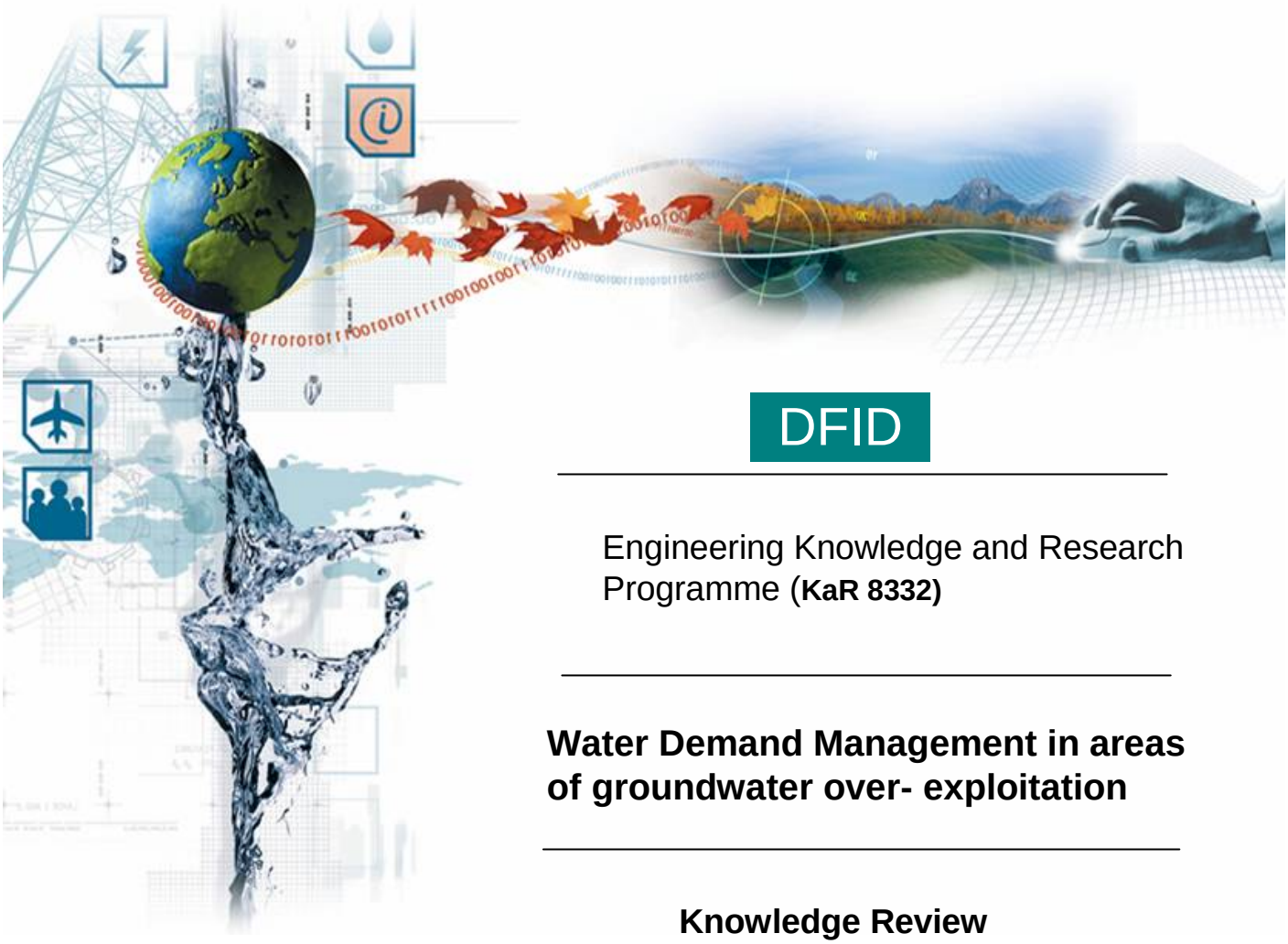


DFID

Engineering Knowledge and Research Programme (**KaR 8332)**

Water Demand Management in areas of groundwater over- exploitation

Knowledge Review

June 2004

BLACK & VEATCH

Black & Veatch Consulting

in association with

VRV Consultants (P) Ltd, Chennai,India

Jouzy & Partners, Amman, Jordan

DFID *Engineering Knowledge and Research Programme*

Knowledge Review

DATE
21st May 2004

PROJECT TITLE **Water demand management in areas of groundwater over-exploitation**

PROJECT NUMBER **R8332**

ORGANISATION **Black & Veatch Consulting Ltd**

ANTICIPATED COMPLETION DATE **DECEMBER 2005**

Preface

This Knowledge Review is submitted in support of the Inception Report for the DFID funded project No.R8332 of the KaR programme "Water Demand Management in areas of groundwater over-exploitation". Although, an extensive literature review was carried out on the subject and issues surrounding it, only selected abstracts most relevant to the study have been presented in this report.

A related bibliography on the following topics can be found at Black & Veatch office in Redhill, UK.

- Water resources policy and planning
- Socio-economic and poverty assessment, livelihoods
- Water resources assessment
- Water demand management
-
- Water Quality, Monitoring and environmental protection
- Water and Sanitation
- Resource augmentation
- Agriculture and irrigation
- Institutions, public awareness, legislation and private sector involvement
- Water sector costs, economics and population projections

The abstracts in this report cover the following subjects: water policy strategies, public private partnerships, sustainable livelihoods, and water demand management.

A list of other key publications is given at the end of this document.

KNOWLEDGE REVIEW
CONTENTS

1. Water Resources Sector Strategy - Strategic Directions for World Bank Engagement. World Bank; 2004

Abstract

Progress in ideas and practice

In 1993 the Board of the World Bank endorsed a Water Resources Management Policy Paper. The Paper reflected the broad global consensus that was forged during the Rio Earth Summit of 1992. This consensus stated that modern water resources management should be based on three fundamental principles (known as "the Dublin Principles"). First is the *ecological principle*, which argues that independent management of water by different water-using sectors is not appropriate, that the river basin should be the unit of analysis that land and water need to be managed together and that much greater attention needs to be paid to the environment. Second is the *institutional principle*, which argues that water resources management is best done when all stakeholders participate, including the state, the private sector and civil society; that women need to be included; and that resource management should respect the principle of subsidarity, with actions taken at the lowest appropriate level. Third is the *instrument principle*, which argues that water is a scarce resource and that greater use needs to be made of incentives and economic principles in improving allocation and enhancing quality.

A decade later, evidence is accumulating on experience with implementing the Dublin Principles. Experience shows that the Dublin Principles have provided inspiration and direction for many water reform processes and that the Principles remain powerful, appropriate and relevant. A major challenge is developing context-specific, prioritized, sequenced, realistic and "patient" approaches to implementation.

The main messages of this Strategy

Message 1: Water resources management and development are central to sustainable growth and poverty reduction and therefore of central importance to the mission of the World Bank. Effective water resources development and management play a fundamental role in sustainable growth and poverty reduction, through four different mechanisms.` First, broad-based water resources interventions, usually including major infrastructure such as dams and interbasin transfers, provide national, regional and local benefits from which all people, including poor people, can gain. Second, because it is usually poor people who inhabit degraded landscapes, poverty-targeted water resources interventions designed to improve catchment quality and provide livelihoods for poor people are of major importance. Third, broad-based water service interventions (aimed at improving the performance of utilities, user associations and irrigation departments) benefit everyone, including poor people. And fourth, poverty-targeted water service interventions (such as water and sanitation and irrigation services for the unserved poor) play a major role in reaching some of the Millennium Development Goals.

Message 2: Most developing countries need to be active in both management and development of water resources infrastructure. For the World Bank to be an effective partner, it must approach water resources challenges without preconceptions. The Bank must not fall into the trap of thinking that all problems can be solved with infrastructure, or the equally dangerous trap of assuming that even in environments with minimal infrastructure all problems can be addressed through better management.

Message 3: The main management challenge is not a vision of integrated water resources management but a "pragmatic but principled" approach that respects principles of efficiency, equity and sustainability while recognizing that water resources

management is intensely political and that reform requires that articulation of prioritized, sequenced, practical and patient interventions.

Message 4: Providing security against climatic variability. Because most developing countries have inadequate stocks of hydraulic infrastructure, *the World Bank needs to assist countries in developing and maintaining appropriate stocks of well-performing hydraulic infrastructure and in mobilizing public and private financing, while meeting environmental and social standards.*

Message 5: There is a large and increasing demand from the World Bank's borrowers for lending and non-lending services related to water resources development and management. The ability of the Bank to respond has been mixed. On the very important "soft" side, Band engagement is growing, rapidly and effectively. But for the many countries that need to make major infrastructure investments to complement management reforms, the Bank is often a reluctant, unpredictable and expensive partner. To be a more effective partner, *the World Bank will re-engage with high-reward-high-risk hydraulic infrastructure, using a more effective business model.*

Message 6: The Bank is perceived by many to have a major comparative advantage in the water sectors, and there is, accordingly, a strong demand for Bank services and a strong demand that the Bank engage. There are two dimensions to the Bank's comparative advantage. On the one hand, as water challenges grow in scale and complexity, the Bank is perceived as one of the few institutions that can provide integrated support on the macro-economic, financial, technical, social and environmental dimensions On the other hand, borrowers find that the Bank is unique in convening power, relations with almost all riparian countries, a combination of knowledge and financial resources, engagement at all scales (local watershed, city, irrigation district, river basin and aquifer, country, regional) and ability to integrate across these. And the Bank, IFC, and Multilateral Investment Guarantee Agency (MIGA) play an indispensable role in attracting much-needed investment by the private sector.

