water professionals, and then subsequently heavily promoted by several donors and international institutions. In spite of the fact that its promoters have spent hundreds of millions of dollars in recent years, the facts remain that the definition of this concept remains amorphous, and the results of its application in a real world to improve water policy, programme and projects at macro- and meso-scales have left much to be desired. At a scale of 1 to 100 (1 being no integrated water resources management and 100 being full integration), any objective analyst will be hard-pressed to give a score of 30 to any one activity anywhere in the world in terms of its application. The paper reviews the reasons for its recent popularity, why the concept has not been a universal solution in the past, as claimed by its promoters, and also discusses why it is highly unlikely to work in the future.

33. Achieving Water Security for Asia

Asit K. Biswas & K. E. Seetharam

Water Resources Development, Vol. 24, No. 1, 145-176, March 2008

Abstract

Sponsored by the Asian Development Bank, Asian Water Development Outlook is a future-oriented analysis of water security for the Asian countries. The future water problems of the Asian countries and their solutions will be very different compared to those of the past. While historical knowledge will

be useful, solving water problems of the future will require additional skills, innovative approaches and new mindsets. It will also require a determined attempt to coordinate energy, food, environment and industrial policies of a nation, all of which have intimate linkages to water. Each will affect the other, and, in turn, be affected by the others. Policies in all these areas will be also influenced by exogenous forces such as demographic transitions, advances in technology and information and communication systems, climatic change, globalization, free trade and increasing social activism. All these and other associated developments will mean that water management in Asia will change more during the next 20 years than in the past 2000 years. In-depth analyses prepared for the Outlook indicate that the Asian countries are not facing a water crisis because of physical scarcities of the resource, but because of poor management. With the knowledge, technology and experience that are now available within the Asian region as a whole, the water problems of all the Asian countries can be solved. Given adequate capacity development, intensified political will, and appropriate investments, one can be cautiously optimistic of Asia's water future.

34. Integrated Water Resource Management in Colombia: Paralysis by Analysis?

Javier Blanco

Water Resources Development, Vol. 24, No. 1, 91-101, March 2008

Abstract

This paper reviews the current instruments in Colombian legislation for water management, including planning, economic and administrative instruments. In particular, it reviews the Watershed Management and Ordering Plans, administrative permits for water use and pollution, as well as water use and water pollution charges. It analyzes how they could interact and be implemented in order to undertake comprehensive and integrated water management by the regional environmental authorities. The paper then reviews how these instruments are currently being implemented by the regional environmental authorities, concluding that IWRM goals are not being achieved.

35. Integrated River Basin Plan in Practice: The Sao Francisco River Basin

B. P. F. Braga & J. G. Lotufo

Water Resources Development, Vol. 24, No. 1, 37-60, March 2008

Abstract

Integrated Water Resources Management (IWRM) is a very encompassing concept that needs breaking down in order for it to be applied to real life cases. This paper breaks down this concept to consider the multiple objectives and uses of water, the incorporation of other sectors in the planning process and the involvement of stakeholders in the decision-making process. The IWRM concept is applied to develop an integrated water resources river basin plan for the Sao Francisco river basin. This basin has an area of 600 000 km² with significant climatic, ecological and socioeconomic variations. A river basin committee, with representatives from government, users, professional associations and NGO, is responsible for approving the river basin plan. The plan was developed by the National Water Agency of Brazil and submitted to the river basin committee for approval. The preparation of the plan involved a large number of stakeholders from state government agencies, local governments, users and the organized civil society. This paper presents this integrated river basin plan and the correspondent participatory development process.

36. Evaporation mapping at two scales using optical imagery in the White Volta Basin, Upper East Ghana

Halidou Compaore, Jan M.H. Hendrickx, Sung-ho Hong, Jan Friesen, Nick C. van de Giesen, Charles Rodgers, Joerg Szarzynski, Paul L.G. Vlek

Abstract

Maps of regional distributions of evaporation provide critical information on the interactions between land surface and the atmosphere since they allow (i) to follow where, when, and how much water has moved into the atmosphere by evaporation; (ii) to monitor crop performance and the effects of droughts for famine prediction; (iii) to better evaluate the performance of irrigation systems; and (iv) to improve

weather predictions. Since evaporation is subject to rapid changes in time and space, it is nearly impossible to determine its spatial and temporal distributions over large areas from ground measurements alone. Therefore, estimation from remote sensing images is very attractive as it enables extensive area coverage and a high repetition rate. In this study, the surface energy balance algorithm for land (SEBAL) is used to map evaporation in the White Volta Basin of Ghana, West Africa, at the start and at the end of the dry season using Landsat and MODIS images. The study objective is to use an independently developed land use/land cover (LULC) map for the evaluation and qualitative validation of SEBAL for evaporation mapping at spatial scales of 30 m (Landsat) and 1000 m (MODIS). The results of this study demonstrate that SEBAL is an accurate algorithm for mapping evaporation over tropical areas where few or no ground measurements are available using common satellite products such as Landsat and MODIS.

