



## REPORT – 2.1 CORE GROUP

# Balancing Multiple Uses Through Integrated Water Resources Management

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*TIME FOR SOLUTIONS*

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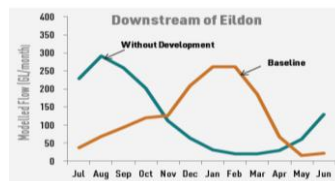
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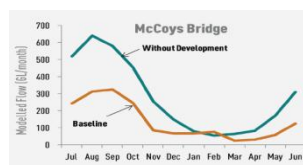
# 1. Introduction

The need to balance water uses arises when water resources do not meet the needs of all users, including both human and environmental. This is the case, of course, where and when water is scarce. But the same need arises when the overall resource is abundant but subject to competition due for instance to quality or accessibility reasons. This situation may have several origins such as: increasing variability in surface water flows, declining groundwater quantity and/or quality, population growth and subsequent increase of the demand, inefficient hydraulic systems, governance and stakeholder issues, increasing recognition of ecosystem services water requirements and inequitable access to the resources, etc. In addition to physical water scarcity, economic water shortages occur where poverty limits planning and water distribution, as efforts necessary to control and withdraw the water, then to transport and store it, are wide-ranging in terms of investment, labor and energy, thus in cost.

The uses of water and the purposes of use are themselves very diverse, and the needs as regards to quantity and the quality are very different. It has also to be pointed out that the water withdrawn from lakes, rivers or aquifers returns totally or partly either to the atmospheric hydrological cycle or to the watershed, where it becomes again available to other users, but affected in time or in quality. In this complex context of growing competition for scarce water resources there is an absolute need for integrated management of these resources. This implies, in particular, identifying and recognizing decision criteria for the quantity, quality and timing of water needed for each use and the value of water in each use.



Change of peak flows from without development condition to current baseline condition due to irrigation needs causing deterioration of river health, Goulburn River, Murray-Darling Basin, Australia (MDBA 2011). In addition much less water flows in the river after agricultural use has diverted its share; Goulburn River hydrographs downstream of irrigation diversions:



Well managing water resources involves multiple level challenges that require dealing with a range of policy, institutional, and technical issues. Integrated Water Resource Management (IWRM) aims at considering together all the different uses of all water resources. Water allocations and management decisions consider the effects of each use on the others, and take in account overall social and economic goals, including the achievement of sustainable development. The essential purpose of IWRM is to manage water more efficiently (use less water, more value per drop, conserve) and effectively (delivery of reliable services, improved performance in each sector). Balancing Multiple Uses of Water (BMUW) is one of the key outcomes of IWRM, which focuses on solutions how to cope with the rising competition for water between multiple kinds of users and allocate water in ways that are equitable, efficient, timely and sustainable.

“Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare without compromising the sustainability of ecosystems and the environment” (GWP 2000 and 2004).

The challenge is to put forward concrete developments in terms of methods, tools and implementation. Completion of the PFA 2.1 Targets and Solutions including - governance and planning adoption of IWRM processes, development of international water use quantity, quantity and value frames of reference, recognition of competing users with different time delivery needs (i.e. agriculture vs environment), validation of IWRM models and other tools, development of international recommendations for reliable water resources measurement and accounting and integration of all water uses and sources - will greatly improve management of water and other resources and contribute to economic development and other goals.

A list of the PFA 2.1 Core Group and Target and Solutions Group Coordinators is provided in the appendix to this report.

## 2. Background and rationale of the PFA/CS

Humanity withdraws and uses now barely a tenth of the overall flow of continental waters renewed by the global water cycle, but this is certainly a larger part which is actually used, probably about a third of the bodies of fresh water, when applying techno-economic and environmental criteria. To these total withdrawals – about 4,000 billion m<sup>3</sup> yearly – should be added many uses of water in situ, which are not accounted but which require local conservation of the natural environment, typically lakes, sometimes in competition with withdrawals.

The current human pressures on inland waters (ratios of abstractions over natural resources to feed) are largely depending on the country, from a few percent to more than 100% in countries where destocking natural reserves – primarily groundwater – has begun. Thus, situations of water scarcity are already present and tend to worsen when the "natural" resources are on average below the agreed threshold of 1000 m<sup>3</sup> per capita par year: this was the case in 2005 in 29 countries inhabited by about 300 million people, located mainly in arid or semiarid areas (round the Mediterranean).

The scarcity of water has several origins such as: variability in surface water supplies, declining groundwater resources, population growth, inefficient/wasteful water use, water supply/use quality constraints, increasing recognition of ecosystem services water requirements and inequitable access to the resources. Indeed, in addition to physical water shortages, economic water shortages occur where water allocation is not based on value and poverty limits planning and water distribution: Depending on its abundance or local rarity, and its temporal variability, efforts necessary to control and withdraw the water, then to transport and store it, are wide-ranging in terms of investment, labor and energy, thus in cost.

The uses of water and the purposes of its use are themselves very diverse, and their needs as regards to quantity, quality and the timing of delivery are very different. It has also to be pointed out that the water taken from lakes, rivers or water tables returns totally or partly either to the atmospheric hydrological cycle or to the watershed, where it becomes again available to other users, but affected in time and/or in quality.

In this complex context of growing tension over water resources, there is an absolute need of an optimal management of these resources based on the specific needs for each use. This implies, in particular, to highlight the decision criteria on both the quantity, quality and the timeliness of water needed for each use.

Well managing the water resources involves multiple level challenges that require dealing with a range of policy, institutional, and technical issues. “Implementing an IWRM process is in fact, a

question of getting the “three pillars” right: moving toward an enabling environment of appropriate policies, strategies and legislation for sustainable water resources development and management; putting in place the institutional framework through which the policies, strategies and legislation can be implemented; and setting up the management instruments required by these institutions to do their job.” (pg. 16, GWP IWRM and Water Efficiency Plans, 2004). Balancing Multiple Uses of Water (BMUW) is one of the key outcomes of IWRM, which focuses on solutions how to cope with the rising competition for water between multiple kinds of users and allocate the water in ways that are equitable, efficient, and sustainable.

IWRM aims at considering together all of the different uses and sources of water. Water allocations and management decisions consider the effects of each use on the others. They are able to take account overall social, environmental and economic goals, including the achievement of sustainable development. The essential purpose of IWRM is to manage water and associated resources more productively i.e. more efficiently (use less water, more value per drop, conserve) and effectively (delivery of reliable services, improved performance in each sector).

“Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare without compromising the sustainability of ecosystems and the environment” (GWP 2000 and 2004).

A challenge is to put forward concrete developments of methods, tools, inclusiveness and decision making processes. These issues will be addressed through the completion of targets and solutions (e.g. governance, stakeholder involvement, quality and quantity of uses, water values, modeling monitoring advances and establishment of goals, commitments and deadlines) for overcoming problems related to implementing IWRM to balance multiple uses and better manage water and associated resources.

Three major issue areas were identified for success in balancing multiple water uses through IWRM.

- **Appropriate governance and relevant regulations**, so as to allocate equitably and sustainably to each use appropriate quantities and qualities of water from available resources.
- **Shared understanding of IWRM and widely recognized assessment of the actual needs of different uses**, quantitatively, qualitatively and timely, and the **suitable tools** to help decision makers to arbitrate in full knowledge of the facts, including as regards the economic, social and environmental values of water.
- **Efficient operation** of water systems for sharing the available resources according to the needs of each use. Water systems should consider and be operated to most effectively serve multiple types of uses and purposes efficiently and equitably (e.g. Multiple Use Systems or MUS approaches). The challenges are on one hand a well-adjusted withdrawal from different resources, and on the other hand efficient transport, distribution, treatment and allocation.

These issues are being addressed by seven Target and Solution sessions and reports within Forum Priority 2.1, Balancing Multiple Uses through Integrated Water Resources Management.

The seven Target and Solution and Multistakeholder topics, Target Coordinators and Core Group Contacts for Priority 2.1 are listed below. Additional information on each Target and Solution area is provided with abstract summaries for each Target in Section 3 of this report and in detail in the individual Target and Solutions Reports available on-line on the 6th World Water Forum web site (Note: insert web address when reports are uploaded).

1. **Target 1:** By 2015, according to their laws and regulations, XX (number to be set by TSG) new countries adopt processes that encourage/ensure the participation of all stakeholders in IWRM, and thus set up and empower appropriate Integrated Water Resources Management authorities at relevant levels, representing the stakeholders.

Coordinator: Pakistan Water Partnership, Ali Karamat; [karamat@pwp.org.pk](mailto:karamat@pwp.org.pk)

Core Group Contact/Co-Coordinator: Eugene Stakhiv, International Center for Integrated Water Resources Management; [Eugene.z.Stakhiv@usace.army.mil](mailto:Eugene.z.Stakhiv@usace.army.mil)

2. **Target 2:** By 2018, the same XX countries make water resource planning a reality by adopting Integrated Water Resource Management (Master) Plans (IWRMP) at various scales within the perimeter of the IWRM authorities they have constituted and empowered.

Coordinator: International Land and Water Program (ILWP), Mathieu Pinkers; [m.j.h.p.pinkers@minlnv.nl](mailto:m.j.h.p.pinkers@minlnv.nl)

Core Group Contact: Ada Benavides, U.S. Army Corps of Engineers; [Ada.Benavides@usace.army.mil](mailto:Ada.Benavides@usace.army.mil)

3. **Target 3:** By 2015 establish a worldwide recognized frame of reference related to the quantity and the quality required for different uses, through joint work between international professional associations representing all usages of water and scientists.

Coordinator: International Water Resources Association (IWRA) Tom Soo; [office@iwra.org](mailto:office@iwra.org)

Co-coordinator: European Federation of National Associations of Water and Wastewater Services (EUREAU), Dominique Gâtel, Drinking Water Commission, [dominique.gatel@veoliaeau.fr](mailto:dominique.gatel@veoliaeau.fr)  
Core Group Contact: Francois Brelle; [Francois.Brelle@canal-de-provence.com](mailto:Francois.Brelle@canal-de-provence.com)

4. **Target 4:** By 2015 establish an internationally recognized frame of reference related to the methodology for valuing water according to its various uses, through joint work between international professional and water user associations representing all usages of water, scientists and economists.

This has been merged with PFA 2.2.4; **Coordinator:** Olivier Bommelaer, French Ministry of Ecology, [Olivier.Bommelaer@developpement-durable.gouv.fr](mailto:Olivier.Bommelaer@developpement-durable.gouv.fr)

**Core Group Contact:** Ari Michelsen, American Water Resources Association; [amichelsen@ag.tamu.edu](mailto:amichelsen@ag.tamu.edu)

5. **Target 5:** By 2015 elaborate and validate models which could be used as tools for helping decision makers implement IWRM to balance multiple water uses to best achieve desired goals.

**Coordinator:** Global Water Partnership (GWP), **Mohamed Aït Kadi;** [aitkadi.med@gmail.com](mailto:aitkadi.med@gmail.com)

**Core Group Contact:** Mohamed Aït Kadi; [aitkadi.med@gmail.com](mailto:aitkadi.med@gmail.com)

6. **Target 6:** By 2015, water service professionals, jointly with international associations representing all usages of water, issue appropriate guidelines (with indicators of impact assessment on health, environment, resource management and hydraulic system

sustainable operation) for managing multiple resources, either surface or groundwater (implementation of IWRM in groundwater-dominated systems), and multiple use (hydraulic) systems (MUS) in line with those approved by international organizations and funding institutions.

**Coordinator:** Société du Canal de Provence (SCP), AFEID (French Committee of ICID);  
**François Brelle**, [Francois.Brelle@canal-de-provence.com](mailto:Francois.Brelle@canal-de-provence.com)

**Co-coordinator:** American Water Resources Association (AWRA), **Michael Campana**,  
[Michael.Campana@oregonstate.edu](mailto:Michael.Campana@oregonstate.edu)

7. **Target 7:** By 2015, IWRM authorities, jointly with water service professionals will identify reliable methods and provide recommendations on appropriate equipment for accounting/ measurement of withdrawn water resources as well as produced, distributed, consumptive use and return flow water volumes. As part of this process International Organizations will develop recommendations regarding which water related information should be retained or shared.

**Coordinator:** International Water Resource Association (IWRA), **Jun Xia**; [xiaj@igsnr.ac.cn](mailto:xiaj@igsnr.ac.cn)

**Core Group Contact:** Jun Xia; [xiaj@igsnr.ac.cn](mailto:xiaj@igsnr.ac.cn)

8. **Multistakeholder Session:** Groundwater: Can We Put the 'Integrated' in IWRM? By 2015: 1) improve our understanding of the role of groundwater in, and its integration into, Integrated Water Resources Management; and 2) Develop/refine approaches to manage nonrenewable groundwater.