Message 7: The Bank's water assistance must be tailored to country circumstances and be consistent with the overarching Country Assistance Strategies and Poverty Reduction Strategy Papers. The 1993 Policy Paper and this Strategy can necessarily provide only broad principles for World Bank engagement and not inflexible prescriptions. What is appropriate in a particular country (or region) at a particular time will involve adaptation of these general principles to the specific economic, political, social, cultural and historical circumstances. An important new instrument developed in this Strategy is the Country Water Resources Assistance Strategy, which will pull together three different strands. The first strand is the specific water resources challenges, development opportunities and policies in a particular country at a particular time. The second strand is the framework that the government and the World Bank have agreed on for the next three years. The third strand contains the broad principles articulated in the World Bank's 1993 Policy Paper and in this Strategy. The resulting Country Water Resources Assistance Strategies will provide an explicit program of Bank lending and non-lending support in water that is consistent with the Poverty Reduction Strategy Paper and the Country Assistance Strategy and that will govern the Bank-country partnership in water for the next three years.

2. World Bank/UNDP/FAO: Water sector policy review and strategy formulation – a general framework, FAO Land and water Bulletin No 3, 118pp, FAO, Rome 1995

Abstract

Many countries have reached a position where the availability or quality of fresh water resources is imposing limits on present use of the resource and on economic development. Other countries are rapidly approaching a similar critical situation. All these countries face a common problem; existing policies and strategies, and the institutions to implement them, are inadequate to meet water use needs and sustainable development.

The World Bank policy paper *Water Resources Management*, published in 1993, provided a conceptual framework and stressed the importance of a holistic approach to water resources management. Specific guidelines for processes and methods for water policy reforms and the formulation of water resources strategies were suggested in the subsequent joint UNDP-World Bank technical paper *A Guide to the Formulation of Water Resources Strategy*, published in 1994, and in *Reforming Water Resources Policy: A Guide to Methods, Processes and Practices,* published by FAO in 1995.

In September 1994, The Sub-committee on Water Resources of the UN Administrative Committee for Coordination (ACC-SWR) requested UNDP, FAO and the World Bank to prepare a joint guide on water resources policy review and reform and on strategy formulation. These agencies merged their respective publications, and FAO produced this joint document.

The general framework presented in the document is based on elaboration of the strategic planning process, focusing on policy review and strategy formulation for water resources management. Policy review is intended to re-assess objectives, existing policy and status of the water sector, and to provide new goals and policies on which a detailed strategy can be based. The process of strategy formulation is concerned with the detail of how to put policy into practice at national, regional (basin) and local levels.

International meetings (ICWE, Dublin, and UNCED Rio di Janiero, both in 1992) on water and the environment have focused popular attention on the increasingly limited availability of water resources and the need for improved management and conservation as a corollary to development. Rising population and the rapid rate of urbanization continue to increase demand for the basic services of potable water and sanitation and the need for secure food supplies.Irrigation is the dominant water user in many developing countries and faces increasing competition from other sectors, raising severe localized problems of re-allocation in some cases.

Issues to be addressed include the increasing cost of developing new water supply infrastructure; consideration of the environmental needs for water and mitigation of the impact of water development; and the recovery of part or all of the operational costs of supply. Public expenditure by governments is increasingly burdensome. The need for massive levels of new investment has also prompted renewed interest in attracting private sector finance to augment or relieve state commitments.

Component parts of the policy review include determining the importance of water in specific national and regional contexts, conducting a comprehensive water resources assessment and thereby generating a matrix of problems and critical issues, set against old and emerging objectives for water policy. Broad options, based on defined principles, are evaluated and set the scene for detailed strategy formulation, which establishes

critical elements such as oversight bodies and expert teams and identifies all the interested parties (stakeholders). Extensive use of public consultation and participation is envisaged, although realistic assessment of the time, effort, cost and logistical feasibility of appropriate stakeholder participation is called for. The end point of the strategy formulation exercise is the definition of an action programme and implementation schedule.

The principle elements and key issues in strategy formulation are introduced with consideration of the need for a holistic and integrated approach to assessment, development and management of freshwater resources. Categories of actions determined in the policy analysis matrix are elaborated with consideration of data requirements and information management and the role of modelling in assessing options. Institutional and legal reforms are a major part of strategy formulation, encompassing specification, allocation and recognition of water rights, changes in organizational and ownership arrangements, and decentralization and devolution of responsibility in public sector management. The roles of economic tools and incentives and technological innovation are also introduced before more detailed consideration is given to the following key issues:

- institutions and human resources;
- stakeholder participation;
- information systems and management;
- the role of economics;
- environmental and health considerations; and
- international issues.

The final section draws together recent experience in water resources reform. It highlights the outcomes of policy reform under the headings of water rights; privatization and corporatization; the promotion of price and market mechanisms; and reforms in planning and management.

3. Water Demand Management: Concept, applications and innovations in the Middle East and North Africa. Hamid A. Bakir, World Health Organization (WHO), Regional Center for Environmental Health Activities, 2001

Abstract

The paper examines the water shortages in the Middle East and North Africa and distinguishes between the structural causes (e.g. population growth) of water shortages and the non-structural causes (unwise and inefficient use, pollution, and over exploitation) brought about by the way water is managed. The paper argues that the supply driven approach, searching for new supplies to match the perceived demands, further worsens the natural water shortages and will not enhance water security in a water scarce region. Accessible freshwater sources are tapped beyond their capacity. Securing additional water from across national borders, while achievable, remains costly and risky. Desalinated water is a potential source but remains out of the reach of most MENA countries until desalination costs are reduced.

There is no other region on earth where the need is so acute for a major shift in water policies from the supply approach to the demand management approach within integrated water resources management. The demand can be manipulated through:

> efficient allocation in quantity and quality to the competing users of water (agriculture, industry, and domestic) to ensure that water is used wisely and optimally for the public interest;
>
> efficient water use by all users to eliminate wasteful consumption and reduce consumptive use of water;
>
> and sufficient and efficient environmental protection for pollution control and maximized safe recycling.

The paper draws on the experience of several countries in MENA and suggests that only comprehensive, sustained, and proactive interventions can achieve lasting results. Sporadic, ad-hoc and poorly targeted water conservation and education drives alone rarely achieve results. The shift to water demand management starts with an understanding of the non-structural causes of water shortages and recognition at the highest policy level for the need for such a shift. Institutional and sector reforms that are supportive to the water demand management shift then become necessary. Rational planning processes are needed to ensure that water is developed, allocated, used, and protected in ways that ensure efficient, sustainable and beneficial use of water in the public interest.

The paper reviews existing management tools, enabling strategies, technologies and innovations. Additional innovations are proposed. Decentralized but holistic wastewater management is proposed to facilitate the recovery of every drop of wastewater. Site-tailored modular wastewater systems are suggested. The closed-water-loop-system is presented as a working model in order to translate a decentralized wastewater management concept and demand management principles into practice at household and community levels.

4. How do we get more crop from every drop? Water Policy Briefing, Issue 8, International Water Management Institute (IWMI), March, 2003

Abstract

Research over the past decade shows that by improving the productivity of water on irrigated and rain-fed lands, we can have enough water for cities, industry and environmental needs. But this requires a commitment to institutional and management reforms, and substantial investment in crop research, technology and infrastructure. Improving the productivity of water used in agriculture is the key to solving these problems. Getting more crop per drop enhances food security and makes more water available to meet other needs. It enables us to reduce investment in new water storage and irrigation infrastructure –investments many countries can't afford.

Many people associate water savings with municipal water use –encouraging domestic users to practice water conservation and cities to plug leaking supply systems. While these efforts have localised benefits, it is important to realise that cities actually consume very little of the worlds water. Even in developed countries where most households have easy access to municipal water supplies, a person uses less than 150 litres of water per day. Compare this to the 2000 to 5000 litres of water required to produce enough food to feed one person one day and you begin to understand why finding ways of getting more crop per drop is vital to the world future.

Recommendations for policy makers

- Before investing in expanding irrigated area, look at options for improving productivity.
- Take a basin perspective on water savings and understand how changes in water management or allocation in one area affects users in another
- Integrate management of "blue" water
  - from rivers and reservoirs with "green" water
  - rainfall stored in the soil profile or in aquifers.
- Invest in efforts to provide reliable irrigation to farmers in existing schemes.
- Create policies and incentives to support the uptake of technologies and practices that will improve water productivity and reduce degradation of agro-ecosystems.
- Ensure that the poor benefit from investments in improving water productivity by ensuring access to water for income generation, promoting and developing affordable water productivity enhancing technologies, and giving the poor a voice in water decisions.