37. The use of GIS for the integration of traditional and scientific knowledge in supporting artisanal fisheries management in southern Brazil

De'borá M. De Freitas, Paulo Roberto A. Tagliani

Journal of Environmental Management (2008) 1–10

Abstract

The integration of local harvesters' knowledge of attitudes and practices toward the resources they harvest with scientific information is essential to natural resources management. However, the development and implementation of management policies have, in most cases, not been effective because of a failure to use all available sources of information and knowledge. In fisheries management, local knowledge is usually not collected in a systematic format and little published literature has discussed the use of local knowledge data collection and analysis methods. This paper describes the implementation of geographic information systems to systematize, analyze, and display traditional and scientific information to support fisheries management in the Patos Lagoon Estuary, southern Brazil. Artisanal fishing data were documented through a series of interviews conducted during and after fishing trips at harvest spots, and scientific data on environmental variables were obtained from different research institutions. A multi-layer GIS database integrating local fishers' and scientific knowledge information was developed with ArcGIS 8.3 ArcView_ tools to integrate and translate information into an accessible and interpretable format. The geo-spatial database interface allowed the selection of specific data characteristics by target species, harvest areas, fishers' communities, fishing gear, catch-per-unit of effort (CPUE), and monthly landings. The observed fishing spatial dynamics presented among the fishers' communities shows that, in most cases, artisanal fishermen tend to concentrate in shallow estuarine waters surrounding their villages.

38 A comparison of sap flux-based evapotranspiration estimates with catchment-scale water balance

Chelcy R. Ford, Robert M. Hubbard, Brian D. Kloeppel c, James M. Vose

Agricultural and Forest Meteorology 145 (2007) 176–185

Abstract

Many researchers are using sap flux to estimate tree-level transpiration, and to scale to stand- and catchment-level transpiration; yet studies evaluating the comparability of sap flux-based estimates of transpiration (E_t) with alternative methods for estimating E_t at this spatial scale are rare. Our ability to accurately scale from the probe to the tree to the watershed has not yet been demonstrated, nor do we know the relative impact of the main sources of variability on our scaled estimates. Accounting for the variability in the radial distribution of sap flux within the sapwood, the variability of transpiration among trees and between plots within the catchment, and the variability in stand density, sapwood area, and leaf area are critical for making landscape inferences about transpiration. During 2004 and 2005, we continuously monitored 40 trees in three plots within a 13.5-ha gauged watershed comprising a 50- year-old eastern white pine plantation within the Coweeta Basin in western North Carolina, USA. We scaled sap flux-based estimates of stand transpiration (E_t) and surface area-based estimates of stand interception (E_i) to the catchment and compared these with water balance

estimates of evapotranspiration (E , precipitation minus runoff, $P - R_o$). For both years, the sum of sap flux scaled \bar{E} and \bar{E} were 14 and 7% lower than evapotranspiration estimated from $P - R_o$. Our results show that a considerable amount of variation exists at each scaling step encountered; however, a simple scaling exercise revealed that omitting among plot variation affected the sap flux scaled \bar{E} estimate by 48%. Thus, the largest source of variability in scaling to the landscape was landscape variation in stand density and sapwood area.

39 Challenges for Integrated Water Resources Management: How Do We Provide the Knowledge to Support Truly Integrated Thinking?

Rachael A. McDonnell

Water Resources Development, Vol. 24, No. 1, 131-143, March 2008

Abstract

The ideas of good governance through integrated water resources management (IWRM) are predicated on bringing together our understanding of water from many domains, thus the provision of knowledge and information is an important part of any enabling environment. Strategies put forward so far have been based on developing systems to integrate existing data from many sources then using different analytical methods such as Environmental Impact Assessment (EIA) to determine the effects of particular policies or management strategies on various water subsystems. This paper reviews some of the challenges associated with such approaches, ranging from the practical problems of data provision to the more fundamental ones associated with adopting such a positivist, techno-scientific framework. It becomes obvious that new approaches are needed which take on board important research findings emanating from fields such as social theory and geographical information science (GIScience).

40. The design of water markets when instream flows have value

James J. Murphy, Ariel Dinar, Richard E. Howitt, Stephen J. Rassenti, Vernon L. Smith, Marca Weinberg

Journal of Environmental Management (2008) 1-8

Abstract

The main objective of this paper is to design and test a decentralized exchange mechanism that generates the location-specific pricing necessary to achieve efficient allocations in the presence of instream flow values. Although a market-oriented approach has the potential to improve upon traditional command and control regulations, questions remain about how these rights-based institutions can be implemented such that the potential gains from liberalized trade can be realized. This article uses laboratory experiments to test three different water market institutions designed to incorporate instream flow values into the allocation mechanism through active participation of an environmental trader. The smart, computer coordinated market described herein offers the potential to significantly reduce coordination problems and transaction costs associated with finding mutually beneficial trades that satisfy environmental constraints. We find that direct environmental participation in the market can achieve highly efficient and stable outcomes, although the potential does exist for the environmental agent to influence outcomes.

If you are a member of the CPWF team and require details of the above manuscripts, please contact and request to: gis-communications@cgiar.org
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