**Coordinator:** American Water Resources Association (AWRA), **Michael Campana**,  
[Michael.Campana@oregonstate.edu](mailto:Michael.Campana@oregonstate.edu)

### 3. Recommendations

Many international agencies and UNWater have been involved in implementing IWRM throughout the globe. There have been many successes, yet there is still much to be done. These entities have built up considerable experience over time on how to go about starting and sustaining strategic and tactical IWRM initiatives. It is from that small cadre of experienced specialists that members of a steering committee and a coordinating and management body should be sought. An 'action plan' itself requires an implementation plan and path. Both the WWF6 and the Rio+20 meeting will be discussing IWRM; its value and how to improve the process. The 'action plan' is merely the nucleus of a set of ideas and initiatives that will be offered at the WWF6, but ought to be further discussed, refined and developed in the interim period for presentation at the Rio+20 Conference by the most likely proponents for IWRM – UN Water and GWP. These entities have the experience to deal with these difficult cases, and capacity to line up the resources for each of the action items, and invoke the various agencies of the UN as well as international donors to ensure that these lagging nations are better served.

### 4. Conclusion

“Targeted support is necessary to continue to improve the institutional framework for water resources management with emphasis on the group of countries with a low Human Development Index (HDI)” [UN Water Status Report, 2011].

## 5. Summaries of Target action plans, solutions and commitments

Brief summaries of each of the Target’s rationale, action plans and preliminary recommendations are provided below. Over 100 potential solutions have been submitted to address the Priority for Action 2.1 Target issues and objectives. A number of these solutions also have potential application to other Targets. The individual Target reports will provide more information on the solutions specific to that Target. Additional summary information on potential Solutions and recommendations will be added following the completion of the Forum sessions and will also be provided in the individual Target and Solutions final reports.

- **Target and Solutions Group PFA 2.1 - Target 1**

**By 2015, according to their laws and regulations, 25 new countries adopt processes and encourage/ensure the participation of all stakeholders in IWRM, and thus set up and empower appropriate IWRM authorities at relevant levels, representing the stakeholders.**

### Abstract

Integrated Water Resources Management (IWRM) ensures that countries manage their built infrastructure wisely, and provides the most effective delivery of services, and most efficient use of resources – both surface water and groundwater. IWRM also ensures that the resources are distributed equitably and that growth and development is sustainable – i.e. does not come at the expense of ecosystem health. However, it is also understood that those nations which find it most difficult to implement any type of reform – whether it be improved flood or drought disaster planning and management, or adaptation to climate change, would find it difficult to implement a seemingly complex governance framework like that implied by IWRM. These are the nations we are focusing on.

Adopting IWRM does not mean a complete overhaul of institutions or traditional ways of doing things. More often than not, it means adapting and building on existing institutions and planning procedures and regulations as the starting point. To meet long-term national sustainable development goals and address specific water challenges such as disaster reduction, adaptation to global warming and reduction of poverty, countries need to make investments in water infrastructure- pipelines, irrigation systems, groundwater wells, water supply distribution systems, treatment plants, hydropower reservoirs, and flood control structures. But this infrastructure requires functioning management systems- investments are needed for improving the management of existing water resources delivery systems, as well as preparing for future needs. The circumstances of each nation are different. While the principles of IWRM are universal, the individual solutions are region and country specific – depending largely on the starting point – where that nation is on the scale of development. That is the largest determinant of where one starts with the implementation of IWRM – building on the broad array of instruments that are available and proven to work. This is consistent with



the principles of the WSSD – that IWRM strategies should respect and be adapted to local conditions.

Thirteen key IWRM areas of change that comprise the basis for an IWRM governance framework – this is what IWRM focuses on – the management tools that help to resolve the problems noted above:

- Coordinate policies for water use, protection, conservation
- Legislative framework to achieve policies
- Financing and incentive instruments
- Organizations – RBC's
- National water master plan
- Plan for IWRM
- Demand mgmt
- Water-oriented civil society – public participation
- Regulatory instruments – monitoring, allocation, regulation, permits, enforcement
- Conflict resolution
- Economic instruments – pricing, cost recovery, etc.
- Information management and exchange

- **Target and Solutions Group PFA 2.1 - Target 2**

**Make water resource planning a reality by adopting IWRM (Master) Plan.**

**By 2018, up to ten or more countries make water resource planning a reality by adopting Integrated Water Resource Management (Master) Plan (IWRMP) at various scales within the perimeter of the IWRM authorities they have constituted and empowered.**

#### **Session Abstract**

**Marseille, March Tuesday 13, 2012, from 11:00 am to 1:00 pm**

Over the years IWRM Plans and processes have been widely advocated and accepted by stakeholders as a useful approach to address strategic as well as operational, management and planning issues at local or river basin level (including trans boundary basins). However there is a need to apply lessons learned in IWRM at a much wider scale as well as improving and bringing to higher standards the processes and approaches to IWRM. The Target Session aims at encouraging and building capacities new and/or renewed IWRM Plan Processes at different scales in as much as countries as a pledge or commitment to the call for Solutions at WWF6.

As many as 30 solutions were submitted for the target 2 of the Key Priority Area 2.1. They cover a wide range of issues to be addressed including how to deal with these issues when developing IWRM Plans. During the Session stakeholders/participants are invited to actively integrate these solutions and other in a framework for and checklist of issues to be dealt with in IWRM Plans.

This session will explore: 1) The terms of reference and the logical framework for developing IRWM Plans at various scales , 2) A checklist and/or preliminary guidelines to identify issues and integrate potential solutions in the process of IRWM planning , 3) develop a 2012-2015 Roadmap for IRWM Plans to be prepared by those who will pledge or commit to do so in the areas of their authority and: 4) (inter) national Partnerships for

the cooperation, mutual exchange of information and lessons learned to bring IWRM Plans to a more advanced level of effectiveness in dealing with managing water resources for its different uses.

- **Target and Solutions Group 2.1 – Target 3**

**By 2015, establish a worldwide recognized frame of reference related to the quantity and the quality required for different uses, through joint work between international professional associations representing all usages of water and scientists.**

### **Session Abstract**

Balancing multiple uses optimally requires the wisely implementation of IWRM. In this perspective, concrete actions should be undertaken to foster regulations and requirements with a clear vision of water resources uses, quantitatively as well as qualitatively.