Low cost technologies are helping small farmers in Africa and Asia increase their yields, improve house hold incomes and make the most productive use of scarce water.

Increases in water productivity are necessary to solve many of the problems of the water crisis, but they are not sufficient. It is imperative that these be accompanied by poverty focus to help the poor to reap the gains of increase in water productivity.

Attention needs to be given to establishing and maintaining access to water for domestic uses and income generation, affordable water productivity enhancing technologies and giving the poor a voice in water decisions.

5."Sustainable Livelihoods Approaches: Engaging with SL or just best development practice?' Catherine Allen and Omar Sattaur, Bradford Workshop, 29-30 May 2002

Abstract

Over the last few years, there has been increasing enthusiasm for using and developing Sustainable Livelihoods approaches (SLAs) amongst development agencies, such as OXFAM, CARE International, UNDP and DFID. These approaches are being used in a variety of project and programme contexts, and must be bought into and understood by a variety of people working at many levels. DFID has invested considerable resources into promoting SLAs, designing and implementing projects that are based on these approaches.

There are now many case studies that demonstrate the value of adopting SLAs. As part of an ongoing process of promoting SLAs, and of sharing the learning resulting from their practice, DFID commissioned CIDT to organise a series of seminars in the UK between October 2001 and March 2002 which attracted participants of varying development backgrounds and expertise. These seminars were planned around development themes and focussed on the potential value of SL approaches to these different areas of development practice, such as governance, rural poverty, private sector and enterprise development, urban poverty and so on. The seminars featured relevant case studies so as to provide the context for participants to explore the relevance of SL approaches to their work.

During the course of the seminar series, participants identified constraints and concerns regarding the operationalisation of SLAs that cut across all sectors. Many of these issues have recurred in previous discussions on the utility of SLAs. They included

- Flexibility in programme and project cycle management
- Managing expectations
- Holistic working in a sectoral environment
- Language
- Monitoring and evaluation
- Capacity
- Practicality

This paper lists the benefits of taking SLAs and the constraints as identified by participants. It summarises discussions that took place during the seminars and makes some suggestions for steps that could be taken to mitigate the impact of the obstacles identified.

One clear conclusion from the seminars was the need to consolidate the lessons from current experience and concentrate on making the approach more accessible, practical and effective.

6. Adopting a sustainable livelihoods Approach to Water Projects: Implications for policies and practice, Working paper 133: Alan Nicol, Overseas Development Institute, April 2000

Abstract

This paper has three elements. The first identifies the pre-eminence of a health-based view within the water and sanitation sector. This view emphasises the health impacts of improving access to supplies of clean drinking water and better sanitation. It then assesses the relevance of this view to wider debates on how to achieve supply sustainability by adopting demand-responsive approaches (DRA) and by shifting the emphasis to the principle of 'consumer pays'. The paper argues that an overemphasis on health impacts does not fit well with DRA, which is being increasingly advocated by agencies at an international level. Thus, in order to encourage demand for water services in particular, and to ensure that communities can be engaged in self-financing their development, greater attention has to be paid to the role of water within wider household livelihood strategies – and livelihood impacts should become a major focus of interventions.

The paper also analyses water in the context of poor households. In doing so it uses the Sustainable Livelihoods (SL) framework as an analytical tool. Combining this theoretical analysis and the experience of water projects by the author, the elements of a SL approach are identified. Adding greater emphasis to these elements will help in the wider uptake of DRA, providing the means by which to ensure supply sustainability. The end result is anticipated to be greater water security for the poor.

Finally, this paper assesses the operational and theoretical implications of adopting a SL approach in terms of the following:

Water should be treated as an asset and a good: Understanding water at a household level means addressing the productive uses of water as an asset as well as its uses as an economic and social consumption good at this level.

Institutional linkages: Institutional development should be more closely linked to developing social capital to benefit the poorest members of communities and to assist in their access to and communication with 'institutions' responsible for supply development, be they from civil society, government or the private sector.

Sequencing and time: Understanding the significance of sequencing interventions to achieve desirable livelihood outcomes is important, as is the time taken to access supplies. A closer examination of this factor in all situations (e.g. by season, or according to urban or rural users) can assist in fine-tuning implementation to achieve maximum livelihood sustainability for the poorest in their specific contexts.

Knowledge environments: Understanding the role knowledge plays in poor households' decision-making over water access is crucial to understanding their wider decision-making. Acquiring and disseminating knowledge as part of project development is essential to building up a long-term picture of how livelihoods are enhanced by using a SL lens within the water sector.

7. Secure Water: Building Sustainable livelihoods for the poor into Demand Responsive Approaches, Concept Paper, DFID, Draft-Dec 2001

Abstract

The paper outlines the underlying concepts and basic aims and objectives of a major new research programme on the theme of "Secure Water", supported by the UK Department for International Development (DFID). The paper draws upon a growing body of literature on water-livelihoods linkages, as well as the initial workshop discussions and scoping studies subsequently conducted in each of the five case study countries.

The concept of water security was formally established in the Global Water Partnership *Framework for Action document* produced for the 2nd World Water forum in the Hague. "Water security, at any level from the household to the global, means that every person has access to enough safe water at an affordable cost to lead a clean, health and productive life "(GWP 2000). However, important questions surround the achievement of Water Security, the characteristics of a sustainable and safe water supply and the definition of affordable cost. This research project has tried to examine these issues in detail within the context of water-livelihood linkages and how the existing approaches to water supply development can be enhanced.

For many years the water sector had been dominated by the perspective of improving health impacts via improved access to water supplies, but more recently the wider objective of poverty reduction has become central. There has been a conceptual shift towards achieving sustainable water supplies through promoting demand-led, as opposed to supply led, development based upon the principle of water as an economic good. Demand Responsive approaches (DRA), spearheaded by the World Bank, which emphasise the sustainability of delivery systems, cost recovery and financing at lower levels are now advocated by a number of international agencies. The present research is guided by a central question "How does DRA as a major shift in the water sector, address poverty issues?" It is argued that in order to balance sustainability and poverty reduction objectives, demand-responsive interventions require a more comprehensive analysis of the economic and social factors underlying supply sustainability.

Emerging Sustainable Livelihood's (SL) based approaches to water issues help to highlight the complex role and importance of water in relation to the livelihood assets and strategies of the poor and the multiple aspects of the sustainable water supply systems. The recent shift of financing responsibility to lower levels is paralleled in ideas about governance, decentralisation, and devolution of responsibility for natural resource management, but a question arises about who wins and who loses. Improved understanding of micro-level issues affecting water availability, access and use is essential in order to devise management and financing arrangements which do not further disadvantage the poorest groups. It is argued here that there is reasonable scope for redefining 'demand' to make it more sensitive to poor people's reality and that further development of SL- based approaches to water, specifically through the use of household Economy approaches (HEA) could usefully inform and enhance DRA thereby improving poverty impacts and supply sustainability. A major focus of this research is to better understand how livelihood outcomes are affected by changes in the nature of water supply at the household level.

There are inevitable trade-offs in access to water which apply at local, national, and international levels. Improved understanding of these trade-offs can inform policy processes. It is however equally important to understand how policy processes in turn influence water uses and livelihood outcomes.

Various World Bank studies show that employing a demand–responsive approach at the community level increases water system sustainability, but also brings significant challenges relating to financing arrangements and institutional capacity (World Bank 2001)

UK -DFID's recent Strategy paper on Water responding to demand as a key lesson from recent experience cites an example where poor people may not always be able to express their demands , so project staff need skills in social mediation and communication. (DFID, 2000)

The key principles of DRA can be summarised as follows:

- Informed choices by communities through participatory planning and community involvement in implementation to ensure ownership.
- Complete community management responsibility for operation and maintenance (O&M)
- Cost Recovery–capital cost sharing (expression of demand and 'ownership') and 100% O&M
- Promoting more options for service delivery
- Integrating water supply with sanitation, environmental management and hygiene education.
- Targeting the poor
- Supporting integrated water resource management
- (WSP, East Africa)

One of the major challenges that DRA raises is balancing financial sustainability and poverty reduction objectives. DRA is intrinsically linked to finance with an implicit assumption that 'demand' as expressed by poor communities can be equated to 'willingness to pay' for a particular kind of service. However, expressions of willingness to pay are often crude, contingent on external factors, and constrained by many cases by absolute limits on capacity to pay. There is a considerable scope for redefining 'demand' to make it more sensitive to poor people's reality and to reflect the true productive value of water in sustaining livelihoods.

The guiding principles of SL specify that activity should be:

- **People centred**: beginning with people's own views of their priorities, opportunities and needs, the approach then works out responses to these that are technically and financially feasible. In this way, it seeks to be responsive and participatory.
- **Differentiated** : it recognises that the characteristic of poverty, and appropriate policy responses differ among different groups of the poor
- **Multi-level:** it recognises that poverty cannot be addressed by local action alone; approaches are needed which link the local level perspectives obtained by SL into higher level processes of designing and implementing policies which impinge on the poor.

- **Conducted in partnership**: between people and private sectors: both NGO'S and private commercial agencies have roles to play which compliment those of the government.
- **Sustainable** in several dimensions : economic, institutional, social and environmental, but this does not imply set patterns of livelihoods which must be sustained indefinitely ; on the contrary livelihoods are recognised as
- **Dynamic,** in the sense that the poor manage complex 'portfolios' of a number of (usually) part time activities, changing the balance among them with changes in the opportunities and constraints they face.
  (After Krantz, 2001)

The authors summarise the overall SL analysis by portraying it as a useful, logical and consistent way of thinking through complex issues influencing the livelihoods of the poor and suggests multiple entry points for water supply interventions (e.g. access to resources, transfer of technology, institution building, etc.).

8. *Water Scarcity and Poverty, Randolph Barker, Barbara van Koppen and Tushar Shah, 2000*

Abstract

In this paper the implications for poverty alleviation of growing water scarcity with particular reference to South Asia and sub-Saharan Africa are discussed. First, the authors briefly summarize the impact of irrigation development on poverty alleviation in South Asia in the recent past. Emphasis is placed on the role that advances in irrigation technologies and private development of groundwater resources have played in providing the poor with access to water. Further, the authors examine the challenges that lie ahead for the development of water resources leading to sustained poverty alleviation.

One of the most recent examples of success in poverty alleviation has been in Eastern India and Bangladesh where the spread of low cost tube well irrigation has stimulated growth in agricultural production and contributed to the reduction of the number of people below the poverty line. The growing scarcity and competition for water, however stands as a major threat to future advances in poverty alleviation. An increasing number of the rural poor are coming to see entitlement and access to water for food production and domestic purposes as more critical than access to health care and education.

In the arid and semi-arid region, the over exploitation of groundwater poses a threat to environment, health and food security, a threat to the welfare of the poor far more serious than that posed by the widely criticized construction of large dams. Two contradictory aspects are discussed: first, the rapid drawdown of fresh water aquifers mainly due to the explosion in the use of wells and pumps for irrigation, domestic and industrial water supplies. Second, the problem of rising water tables of saline and sodic water. Added to these two problems is the pollution of aquifers by toxic elements. The poor often pay the price not only through loss of crop production but also through the shortage of water for range of uses and increased health problems.

While the problems of groundwater are clear, the solutions are not. The authors state that the pricing and regulation for pumping common pool resources are not feasible. Even if technical and management capacities are available, which country would be willing to pay the enormous cost of this policy? The best way to recharge aquifers needs more analysis. Much of the seepage surface runoff from canals recharges groundwater aquifers. Seen in this light, Chambers (1988) suggests that a major and perhaps the main beneficial effect of new canal irrigation is to distribute water through the command allowing it to seep and provide water for lift irrigation.

While there are technical solutions for reducing salinity, the financial costs of various options and the appropriate procedures for implementing management strategies at farm and system levels are not well understood.

9. Coping with Water Scarcity (pp 272); Luis S. Pereira, Ian Cordery and Iacovos Iacovides, (pp 272), International Hydrological Programme (IHP-VI No 58) UNESCO, Paris, 2002

Abstract

This book's main chapter headings are:

1. Introduction; 2. Water scarcity concepts; 3. Physical characteristics and processes leading to water scarcity; 4. Conceptual thinking in coping with water scarcity; 5. Surface water use and harvesting; 6. Groundwater use and recharge; 7. Using non-conventional resources; 8. Water conservation and water saving practices and management; 9. Social, economic, cultural, legal and institutional constraints and issues; and 10. Education.

The concept of sustainable development is discussed in Chapter 2. It is also suggested that water should be considered not only as a natural renewable resource but also as a social, environmental and economic "good". Since scarcity favours assigning a high value to a good, valuing the water only as an economic, marketable good may provide only limited assistance in promoting sustainability. This is because water acts not only as the basis for production, but also supports other natural resources and plays a major role in cultural and social contexts, particularly when scarcity gives it a special value. A continued environmental, economic and social approach is therefore required in valuing water in water scarce environments.

Chapter 4 discusses concepts relating to coping with water scarcity including the social value of water, differences between rural and urban needs, the time taken to collect water, the supply by tankers and the importance of catering for drought periods. Most communities have adapted their water collection and use practices to their environmental situation over many years. However, recent and simple inexpensive technologies mean there are opportunities for improvement. Water availability could be increased and the cost to communities of their water supply could be reduced. Flexible but realistic thinking and willingness to consider new ideas are required.

The authors advocate higher charges for water. "It is probably unfortunate that in many countries the political view has prevailed that the population should not be charged for water". Water pricing is discussed. "… it is often suggested that real pricing of water cannot be implemented because the poor could not afford to pay. This is nonsense. The poor pay for electricity." The authors, however, recognise the problems of pricing mechanisms and the impact of tariff structures on agriculture and food prices. Strategies must be developed which are compatible with local political and cultural realities. One particular coping strategy may appear obvious to one cultural group but totally unacceptable to another.

The questions of subsidies and unrealistically low charges for irrigation water are discussed and the need in some areas the need to discourage irrigation which may not be the optimal use for the available water despite the desire of potential users to irrigate their land.

Chapter 6 covers aspects related to groundwater use and recharge. The main requirements for effective groundwater use under conditions of water scarcity are said to include: full assessment of the resource; development of proper operational and water allocation plans; consideration of groundwater quality and quantity, its protection and

enforcement of legal and institutional measures; integrated water resources management towards securing the sustainability of the source.

The authors discuss the problems of polluted and poor quality sources and the use of brackish, saline and drainage waters and in particular the use of saline water for irrigated crops and the impact on crop yields.

In Chapter 7, desalination processes and costs are discussed. The capital cost of MSF and MED distillation units tends to be in the range of US$1000-2000/$m^3$/d of installed capacity, exclusive of steam supply and site preparation. In general, production costs tend to be in the range US$1-4/$m^3$ of water produced depending on the size of the plant. The 1995 capital costs of electrodialysis units was in the range US$250-750$m^3$/d exclusive of site preparation and ancillary works with production costs in the range US$0.25 to US$1/m^3 depending on size.

RO plants recently built in Cyprus (120,000 m^3/d) are now in operation under the BOOT principle. Desalinated water is presently sold to Government at US$0.85/$m^3$ for the plant commissioned in 1997 and US$ 0.68/m^3 for the plant commissioned in 2001. Disposal of brine needs careful consideration and monitoring.

In Chapter 8 the authors list a large number of water conservation and water saving measures and practices which provides a useful checklist of demand management and supporting measures. The authors discuss the advantages and disadvantages of dual distribution networks for high quality and for treated re-usable water, legislation and regulations, incentives and penalties and crop management.

Detailed attention is given in Chapter 8 to water demand management by: improving surface irrigation systems; improving sprinkler irrigation systems; micro-irrigation systems; irrigation scheduling; reduced demand irrigation scheduling; and deficit irrigation. The Chapter provides a useful background when considering possible water saving measures in the agricultural sector.

The book concludes with chapters on social, economic, cultural, legal and institutional constraints and issues, and with the need for public awareness and education on water scarcity.

10. Privatising Water Supply, Darryl D'Monte , Times of India (April 24, 2000)

Abstract

The best things in life are no longer free, as marketers target the atmosphere and now, water. A major policy change propounded at the recent World Water Forum, the biggest-ever international gathering on this resource, at The Hague was apparent in the very title of the main document: "Making Water Everybody's Business". While this last word may appear innocuous, the implication is quite clear: governments have failed to deliver water and the job should be handed over to the private sector.

Full cost pricing

The World Bank plays a dominant role in such deliberations and a vice president, Dr Ismail Serageldin, has spelled out the new policy objectives. Governments have now vowed that to achieve water security, countries should switch to full-cost pricing for water. This is most controversial because till water began to become scarce in the 1990s, it was looked upon as a free good. It was a renewable resource, freely available to those on whose land it falls. Because of its scarcity, reformers now say, water has to be treated as an economic good. Consumers ought to bear the cost of obtaining the water as well as foot the bill for collecting, treating and disposing of wastewater. Agriculture accounts for by far the greatest consumption of water, particularly in developing countries, followed by industry and next, urbanisation. At the same time, reformers recognise the need for equity and meeting the basic requirements of the poor.

Another justification cited is that governments have been subsidising water on the grounds that the poor cannot afford it. However, according to Dr Serageldin, the poor in developing countries pay, on average, 12 times more per litre than fellow citizens connected to municipal systems. In Port-au- Prince, Haiti, it is 100 times more and 83 times in Karachi. The World Bank believes that if consumers bear the cost of water, it will be more equitably distributed. It notes how around the world, consumers pay widely divergent prices for water. In the North, it can vary from as much as $2.16 per cubic metre in Germany to five times less in Canada. In the South, according to a 1996 survey, municipal water is priced well within a dollar, but also fluctuates. In India, it ranged from one US cent to 82 cents.