The main proposal of this target is to show how regulations have been addressed in order to accomplish a reference capable of supporting decision makers and practitioners, together with stakeholders to establish regulations adapted to multiple uses considering quantity & quality aspects of water. Following this line, the target 2.1.3 also presents the necessity of seeking alternative resources aiming at conserving and expanding available water supplies. Freshwater withdrawals can be spared if water of lower quality is used for less demanding purposes such as irrigation of crops or green spaces. This implies, in particular, the use of treated wastewater, a key alternative resource which will see an increasing use, thus necessitating the evolution of its regulatory framework.

A stock taking report has been presented as one of the identified solutions by the Target and Solution Group. It has been developed spanning existing guidelines on water quality regarding different applications, illustrated by international, national and regional frames of references on water quality. Another solution is set to be completed for the 7<sup>th</sup> World Water Forum in 2015: a compendium with the aim of establishing an international frame of reference related to the quantity and the quality required for different uses, through joint work between international professional associations representing all usages of water and scientists. Regarding the submitted solutions on the platform of solutions, all of them share with the target 2.1.3 the objective of optimizing the available water resource uses, however do not address the issue of parametric value derivation to safeguard public health and environmental status, which is to be done by national and/or environmental authorities.

The Session of the Target 2.1.3 during the WWF6 will bring together important actors in the field of international guidelines on water quality. The objective is to highlight the key criteria (economic, health, environmental) that support the decision-making process of setting national regulation/norms.

- **Target and Solutions Group PFA 2.1 and PFA 2.4 – Merged into Target 4 (revised statement)**

**By 2015, reference methods for guiding the economic valuation of water resources and ecosystems are available to business, governments, and finance institutions. By 2018, those reference methods are standardized to support a systematic inclusion of economic values of water resources and ecosystemic services in decision making.**

### **Target Abstract**

- Establish a common knowledge base of the economics of water resources and water related ecosystems services to enable appropriate comparisons of projects and plans. This base would guide economic assessments relying upon sound fact-based water resources and ecosystems services valuation and, where feasible, pricing. It should notably provide reference values for payment of water resources and ecosystems services, as well as for payment of well documented consumer and polluter charges. Existing works of OECD and other relevant institutions (FAO to be listed) should be mobilized.
- Identify and select relevant approaches, consistent assessment methods and practical valuation tools to be used for integrating water resources values (natural capitals) and payments of water-related ecosystems services into land use planning and project preparation and appraisal, notably in the fields of water infrastructure, food security and energy development. This task should be done by reviewing the existing relevant databases, programs and projects, such as the Wateco and the Evri bases, the Millennium Ecosystem Assessment, the Economics of Ecosystems and Biodiversity, UN Water and the REMEDE projects (list to be extended).
- Produce practical recommendations and assessment tool kits to be used by business, including farmers, governments and finance institutions, NGOs and international organisations in applying green accounting, valuation and compensation in cash or kind of water-related resources and ecosystem services in economic assessments of projects and plans for water infrastructure, food security and energy development.
- Produce practical recommendations and guidance regarding integration of water, agriculture and energy developments into sustainable land use planning. These recommendations should deal with governance and public participation issues, and aim at ensuring efficient coordination across levels of government and actual involvement of relevant stakeholders into the planning and the economic assessment processes.
- Propose draft standards of the identified approaches, assessment methods and valuation tool kits and identify relevant organizations able to develop and finalize the standardization process. Assess the realistic deadlines and budgets required for the adoption of those standards.

### **Target 2.1.4/2.4.4 Solutions**

As water quality is regressing in many basins, it becomes more expensive to put clean drinking water at the disposal of consumers (enterprises, public services, or private consumers). Water authorities are aware that preventive measures are almost always less expensive than treatment processes. Therefore, concrete cases of water bottling

companies or cities securing their water provision with payments for environmental services (PES) are increasing worldwide. Here lies one solution to both protect natural resources, and cope with human increasing demand. PES are connected with capacity building or technical progress or training, and the improvement in Natural Resources management they imply, leads often to improved agricultural yields. Therefore, they represent a sustainable solution: service providers often keep going with water preserving practices, even if monetary payments have come to end.

#### **Target 2.1.4/2.4.4 Conclusions**

- a) Economic values and socio-economic benefits generated by water resources and water ecosystems are either ignored or underestimated. Therefore, politicians should commit to:
- b) Standardize and finance environmental impact assessment studies of all projects and development plans potentially impacting those natural assets.
- c) Make sure that these studies will be seriously conducted and will comprise a relevant economic valuation of ecosystemic services.
- d) Finance the production of the necessary practical tool for economic valuation of ecosystemic services.
- e) Prepare or adapt the appropriate legal acts to make sure that the enforcement of this environmental economic assessment tool on water resources and water ecosystems will be possible and useful. This implies to adopt a more integrated approach when projects and plans are conducted in both public and private sectors.
- f) Make sure that these tools are utilized in their constituencies.

- **Target and Solutions Group PFA 2.1 - Target 5**

***By 2015 elaborate and validate models which could be used as tools for helping decisions makers implement IWRM to balance multiple water uses to best achieve desired goals***

#### **Session Abstract**

**Marseille, March 14, 2012, from 11:00 am to 1:00 pm**

Over the years modelling has been widely accepted by water agencies, donors and at the political level, as a useful and sometimes necessary approach to address operational, management or planning issues at local or river basin level (including trans boundary basins). Despite the general acceptance and frequent use of model codes on specific problems, the uptake of models has been limited, on a global scale, when it comes to the daily use in water resources planning and management or as part of the IWRM processes. As many as 24 solutions were submitted for the target 5 of the Key Priority Area 2.1. They cover a wide range of applications. This set of solutions reveals the need for reviewing how models/DSS frameworks are being developed, implemented and used by water authorities today and their experience in the benefits of using these in the IWRM process.

This session will explore: 1) The requirements to the modelling/DSS frameworks to serve the specific needs of the IWRM process by water agencies; 2) The requirements to the development and implementation process at the water agencies to ensure acceptance by the receiving water agency and relevant stakeholders; and 3) The requirement to create an enabling environment for a sustainable use of the modelling/DSS framework, including organizational setup, staff education, sustainable use, etc.