Thirdly, the major user of water irrigation has been subsidised to keep down the prices of food for poor families, particularly in cities. Currently, governments do not even recover operation and maintenance costs and the reformers predict that in the future, they will begin handing over responsibility for these functions to cooperatives or private owners. There is also the indirect subsidy in the form of energy to pump groundwater. Because electricity is free or not metered properly in countries like India, farmers who can afford pumps over-exploit and waste this resource.

In India, the direct subsidy is estimated at $800 million and the indirect $4 billion each year. Some four million hectares of productive land in this country have been abandoned due to waterlogging and salinity. While there is no denying that the well-to-do have benefited the most from state-run water services, the solutions proposed by these reformers hardly seem the answer. In the very same breath, they stress that full cost recovery has to go hand in hand with protecting the needs of the poor. This is to be achieved by targeted, transparent subsidies, but it is difficult to see how this can be achieved in practice.

Innovative Moves

The World Bank mentions innovative approaches like the Grameen Bank in Bangladesh which makes non-subsidised credit available for poor rural women to build their own tubewells; there is almost full recovery of these loans. Similarly, in the well-organised Orangi slum settlement in Karachi, dwellers pay three-quarters of the cost of sewerage. In Chile, the government has made water utilities financially viable and cross-subsidised "water stamps", food stamps elsewhere, for the poor. Most of these success stories, however, presuppose a social movement that generates public participation, which is not easy to replicate, particularly in rural areas.

The exemplary work of organisations like the Tarun Bharat Sangh in Alwar, Rajasthan, where villagers have built their own storage tanks, leading to the recharge of a dead river, and of individuals like Annasaheb Hazare in Ralegaon Siddhi in Maharashtra, has been widely lauded. But these all revolve around a painstaking process of mobilising people and this "technology" cannot be transferred elsewhere. The danger, therefore, in criticising state-run water schemes is that it may act as a cover for privatising them. This indeed was the agenda at The Hague, where reformers called for more than doubling global water investment from around $80 billion a year to $180 billion in 2025, with almost the entire increase from the private sector.

Public Control

Such a plea for privatisation of this most basic resource overlooks the awkward issues of over-consumption, waste, pollution, dam construction, corruption and inequality. Each North American uses some 400 litres a day in his home, while a European makes do with only half as much. In sub-Saharan Africa, a person has less than 20 litres a day. Will a full-cost recovery system in the North bill a person for sewerage charges or industries for the total cost of treating their effluent?

It may make more sense to charge individual and institutional users a much higher rate when they consume excessive water, which will protect the needy. The parallels with removing subsidies in the food ration and health services, which the Bank has also been recommending, are too strong to be ignored. Countries which have done so are paying for it dearly. Food, water and health are surely human needs which have to be recognized as basic rights that all governments need to fulfil.

Instead of minimizing the role of the state in providing water, the better alternative would be to subject its functioning to public scrutiny, so that inefficiencies and wastage are drastically reduced. All public enterprises are not necessarily bad, any more than private suppliers are over-eager to serve the public good. Communities should organise themselves to ensure that they receive adequate supplies of clean water and have much more say in the design and operation of these public systems. Exactly the opposite process is underway with big dams such as the Sardar Sarovar on the Narmada which was originally justified under the illusion that it will supply water to the drought-prone regions of Saurashtra and Kutch. If "privatisation" is to take place, it should begin by recognising the right of communities to exercise much greater control over this life-giving resource.

11. Public Private Partnerships and the Poor, Interim Findings –Part B, Case Studies, M. Sohail & S. Cavill, Water Engineering and Development Centre (WEDC), 2001

Abstract

The book essentially deals with the challenges and opportunities faced by Public-Private partnerships in their efforts to improve the quality and quantity of the services available to the poor and suggests lessons from the case studies that will be useful when thinking about the poor in the planning and implementing of future projects that use PPP.

Section 1 sets the purpose of the study which is to determine workable processes whereby the needs of the poor are promoted in strategies which encourage PPP's in the provision of water and sanitation services. Section 2 gives a background on PPP. It is used as a general term covering a wide range of partnerships between utilities, govt's and communities in order to improve or maintain existing infrastructure and to extend services.

Section 3 gives a checklist of questions on various elements like contractual and institutional process, transparency and responsiveness, Information exchange, Regulatory framework, Monitoring, Changes in technology, Financial (changes to tariffs), Risk and liability and perceptions of poor with the services under PPP.

Section 4 aims to analyse the contextual factors explicit in the success and failure of strategies to promote the needs of the poor within PPP's. Lack of legal land tenure is the main hurdle to extending services to the poor. Non-payment of water bills is dealt in a variety of ways in the case studies.

There is a potential for small–scale initiatives rather than large scale projects. Smaller operators can make contracts with consumers and entrepreneurs; compete for clients – meaning an efficient, competitive and replicable service. Small scale operators can often target the poor and unserved customers. Ideally the poor would have the most to gain from, yet they also have the most to lose. The lack of explicit recognition or planning for the poor results in a multiplicity of unplanned risks to the poor. The impact on the poor, as a result of the risks of the PPP's includes; non-payment of bills, a higher percentage of income spent on municipal services, disconnection and high reconnection fees and the potential loss of assets through non-payment of bills. Less money for other needs and reduced water consumption. On the other hand there is also a gap in planner's assumption of what the poor are willing to pay and what they themselves will pay.

Section 5 reviews the case studies, summarises the potential factors promoting and hindering success in PPP's.

Section 6 poses questions before embarking on PPP.
The Appendix describes the various case studies where PPP was used.

12. India's water crisis: avenues for policy and institutional reform. Vishal Narain, Tata Energy Research Institute, Monitor on Environmental Science, Vol 2, No 1 June 1997, TERI

Abstract

This article reviews some emerging issues and challenges in the context of the management of water resources in India. India's impending water crisis is identified in the context of policy and the institutional framework.

Point 1: Agriculture contributes roughly 29% of India's Gross Domestic Product (GDP); a large portion of the country's GDP could actually be seen to depend on groundwater. Furthermore, groundwater now supplies 80% of the domestic water supply in rural areas and perhaps 50% of urban and industrial areas.

Point 2: Inefficacy of policy and an appropriate institutional framework have created a number of sustainability, equity and efficiency concerns. India's groundwater economy actually comprises of more than 12 million groundwater structures spread through the length and breadth of the country and these have developed sporadically rather than through a planned and concerted effort. The only State water intervention has been the state tube well programs.

Point 3: Efforts have been made however to regulate groundwater withdrawals by licensing, through credit or electricity restrictions for construction of more wells or by introducing well spacing regulations. None of these measures have had a significant impact. In general, there has been a tendency for the rich and influential farmers to negotiate and obtain licenses issued by State groundwater departments for electricity connections.

Point 4: Looking at the legal framework for management of groundwater in India, there are no *de jure* rights in groundwater but *de facto*, all landowners have the right to groundwater underlying their land. There is no limit to how much water a landowner may withdraw.

Point 5: Post colonial efforts at legislation have been made through the Model Ground Water bills of 1970 and 1992. The central focus of these bills has been the creation of a groundwater authority which gives clearances for the installation of water extraction structures. However, it only seeks to regulate the creation of structures rather than the quantum of water withdrawn.

Point 6: It has been thought by some academics/policy makers that the only solution to groundwater depletion problems is the constitution of a well defined property rights structure that specifies absolute individual and collective limits to groundwater withdrawals. It was also argued that establishment of tradable property rights in water could be an effective means of augmenting urban water supply in the country.

Point 7: A significant development in the sphere of groundwater management has been ground water markets. They play a crucial economy in India's economy for three critical reasons: i) They enable marginal and small farmers to enjoy the benefits of groundwater pumping and thereby help enhance their incomes. ii) Groundwater markets help their owners to improve the economic viability of their pumping and thereby enhance their income. iii) These markets help the society by minimizing investments in groundwater pumping.

Point 8: Erratic power supply hits the interests and incomes of the poor since it is only after meeting their own needs that the sellers would divert their water to potential buyers. Unreliability of power, moreover, makes farmers pump water whenever it is available regardless of whether their crop needs it.

13. An assessment of regional hydro geological framework of the Mesozoic aquifer system of Jordan, PhD thesis of Dr Kamal Moh'd Khdier December 1997

Abstract

The study presents estimates of the direction and magnitude of flow from recharge to discharge areas and discusses where the results agree and disagree with the hypothesis and hydrological estimates reported by other investigators.

The groundwater flow systems of the carbonate aquifer systems of the Western Highlands and Central Plateau of Jordan are complex. They reflect the changes in climate and geology of the study area. These aquifer systems are developed in a thick sequence of Upper Cretaceous –Cainozoic carbonate rocks that dip gently east and north eastward. The sequence exhibits vertical and lateral variation in Lithology; there is a general lateral transition from marine deposits (mainly carbonates) in the north and west to continental deposits (sand facies) in the south and southeast. Since deposition, however, compression, extension intrusive and volcanic episodes, and erosion have greatly modified the distribution and thickness of the carbonate rocks.

Based on regional contrasts in hydraulic conductivity, the regional carbonate aquifer system is divided into three aquifers separated vertically by three intervening confining units. The aquifers from top to bottom are: the Rijam Aquifer system (B4), the Amman-Wadi Sir aquifer system (B2/A7), and the Hummar aquifer system (A4). The B2/A7 is the most extensive and continuous aquifer system in Jordan. It is the main source of water in the country. The regional carbonate aquifer systems are underlain by a thick Precambrian – Lower Cretaceous, mostly arenaceous, sequence which comprises the deep sandstone aquifer system.

The hydraulic parameters of the aquifer systems were inferred from aquifer tests, groundwater flow modelling, and the inherent relation between the stratigraphy and hydraulic parameters. The areal distribution of hydraulic parameters generally reflects the characteristics of the sedimentary sequence; in the northern parts of the study area, where the carbonate rocks dominate and the effect of tectonics and the degree of karstification are high, a wide range and erratic distribution of hydraulic parameters are expected. In the southeast, the hydraulic parameters are more uniform due to the increase in sand content in the sedimentary sequence. Furthermore, the increase in sand content in the Lower Ajlun Group (A1-6) results in the units becoming aquifers which are then in hydraulic continuity with the overlying B2/A7 aquifer system. However, even in the northern and western parts of the study area, the hydraulic conductivity of the A1-6 Group is interpreted to be higher than thought before, and the Group should hence be considered an acquitard which transmits water downwards into the deep sandstone aquifer system. Vertical hydraulic conductivity of the confining units is the most important factor affecting the regional groundwater flow system.

The flow within the regional aquifer system, in general, is controlled by the altitude of major recharge areas, major discharge areas, and major structural features. Thus topography provides the major control for the regional aquifer system.

Recharge occurs by direct infiltration of rainfall in outcrop areas, indirect recharge through the transmission losses of flood flow via wadi beds, vertical leakage through underlying and overlying strata, water transfer from adjacent aquifer systems, or by lateral boundary flow from outside the study area. The areal distribution of recharge to the regional groundwater flow regime of the carbonate aquifer system was calculated for the water

budget from what is known about precipitation, total runoff, and evapotranspiration, and analysed by groundwater flow model simulation.

Most of the recharge enters the aquifer in the structurally high outcrop areas (recharge mound). Much of the groundwater from the carbonate aquifer system is discharged to the land surface by numerous springs. The locations of these springs are controlled by permeability variations in the rocks and water levels related to land-surface altitude which cause the water to discharge at the surface. The springs have been classified as local, intermediate, and regional on the basis of the surface catchment area of the spring.

Groundwater levels in the B2/A7 aquifer system mostly vary in response to short-term fluctuations in recharge and long-term variations in discharge. Most of the fluctuation in recharge results from cyclic patterns in precipitation, and most of the variation in discharge results from pumpage trends. Water levels have declined where and when changes in the rates of recharge and natural discharge have not compensated for increasing rates of groundwater abstraction.

Groundwater flow in the study area was conceptualised as relatively shallow, intermediate, and regional flows primarily through the carbonate sediments of the Western Highlands and the Central Plateau superimposed over deeper flow through primarily sandstone sediments. Three-dimensional groundwater flow models were used to simulate the concept of groundwater flow in the area. The area was subdivided into five sub regions that approximately cover, individually, Upper Zerqa, Wadi Wala, Wadi Mujib, Wadi Hasa, and Jafr basins. Each sub region was modelled separately and then compiled in one regional model. Six model layers were used to simulate relatively shallow and deep flow. The upper five layers were used to simulate the flow in the carbonate aquifer systems. The lowest model layer was used to simulate the concept of deep flow in the sandstone aquifer system.

The results of the model calibration and sensitivity analysis show that the calibrated values of the model input are, for the most part, consistent and within the range of reasonable possibilities.

Definition of the flow system was accomplished through examination of the following results derived from the calibrated model: (1) regional water budget, (2) potentiometric surfaces, (3) vertical leakage between aquifers, and 4) lateral flow directions in the aquifers. The model simulations show that after development the system approaches a new state of equilibrium, in which the amount of abstractions was balanced by an increase in total recharge, a decrease in discharge to river valleys, a decrease in storage, and a decrease in downward leakage and water flowing out of the system outside the study area.

14. The study on Water Resources Management in the Hashemite Kingdom of Jordan, Final Report Volume X - Summary, Yachiyo Engg, Co.ltd Dec-2001,

Abstract

Owing to the chronic imbalance in population and water demands in Jordan, the Ministry of Water & Irrigation (MWI) made a request to Japan International Cooperation Agency (JICA) in Sept 1997 to carry out a study on Water Resources Management in the Hashemite Kingdom of Jordan. The scope of work for the study was agreed in October 1999. The study objectives were:

- To formulate a Water Resources Management Plan in Jordan using the tools that have been developed by the GTZ funded Water Sector Planning Support Project.
- To conduct Pre-feasibility study of priority project based on the findings and results of Master Plan. .
- To transfer technologies to counterpart personnel in the course of the study.

According to the Water Stress Index (which indicates the degree of water shortage), Jordan is classified in the category of "Absolute Scarcity". Annual rainfall fluctuates year by year with 85% of the total rainfall being lost in evaporation. The recent drought conditions have further laid stress on the availability of surface water. Thus, there is a major dependence on groundwater resources out of which 14% is from the non-renewable groundwater resource. Due to over abstraction of groundwater, the regional groundwater level has declined considerably coupled with deterioration in the water quality.

The Water Resources Management Master Plan covers the period to 2020, and aims at "Unified, Comprehensive and Sustainable Management of the Water Resources" and "Strategic development of the remaining scarce water resources" while keeping in mind the future goal of "Shift to water recycling society". Concepts like "Global Climate change" (specific to the arid region) and "cooperation for regional peace water development "have been incorporated in the formulation of the Master Plan for twelve governorates. Furthermore, the system and database of the "Digital Master Plan" which was prepared in MWI with the technical cooperation of GTZ, was utilized for the formulation of the Master Plan. The study covered Jordan as a whole and 12 Governorates in Jordan. The planning horizons were: Short term (2000 to 2005); Mid Term (2006 to 2010; Long term (2011 to 2020).

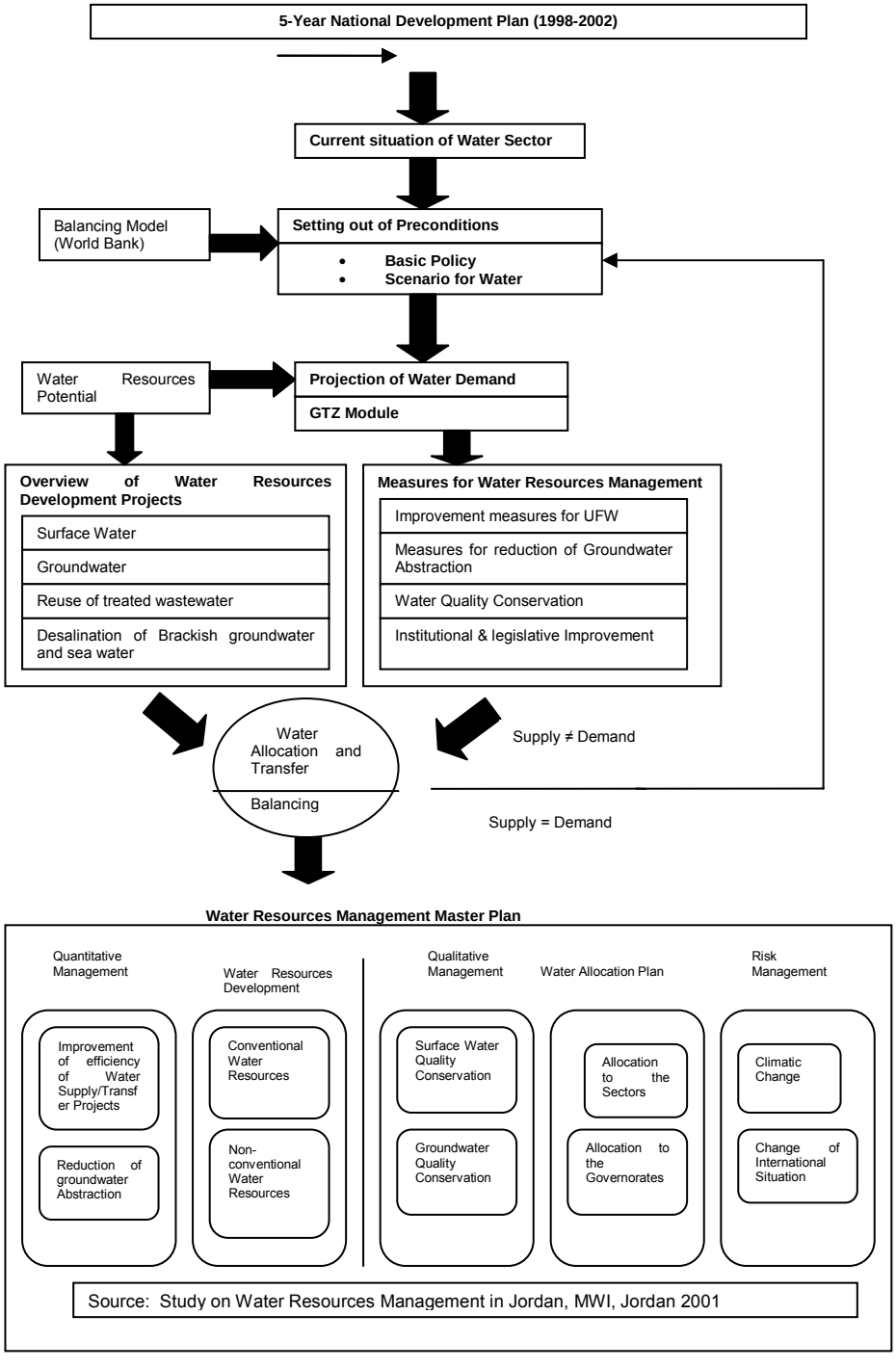
The water resources study included desalinated brackish groundwater, desalinated sea water and treated wastewater, in addition to the conventional surface water, ground water, peace water, renewable groundwater and fossil fresh groundwater.