- **Target and Solutions Group PFA 2.1 - Target 6**

**By 2015, water service professionals, jointly with international associations representing all usages of water, issue appropriate guidelines (with indicators of impact assessment on health, wealth, environment, resource management and hydraulic system sustainable operation) for managing multiple resources and multiple use services (MUS) in line with those approved by international organizations and funding institutions.**

### **Abstract of Session 2.1.6**

Whatever the resources are, the challenge is to manage the resources in good coordination and to ensure a high efficiency of the withdrawal, the transport, the distribution and the treatment if necessary, whether the different uses are served by dedicated specific systems or by systems providing Multiple Use Services (MUS). It appears necessary to move away from the usual sector grounded approach to water resource / system service oriented management, encompassing social aspects and ecosystem services.

Making water available for different uses at better cost – and thus at best price of service – implies that physical systems are constructed for diverting, controlling, transporting, and distributing water, and are operated to ensure good water delivery service as expected by the users. Related costs as amortization of investments, costs of credit and of operation and maintenance cannot be ignored. They must however be optimized, or even controlled, as there is no possible balancing by an actual "supply - demand" control, a fortiori because of the monopoly of a specific service on a given territory.

The issue of Multiple Use Services has often been addressed, either within search programs or at the occasion of international events or conferences. Since the WWF4 and WWF5, the MUS (Multiple-Use water Services) approach, promoted by FAO and IWMI, has rapidly further been recognized. It aims at generating more livelihood benefits, strengthening ownership, preventing damage from unplanned uses. As planners consider all uses upfront, conflicts are reduced and MUS may be considered as “bottom-up IWRM”.

Multiple use and functions of water services was dedicated a session in the 5th World Water Forum, addressing the questions of "how to obtain more benefits per drop from multiple uses and functions", "how to bridge sectors to strengthen multiple uses and functions of water services", and "how to allow multiple-use services to reach more MDGs per drop".

Multiple uses services as such should be considered as a solution, of which field of application is far wider. Examples that have proved their robustness and sustainability exist throughout the world, in both developing and developed countries, at various scales. Within this session, such case studies in various contexts will be presented. The outcomes of the session should thus contribute to achieve the target by issuing appropriate guidelines for managing multiple resources and multiple use services.

- **Target and Solutions Group PFA 2.1 - Target 7**

**By 2015, IWRM authorities, jointly with water service professionals will identify reliable methods and provide recommendations on appropriate equipment for accounting/ measurement of withdrawn water resources as well as produced, distributed, consumptive use and return flow water volumes. As part of this process International Organizations will develop recommendations regarding which water related information should be retained or shared.**

### **Target 7 Session Abstract**

The Task for the Target 7 is to identify, disseminate and share methods and means for efficient water systems operations by 2015, which will focus on *Water Accounting* to accurately assess all the uses and users of water that can quantify the different uses of water and provides a better understanding of the relative quantities used by different sectors. For actual solutions of water accounting under the condition of multiple use of water in the basin, it can give an indication of the performance of water authorities, water service professionals and water users within the IWRM framework.

Five representative examples of solutions for Target 7 are given by case studies and practices in China, Australia, France, Spain and Jordan. Key points: (1) Water accounting is a approach of organizing and presenting information relating to the physical volumes of water in the environment and economy as well as the economic aspects of water supply and use (Australia case); (2) Building up the most strict water management system through three red lines control & water accounting, this approach can provide real solutions to IWRM(China case); (3) IWRM needs support of modernization tools & methods for water accounting. The solution is already being implemented and has demonstrate long-term sustainability and added value (France case); (4) Accounting of groundwater is a safeguard against deterioration of quality and quantity of groundwater, IWRM and wise water demand management constitute promising solutions for sustainability of the groundwater basins (Jordan case); and (5) Water footprint accounting of green and blue water will be a good way and face to challenges. The solution is an emerging initiative or idea not fully implemented yet, which still at the research and development stage (Spain case).

- **Target and Solutions Group PFA 2.1 – Multistakeholder - Groundwater**

**By 2015: 1) improve our understanding of the role of groundwater in, and its integration into, Integrated Water Resources Management; and 2) Develop/refine approaches to manage nonrenewable groundwater.**

### **Groundwater: Can We Put the 'Integrated' in IWRM? Tuesday, 13 March 2012, 1700 - 1900 Groundwater Multistakeholder Session Abstract**

Approximately 30% of the world's population depends upon groundwater, a resource comprising about 98% of the world's liquid freshwater. Besides providing water directly for human use, groundwater also supplies stream baseflow, maintains ecosystems, and can function as a waste repository and energy source. Despite groundwater's

importance, more progress is needed to manage it as an element of an IWRM strategy (sustainability) and as a nonrenewable resource.

Our session will explore: 1) groundwater's role in the context of IWRM, including case studies; 2) the role and management of nonrenewable groundwater in meeting the world's freshwater needs; and 3) governance and management models for renewable and nonrenewable groundwater.

Solutions include the use of collaborative modeling in applying IWRM to a groundwater basin and a surface water-groundwater modeling approach to river basin management. Approaches to nonrenewable groundwater management will be addressed.

We will propose the formation of a study or working group (email list and/or WWW site) to promote: 1) groundwater and IWRM; and 2) nonrenewable groundwater management. The group's aim is to enhance the global water resources community's understandings of groundwater management vis-a-vis IWRM and nonrenewability.

The session concludes with the launch of the WWAP-IHP UNESCO publication, *Groundwater: securing water availability and environmental values in time of rapid change*. This event dovetails nicely with the session's focus on groundwater, IWRM, and non-renewability.

## **6. References and Related Reports and Case Studies (with abstracts) for Priority 2.1, Balancing Multiple Uses through IWRM**

### **Integrated Water Resources Management (IWRM)**

Global Water Partnership <http://www.gwp.org/en/The-Challenge/What-is-IWRM/> and [http://www.gwptoolbox.org/images/stories/gwplib/Background/tac\\_4\\_english.pdf](http://www.gwptoolbox.org/images/stories/gwplib/Background/tac_4_english.pdf)

As defined by the Technical Committee of the Global Water Partnership (GWP), Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare without compromising the sustainability of ecosystems and the environment. Operationally, IWRM approaches involve applying knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement efficient, equitable and sustainable solutions to water and development problems. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of ecosystems for future generations. Water's many different uses—for agriculture, for healthy ecosystems, for people and livelihoods—demands coordinated action. An IWRM approach is an open, flexible process, bringing together decision-makers across the various sectors that impact water resources, and bringing all stakeholders to the table to set policy and make sound, balanced decisions in response to specific water challenges faced.