The JICA team started the study in February 2000 and conducted the Phase-I Investigation which aimed to formulate the Water Resources Management Master Plan. The Phase-2 Investigation carried out pre-feasibility studies on priority projects selected in the Master Plan. The general flow diagram showing various stages of study is attached.

For the formulation of the Water Resources Management Master Plan, both Conventional and Non-Conventional water resources were evaluated. In addition, the Qualitative and Quantitative, Institutional and Legislative Management under the umbrella of "Jordan's Water Strategy" and "Water Policies" were examined as well. Within the restricted water supply, the Municipal/Industrial/Touristic (MIT) demand and agricultural demand were balanced as far as possible, by taking account of the study results of USAID and GTZ projects. After the global balancing of water demand and supply for the whole of Jordan, the water resources development and water resources management plans including inter-

Governorate water allocation and water conveyance plans were formulated for twelve Governorates. The priority projects selected for Phase 2 are as follows:

- Treated Wastewater Reuse scheme of five existing treatment Plants Ma'an (including expansion of treatment plant), Abu Nuseir, Fuhis , Tafielah and Wadi Essir.
- Construction of Wadi Zarqa Treatment Plant
- National Water Supply Control System Integrating Surface and Groundwater
- Municipal Water Distribution Networks Rehabilitation Karak, Tafielah, Ma'an, Madaba and South Amman.
- Al Wehda Dam Water Supply Project/Irbid



15. Earth's Reserves of Groundwater Threatened (Second World Water forum), March 17-22, 2000, Hague

Abstract

More than 1.5 billion people worldwide depend on groundwater for drinking water, and many others rely on agricultural products grown with ground water. The most endangered aquifers are found in the United States, Mexico, India, China and Pakistan, as well as in parts of Europe, Africa and the Middle East.

One answer to the problems of groundwater over-exploitation is aquifer recharge**.** India has undertaken some of the most innovative methods to revive its aquifers. These methods fuse age-old traditions with new technologies, and include:

In western regions of India hit hardest by groundwater depletion, local organizations supported by NGOs have created a massive well-recharge movement based on the principle: "water on your roof, stays on your roof; water on your field, stays on your field; and water on your village, stays in your village." Some 300,000 wells have been modified to divert rain water into them; and thousands of ponds, small dams and other rain water harvesting and recharge structures have been constructed by people on the self-help principle to keep the rain water from flowing into the Arabian Sea.

In South India, a strategy has been recommended to transform the region's more than 200,000 irrigation tanks into recharge tanks by filling them up with canal water. The work of NGOs like Tarun Bharat Sangh and Pradan, with the rehabilitation of centuries old tanks (known locally as johads or paals) have had a dramatic impact on groundwater recharge and on the revival of dried-up springs and rivulets in a 6500 square kilometer area.

The family cistern is finding its use again. In the city of Rajkot in the water-short Saurashtra region of western India, 1500 new houses and apartments built during 1997 incorporated design-changes for rain water harvesting and storage found in old houses in the region but forgotten in recent decades.

Other countries are also reviving these old methods, including more technologically advanced countries:

- Some exciting work on bringing back traditional rainwater harvesting technologies is being done by individuals and small groups in the United States. Several variations involve capturing and storing rainwater in a tank and using the water with or without treatment. The University of Texas built a system of three cascading ponds to support aquatic life for its biology laboratory, fed by harvested rainwater.

- The user association that manages the Hermosillo aquifer in Mexico has managed the extraordinary feat of getting 50 percent reductions in pumping of groundwater, so that withdrawals of water now equal aquifer recharge. A 1992 water law established individual property rights in water and made these rights transferable. Water users, mainly farmers, voluntarily cut their rights for water withdrawals in half. Whoever needed additional water had to buy it. Thereafter. These measures convinced many farmers to switch from high water use crops such as maize and beans to low water use but high value crops such as table grapes and squash.

- In the Azraq oasis of central Jordan, excessive pumping of groundwater has destroyed a key wetland. A project supported by international organizations pumped groundwater imported from a nearby area into the epicenter of the oasis's lakes. The project was able to restore the wetland to much of its original diversity. Birds and animals have come back; and Azraq's tourism economy has come back

to life. However, it is seen as a temporary solution until newly introduced regulatory reforms can control widespread groundwater depletion.

- In South Africa, a non-native weed has supplanted a native one, becoming a major threat to groundwater. Some 25 million acres (10 million hectares) of land in South Africa became infested by an alien weed that uses almost 7 percent more of the country's total run-off than the indigenous plants it replaced. A special long term program by the South African Government's Department of Water Affairs and Forestry, called 'Working for Water,' employs 42,000 people at peak times every year to remove these weeds, but it will take 20 years or more to complete the job.

- A small but growing worldwide movement is underway to promote the cultivation of vetiver grass hedgerows as a powerful way of reducing the velocity of rainwater run-off and recharging groundwater. The vetiver network is supported by the World Bank, the Danish government and several global NGOs. Rainwater run-off is reduced by 70% percent when vetiver hedgerows are planted across the slope, by slowing down and spreading out the runoff over larger areas. The strong roots of this grass can also penetrate hard earth and improve infiltration.

- One major problem is transboundary aquifers, which run beneath the borders of two or more countries. A South American project is just getting underway to protect one of the world's great aquifers, the Guaraní Aquifer that runs under Brazil, Uruguay, Argentina and Paraguay. The project, supported by the Global Environmental Facility and the World Bank, is aimed at management of the aquifer's resources to prevent its pollution and overuse.

major aquifers that are being depleted or polluted include:

- **Ogallala Aquifer, the United States**: A vast reserve of groundwater in a geologic formation called the Ogallala lies under the Great Plains. One of the planet's great aquifers, it spans portions of eight states, covers 175,000 square miles (453,000 square kilometers) and, prior to development, held a volume equal to the annual flow of more than 200 Colorado Rivers. After World War II and the introduction of powerful centrifugal pumps, Great Plains farmers began tapping this water on a large scale. Today, the Ogallala waters one-fifth of the nation's irrigated land.

Driven by falling water tables, increased pumping costs and historically low crop prices, many farmers who depend upon the Ogallala have already abandoned irrigated agriculture. In 1978, six states using this aquifer had nearly 13 million acres under cultivation (5.2 million hectares). Less than a decade later, the cultivated area had dropped to just 10 million acres (4.2 million acres). Some projections estimate that it could drop another 20 percent by 2025.

However, users have dramatically reduced withdrawals from this aquifer in recent years. Because of this, the water table is dropping just a fraction of what it once was. With further cooperation being discussed, this major water source can eventually be restored, if not fully, at least to health.

- **Bangladesh** — Water tables have been falling in parts of Bangladesh, mainly because of increased rural domestic use. The falling water tables constitute a key factor in the increase of toxic concentrations of naturally occurring arsenic. More than 20 million people have been potentially exposed to drinking water with dangerous levels of arsenic.

- **California** — California is overdrawing groundwater at the rate of 1.6 billion cubic meters per year, equal to 15 percent of the state's annual net ground water use. Two

thirds of this depletion occurs in the Central Valley, which supplies half of America's fruits and vegetables. Annual pumping varies considerably between dry and wet years, but the long-term trend is toward depletion.

- **North Africa aquifers** — In this dry climate, the aquifers contain water that fell as rain up to 20,000 years ago, when the region was much lusher than today. Pumping water out of such aquifers depletes the water forever, much as extracting oil depletes an oil reserve. Nearly 40 percent of the depletion occurs in Libya, which is now pursuing a massive water project called the Great Man-Made River Project, a $25 billion plan to pump water from desert aquifers in the south and transfer it 900 miles (1,500 kilometers) north through 2,400 miles (4,000 kms) of pipe line.

- **Arabian Peninsula aquifer** — Another country that has suffered a recent history of groundwater depletion is Saudi Arabia, also sitting above a "fossil-water" aquifer. After the oil embargo of the 1970s, the Saudi Government realized that they were vulnerable to a retaliatory grain embargo. The Government launched a major initiative to make Saudi Arabia self-sufficient in grain. It heavily subsidized land, equipment and irrigation water, and by buying crops from farmers at several times the world market price, it encouraged large-scale wheat production in the desert. The annual harvest grew from a few thousand tons in the 1970s to a peak of 5 million tons in 1994. Saudi water demand in 1994 totaled nearly 20 billion cubic meters a year, and 85 percent of it came from mining non-renewable groundwater. At that rate, underground water reserves would have run out by 2040 or sooner. In recent years, removal of price support has resulted in grain production falling, and the nation has again become a grain importer.

- **Sri Lanka** — In areas of Sri Lanka, more than 60 percent of nitrogen applied as fertilizer is being lost into ground water. This has resulted locally in a concentration of nitrates that has reached 20-50 milligrams per liter, an extremely high concentration for use by humans and animals, and for agriculture.

- **Thailand aquifers** -- More than 50 percent of Bangkok's water comes from ground. In 1954-55, Bangkok residents and businesses were pumping about 8,000 cubic meters per day of groundwater, a figure that rose in the 1990s to about 1.4 million cubic meters per day. As a consequence of the over use of groundwater, the water level in aquifers has fallen nearly 200 feet (up to 60 meters) below mean sea level in places. Two main problems have ensued. Areas of Bangkok sunk more than six feet, a process that was first observed in the late 1970s. Secondly, in places the chloride concentration has risen to more than 3,000 milligrams per liter (mg/L) today, from around 600 MG/L per liter in the 1970s.

- **Indian aquifers** — The groundwater level in India's western states of Punjab and Haryana — the nation's principal breadbaskets -- has dropped precipitously because of overuse. Poor farmers once had to drill a well just 33 feet (10 meters) to get water. Now, wells must go down 330 feet or more (100 meters), which costs too much for these impoverished people. In the southern state of Tamil Nadu, underground water levels have dropped up to 100 feet (30 meters) because of over-pumping there.

- **China** — Groundwater over-pumping in North China, which produces 40 percent of the nation's grain, amounts to some 30 billion cubic meters per year. Water levels are dropping 3-4 feet (1-1.5 meters) per year, even as water demand is increasing sharply. As in India, over-pumping can not make up for surface water deficit forever. It will force farmers to irrigate more efficiently, switch to less thirsty crops, or either take land out of irrigated agriculture.

16. Lower Gascoyne Management Strategy, Action Plan, 2001/2002 Business Plan (http://www.wrc.gov.au/region/MWG/projects/LGMS.html)

Abstract

Water supply for Carnarvon and the associated Irrigation District is obtained from the Gascoyne River alluvial aquifer. Security of water supply is critical to the local horticulture industry which is almost entirely reliant on groundwater for crop irrigation. Currently there is no "community" understanding of the resource or its management. Consequently progress towards grower management is hampered by conflicting views. Long term groundwater abstraction has substantially modified the ground water flow pattern, and excessive pumping has drawn in salt water from the ocean and more saline portions of the surrounding aquifer.

Understanding the Aquifer

On the basis of available data it is considered that the cumulative impacts of combined abstraction by the Water Corporation and privately owned bores are contributing to a decline in water levels and bore yields and deterioration in groundwater quality, thereby compromising the security of water supply for irrigation purposes. This highlights the need for the development and implementation of a groundwater management strategy which protects water supply from the effects of drought and salt intrusion by maintaining a balance between abstraction and aquifer recharge.

To assist in the sustainable long term management of this groundwater system, the Water and Rivers Commission (WRC) is presently developing a groundwater model of the Gascoyne River alluvial aquifer. The model is capable of simulating the interaction between the upper and lower alluvial aquifers of basins A to L as well as the relationship between different sections of the aquifer system. The model will be used to:

- determine the sustainability of abstraction from existing sources;
- identify the potential (if any) for increased abstraction from the aquifer system; and
- simulate the effects of different recharge and abstraction scenarios on water levels and water quality within the aquifer system.

Options which have been identified to increase the security of water supply in the Lower Gascoyne Region include:

- increasing the volume of water available for irrigation through:
- development of additional surface water storage (including major dam, off-stream and on-farm storage facilities), identification and development of additional groundwater resources
- artificial recharge to the aquifer system and
- minimisation of evapotranspirative losses from the shallow aquifer system, which have been estimated to be as high as 50% (*Dodson, 1998*);
- introducing management practices to reduce the extent and impact of saline intrusion (thus minimising "down time" for bores in which abstraction is periodically suspended due to excessive salinity); and
- optimising water usage to reduce water consumption per irrigated hectare.

Recommendations

(i) Develop a common understanding of the aquifer and the security of the water supply for all users at Carnarvon.

(ii) Undertake a detailed water quality study at the downstream end of Gascoyne River to enable the aquifer to be better managed in Basin A over the dry periods.

(iii) Once a water quality study has been completed and analysed, the local management of the aquifer could be directed to reduce extraction in any 'problem areas' and, delineate some preferred pumping areas in the lower section of the river if there is a consistent pattern. An increase in the overall understanding of the aquifer dynamics from Wade Dodson's model, particularly the sustainable extraction, will also assist in managing water quality.

(iv) Disused Water Corporation bores represent a potential resource to the community. However, their ability to provide additional irrigation water supply depends on increased water allocation to permit abstraction from these sources and the provision of additional funds for bore rehabilitation, maintenance and operation.

(v) Develop a common understanding between growers and the Water Corporation of the state and value of Water Corporation infrastructure and the economic challenges being faced by the Water Corporation.

(vi) The full costs and benefits of water supplied from the Carnarvon Water Supply Scheme need to be identified and used in negotiation with growers in determining equity in pricing.

(vii) Develop a common understanding between growers and the Water Corporation of the costs of water.

(viii) Develop a communication strategy for the Water Corporation at Carnarvon, to facilitate the possible transfer of management and ownership of the water supply to local operators.

(ix) Continue the consultative process of transfer of management of the water supply to growers.

(x) Issue a consultancy for a study of Transferable Water Entitlements as applied to the Carnarvon situation, to develop an analysis and recommendations for action at Carnarvon.

LIST OF OTHER KEY SOURCES

Pv. Hofwegen, Virtual Water Trade – Conscious Choices, Synthesis E-Conference, World Water Council, 4th World Water Forum, 2004.

Poverty and Water Security. Understanding How Water Affects the Poor. Asian Development Bank. January 2004.

Soussan. John. *Water and Poverty. Fighting Poverty through Water Management.* Asian Development Bank. January 2004.

Water and Poverty: The Themes. A Collection of Thematic Papers. Asian Development Bank. January 2004.

International Comparison of Irrigation Sector. Final Report. Volume 2: Country Case Study. JORDAN. December 2002. Japan Bank for International Cooperation.

Norton, Andy & Mick Foster, *The Potential of Using Sustainable Livelihoods Approaches in Poverty Reduction Strategy Papers*, Working Paper 148, Centre for Aid and Public Expenditure, Overseas Development Institute, 2001

Norton A et al, *A rough guide to PPAs, Participatory Poverty Assessment – An introduction to theory and practice*, ODI; 2001.

DFID; Addressing the water Crisis – healthier and more productive lives for poor people, Strategies for achieving the international development targets, 2001.

Foster, S., J. Chilton, M. Moench, F. Cardy & M. Schifler, *Groundwater in Rural Development: Facing the Challenges of Supply and Resource Sustainability*, World Bank Technical Paper No. 463, Washington DC, World Bank, 1999.

Allan JA; *Productive Efficiency and Allocative Efficiency: why better management may not solve the problem*; in Agricultural Water Management 40 (1999), Elsevier, Amsterdam, 1999.

Institute for Water Studies, *State Framework Water Resources Plan, Chennai Basin Group* Water Resources Organization, Public Works Department, Government of Tamil Nadu, 1997.

FAO/World Bank/UNDP; *Water Sector Policy Review and Strategy Formulation, 1995*.

Winpenny J; *Managing Water as an Economic Resource*; Routledge, 1994.

Earth Summit; 1993, *The Earth Summit: the United Nations Conference on Environment and Development – Agenda 21: Freshwater, Rio de Janeiro*; Graham & Trotman/Martinus Nijhoff, 1993.

Dublin Statement; 1992, *The Dublin Statement on Water and Sustainable Development and Report of Conference*; Int. Conf. on Water and Environment; WMO, Geneva, 1992.

United Nations Department of Technical Cooperation for Development, *Hydrogeological and artificial recharge studies Madras – Technical Report* (DP/UN/IND-78-029/2) United Nations Development Programme, New York, 1987.

Marker. Phil, Kerry McNamara and Lindsay Wallace. *The significance of information and communication technologies for reducing poverty.* DFID.