**Integrated Water Resources Management Reader** – UN-Water Decade Program, 2010  
[http://www.un.org/waterforlifedecade/pdf/05\\_2010\\_reader\\_iwrn\\_eng.pdf](http://www.un.org/waterforlifedecade/pdf/05_2010_reader_iwrn_eng.pdf)

The reader provides basic references for some of the latest and most relevant United Nations publications on IWRM issues.



### **Integrated Water Resources Management** (UN-GWP, Cap-Net Tutorial; IWRM Principles)

[http://www.archive.cap-net.org/iwrm\\_tutorial/mainmenu.htm#](http://www.archive.cap-net.org/iwrm_tutorial/mainmenu.htm#)

What is meant by integrated water resources management? Why is it so important? What are we losing without it? What are the gains to be made from introducing it? If it is so good, why isn't everybody doing it already? This brief introductory tutorial is aimed at policy makers, water managers, trainers and educators who want a basic understanding of IWRM principles. This tutorial provides the ammunition (arguments, examples, methodologies) to make the case for IWRM and to counter those who may oppose it on institutional or sectoral grounds.

### **A Handbook for IWRM – GWP and International Network of Basin Organizations**

Global Water Partnership and International Network of Basin Organizations. 2009. A Handbook for Integrated Water Resources Management in Basins. Elanders, Sweden.

<http://www.riob.org/IMG/pdf/GWP-INBOHandbookForIWRMinBasins.pdf>

### **International Center for Integrated Water Resources Management – ICIWaRM**

<http://www.iciwarm.org/en/>

The International Center for Integrated Water Resources Management (ICIWaRM) is a UNESCO Category 2 water centre headquartered at the U.S. Army Engineer Institute for Water Resources (IWR) in Alexandria, Virginia, USA. "Category 2" centers are provided for and funded by the host nation, but are under the auspices of UNESCO. ICIWaRM was officially created by an agreement between the U.S. Government and UNESCO in October 2009.

### **Integrated Water Resources Management (Water Encyclopedia)**

<http://www.waterencyclopedia.com/Hy-La/Integrated-Water-Resources-Management.html>

Integrated water resources management is the practice of making decisions and taking actions while considering multiple viewpoints of how water should be managed. These decisions and actions relate to situations such as river basin planning, organization of task forces, planning of new capital facilities, controlling reservoir releases, regulating floodplains, and developing new laws and regulations. The need for multiple viewpoints is caused by competition for water and by complex institutional constraints. The decision-making process is often lengthy and involves many participants.

According to a 1996 report of the American Water Works Research Foundation, Total Water Management is the exercise of stewardship of water resources for the greatest good of society and the environment. A basic principle of Total Water Management is that the supply is renewable, but limited, and should be managed on a sustainable-use basis.

Taking into consideration local and regional variations, Total Water Management:

- Encourages planning and management on a natural water systems basis through a dynamic process that adapts to changing conditions;
- Balances competing uses of water through efficient allocation that addresses social values, cost effectiveness, and environmental benefits and costs;
- Requires the participation of all units of government and stakeholders in decision-making through a process of coordination and conflict resolution;
- Promotes water conservation, reuse, source protection, and supply development to enhance water quality and quantity; and
- Fosters public health, safety, and community goodwill.

## **Global Water Partnership IWRM Toolbox**

[http://www.gwptoolbox.org/index.php?option=com\\_content&view=article&id=66&Itemid=64](http://www.gwptoolbox.org/index.php?option=com_content&view=article&id=66&Itemid=64)  
GWP's experiences from national IWRM planning processes include:

- A realistic IWRM plan requires the design of functions, structures and procedures to take into account the financial and human resource constraints, the existing institutional structures, the management capacity and the capacity for change.
- Successful IWRM plans need to be aligned with high-priority national development processes and broad cross-sectoral and stakeholder support, even if these are outside the water sector.
- Multi-stakeholder involvement in the decision making processes is essential for the acceptability of the outcome.
- Economic arguments for financing water resources management must be developed and well communicated.

## **IWRM.Net : Towards a European-wide exchange network**

<http://www.iwrm-net.eu>

The interaction between scientists, policy makers and water managers is vital to ensure the most effective use of current knowledge. It is also important to continually search for improvements in water management through exchanges between this trio. This website aims to highlight the work of the International Office for Water in science policy interface and be a portal to similar work elsewhere.

The 17 partners, from 14 European member states, plus 14 observers from 7 additional countries, all involved in the project, agreed on a shared Vision of what should be IWRM-NET by 2010:

1. THE source for knowledge about IWRM-research being undertaken in Europe at Member-States level, with a focus on the WFD
2. A forum for future perspectives and co-ordination of research needs and programs on related issues in different countries, including accession states and EU neighbors
3. The link between research and water policy makers and managers to bridge the communication gap
4. A facilitator for bringing together researchers and funders from different countries to work on joint research programs
5. A forum for exchanging best practices on administrating research programs across Europe

IWRM-NET streamline is based on a bottom-up and top-down approach. Stakeholders (research program managers, researchers, practitioners, NOG) are closely associated to each stages of IWRM-NET. On the other hand, the institutional context gives the main orientations of the strategic activities that will be implemented by the consortium.

## **IWRM CASE STUDIES/EXAMPLES**

**IWRM in Practice** – 2009 Case study book edited by Roberto Lento and Mike Muller  
<http://www.earthscan.co.uk/?tabid=49405>

The approach known as Integrated Water Resources Management (IWRM) is widely recognized as the best way forward, but is poorly understood, even within the water sector. Since a core

IWRM principle is that good water management must involve the water users, the understanding and involvement of other sectors is critical for success. There is thus an urgent need for practical guidance, for both water and development professionals, based on real world examples, rather than theoretical constructs.

**Status of Integrated Water Resources Management (IWRM) Plans in the Arab Region**

<http://water.cedare.int/cedare.int/files15%5CFile2298.pdf>

CEDARE 2005.

**Status Report on IWRM and Water Efficiency Plans** – Prepared for the 16<sup>th</sup> Session of the Commission on Sustainable Development, May 2008, United Nations.

[http://www.unwater.org/downloads/UNW\\_Status\\_Report\\_IWRM.pdf](http://www.unwater.org/downloads/UNW_Status_Report_IWRM.pdf)

**Strategy for Integrated Water Resources Management** [PDF]

Source: No. ENV 125. Washington, DC.

By: Inter-American Development Bank (IADB). 1998.

This report is an example of applying an IWRM approach. It focuses on the Latin America Caribbean region. While it is from the perspective of a Bank, it offers an example of how IWRM can be applied. It suggests key principles the Bank will apply in its water-related activities and strategic instruments that may be used on a case-by-case basis. It also outlines operational guidelines on how to integrate the principles of the strategy with the operational plans of the Bank. Annex I has a useful table showing the differences between different approaches - from project-oriented water resources development to integrated water resources management. Annex II has a summary of international declarations regarding IWRM. Annex III list different forms and responsibilities of private sector participation in public services provision. Annex IV gives a simplified overview of the strategy.

<http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1481461>

**Delaware River Basin Commission**

<http://www.state.nj.us/drbc/> (home page)

Delaware River Basin Plan: The purpose of the Basin Plan is to provide a unified framework for addressing new and historic water resource issues and problems. The Plan emphasizes an integrated approach, recognizing that water supply and water quality cannot be managed separately; that ground water and surface water are two aspects of the same resource, separated in time and space, but fundamentally interrelated. Integrated management means considering all aspects of the water resource in decision making.

<http://www.state.nj.us/drbc/BPSept04/index.htm>

Delaware River Basin Progress Reports - <http://www.state.nj.us/drbc/basinplan.htm>

**Northwest Power Planning Council**

<http://www.nwcouncil.org/> (home page)

“Striking a balance between energy and the environment in the Columbia River Basin.”

**Murray-Darling Draft Basin Plan**

There is widely held agreement that we need to change the way the Basin is managed. Governments and communities all acknowledge that the Murray–Darling Basin must be returned to a healthy, working condition if it is to have a sustainable and productive economic future. Our use of the water in the Basin has changed how the rivers flow. These changes in volume and timing have led to increases in salinity, blue-green algal blooms and water quality degradation, while wetlands, red gum forests, native fish and water bird populations are decreasing. All of

these features are symptoms of overuse and they are what have led to the latest impetus for water reform. We want a future for the Basin which is prosperous and vibrant. We want a healthy economy, a healthy social fabric and a healthy environment for the Basin. The shared vision is for a healthy working Basin. This means that:

- Key environmental assets are protected and progressively improved, and there is adequate water to sustain their ecological resilience during periods of drought
- There is enough flow from the Basin to keep the River Murray mouth open to the sea in most years
- The river system transports salt and nutrients from the Basin to the sea
- Water quality is adequate to sustain key uses
- Food and fibre production across Basin communities continues to increase in quantity and value
- New investment is made in agriculture and other industries across the Basin
- An unconstrained and efficient water market facilitates free trading of water entitlements
- Self reliant communities are fully engaged in managing the well being of the Basin

<http://www.mdba.gov.au/draft-basin-plan>

#### **The strategy of the French basins to achieve good water status by 2015**

In France, the water resources are managed in an integrated manner, in river basin districts. The river basin districts are delineated by the dividing lines of the surface water.

12 basins have been delineated, 7 in Metropolitan France and 5 overseas.

The strategy of the French basins to achieve good water status by 2015, which is the objective set by the Water Framework Directive of 2000, comprises plans for managing water in major river basin districts, and the Water Development and Management Master Plan (SDAGE).

These Water Development and Management Master Plans are prepared and validated by the stakeholders in the water sector, within the main orientations of national and European water policies, in basin committees fostering debate and local consensus-building in the spirit of the French Grenelle Environment policy.

The mission of the water agencies and overseas water offices is integrated into the strategy of the Water Development and Management Master Plans, which define, for each river basin district, the basic orientations for well-balanced management of the water resources and the water quantity and quality targets. The objectives of the Water Development and Management Master Plans constitute a French commitment to the EU authorities.

The Water Development and Management Master Plans 2010-2015 came into effect on December 22, 2009, following a vast development and consensus-building process (including with the general public) led by the basin committees. They are supplemented with operational programs (action plans). The implementation of these programs of measures, in the form of regional and local action plans, are managed by two authorities: the water agencies and the State.

The scope of the Water Development and Management Master Plans is broad. The urban planning documents (regional coherence schemes, local urban plans, communal plans etc.) must be compatible with their basic orientations and objectives, meaning that they must not feature provisions that conflict with the Water Development and Management Master Plans. The same holds true for the administrative decisions in the water sector, and those concerning facilities classified for the protection of the environment.

<http://www.agencesdeleau.fr/v3/en/les-agences-de-leau/les-six-agences-de-leau-francaises/>

Booker, J.F., A.M. Michelsen and F.A. Ward. 2005. "Economic Impact of Alternative Policy Responses to Prolonged and Severe Drought in the Rio Grande Basin." Water Resources Research. 41(WO2626):1-15.

Bourget, Paul G. 2006. Integrated Water Resources Management Curriculum in the United States: Results of a Recent Survey. Journal of Contemporary Water Research and Education. Universities Council on Water Resources. Issue 135:107-114. Southern Illinois University, Carbondale. <http://www.ucowr.org/updates/135/13.pdf>

Cai, Ximing, L. Lasdon, A.M. Michelsen. 2004. "Group Decision Making in Water Resources Management Using Multiple Objective Analysis." Journal of Water Resources Planning and Management. 130(1):4-14.

China Institute of Water Resources and Hydropower Research. 1994. Macroeconomic Based Water Resources Management Study for North China: Executive Summary, (English and Chinese), United Nations Development Program and State Science and Technology Commission, CPR/88/068, Beijing, China.

Dimple, Roy, Bryan Osborne and Henry David Venema. 2009. Integrated Water Resources Management (IWRM) in Canada: Recommendations for Agricultural Sector Participation. International Institute for Sustainable Development. [http://www.iisd.org/pdf/2009/iwrm\\_agriculture.pdf](http://www.iisd.org/pdf/2009/iwrm_agriculture.pdf)

Global Water Partnership Technical Advisory Committee. 2000. Integrated Water Resources Management. Background Paper No. 4. Stockholm, Sweden. [http://www.gwptoolbox.org/images/stories/gwpliblibrary/background/tac\\_4\\_english.pdf](http://www.gwptoolbox.org/images/stories/gwpliblibrary/background/tac_4_english.pdf)

Global Water Partnership and International Network of Basin Organizations. 2009. A Handbook for Integrated Water Resources Management in Basins. Sweden. <http://www.riob.org/IMG/pdf/GWP-INBOHandbookForIWRMinBasins.pdf>

Global Water Partnership. 2006. Integrated Water Resources Management: Strengthening Local Action. 4<sup>th</sup> World Water Forum, Thematic Document, Framework 2, Integrated Water Resources Management. Mexico City, March. [http://www.worldwaterforum4.org.mx/uploads/TBLDOCTOSB\\_4\\_38.pdf](http://www.worldwaterforum4.org.mx/uploads/TBLDOCTOSB_4_38.pdf)

Grigg, Neil S. 2009. Integrated Water Resources Management: Balancing Views and Improving Practice. Water International. Vol. 33(3):279-292.

Grigg, Neil S. Water Resources Management: Principles, Regulations, and Cases. New York: McGraw-Hill, 1996.

International Center for Integrated Water Resources Management (ICIWaRM) <http://www.iciwarm.org/en/>

IWRM-Vietnam Research Project. <http://www.iwrm.vn/index.php>

Jonch-Clausen, Torkil. 2004. Integrated Water Resources Management (IWRM) and Water Efficiency Plans by 2005: Why, What and How? Global Water Partnership. Sweden.  
[http://hqweb.unep.org/civil\\_society/GCSF8/pdfs/IWRM\\_water\\_efficiency.pdf](http://hqweb.unep.org/civil_society/GCSF8/pdfs/IWRM_water_efficiency.pdf)

Lakshman Guruswamy and A. Dan Tarlock. 2005. "Sustainability and the future of western water law." Chapter 6 in "In Search of Sustainable Water Management: International Lessons for the American West and Beyond." Ed. Douglas S. Kenney. Edward Elgar.

Lenton, Roberto and Mike Muller (eds). 2009. Integrated Water Resources Management in Practice: Better water management for development. Earthscan, London.  
<http://www.earthscan.co.uk/?TabId=49404&v=449398>

Marino, Miguel A. and Slobodan P. Simonovic. 2001. Integrated Water Resources Management. International Association of Hydrological Sciences. IAHS No. 272. IAHS Press.  
[http://iahs.info/redbooks/a272/iahs\\_272\\_000.pdf](http://iahs.info/redbooks/a272/iahs_272_000.pdf)

MDBA. 2011. Delivering a Healthy Working Basin; about the Draft Basin Plan. Murray-Darling Basin Authority, Canberra, Nov. 2011. <http://www.mdba.gov.au/draft-basin-plan>

Mitchell, Bruce. "Integrated Water Management." In Integrated Water Management: International Experiences and Perspectives, ed. Bruce Mitchell. London, U.K.: Belhaven Press, 1990.

Mokhtar, M.B., M.F. Al Ajlouni and R. Elfitrie. 2008. Integrated Water Resources Management Improving Langat Basin Ecosystem Health. *American Journal of Environmental Sciences*. 4(4):380-382. <http://www.scipub.org/fulltext/ajes/ajes44380-382.pdf>

NATO Science Series. Implementing Integrated Water Resources Management in Central Asia. 2007. Edited by P. Wouters, V. Dukhovny and A. Allan. IV. Earth and Environmental Sciences, Vol. 77. <http://www.springer.com/law/book/978-1-4020-5731-1> (and other sources)

Rahaman, M.M. and O. Varis. 2005. Integrated Water Resources Management: Evolution, Prospects and Future Challenges. *Sustainability: Science, Practice and Policy*.  
<http://ejournal.nbii.org>

United Nations ANA/GEF/UNEP/OAS. 2009. Strategic Action Program for the Integrated River Basin Management Practices in the Pantanal and Upper Paraguay River Basin.  
[http://www.ana.gov.br/GestaoRecHidricos/ProgramasProjetos/docs/Sintese\\_Pantanal\\_Ing.pdf](http://www.ana.gov.br/GestaoRecHidricos/ProgramasProjetos/docs/Sintese_Pantanal_Ing.pdf)

United Nations Development Program, Cap-Net and GWP. 2005. Integrated Water Resources Management. Tutorial. [http://www.archive.cap-net.org/iwrm\\_tutorial/mainmenu.htm#](http://www.archive.cap-net.org/iwrm_tutorial/mainmenu.htm#)

United Nations Development Program. CEDARE. 2005. Status of Integrated Water Resources Management (IWRM) Plans in the Arab Region.  
<http://water.cedare.int/cedare.int/files15%5CFile2298.pdf>

UN-Water. 2010. Integrated Water Resources Management Reader. UN-Water 2005-2015 Decade Programme on Advocacy and Communication.  
[http://www.un.org/waterforlifedecade/pdf/05\\_2010\\_reader\\_iwrm\\_eng.pdf](http://www.un.org/waterforlifedecade/pdf/05_2010_reader_iwrm_eng.pdf)

UN-Water. 2008. Status Report on Integrated Water Resources Management and Water Efficiency Plans. Prepared for the 16<sup>th</sup> Session of the Commission on Sustainable Development. [http://www.unwater.org/downloads/UNW\\_Status\\_Report\\_IWRM.pdf](http://www.unwater.org/downloads/UNW_Status_Report_IWRM.pdf)

Ward, F.A., J.F. Booker and A.M. Michelsen. 2006. "Integrated Economic, Hydrologic and Institutional Analysis of Policy Responses to Mitigate Drought Impacts in the Rio Grande Basin." Journal of Water Resources Planning and Management. 132(6): 488-502.

Ward, F.A. and A.M. Michelsen. 2002. "The Economic Value of Water in Agriculture: Concepts and Policy Applications." Water Policy. 4:423-446.

Ward, F.A., R.A. Young, R. Lacewell, J.P. King, M. Frasier, J.T. McGuckin, C. DuMars, J. Booker, J. Ellis, R. Srinivasan. 2001. "Institutional Adjustments for Coping With Prolonged and Severe Drought in the Rio Grande Basin." New Mexico Water Resources Research Institute, Texas Water Resources Research Institute, Colorado Water Resources Research Institute, Joint Technical Completion Report 317. <http://twri.tamu.edu/reports/2001/tr317/tr317.pdf>