CPWF TOPIC 2
synthesis

Multi-purpose Water Systems

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CGIAR Challenge Program on WATER & FOOD

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Acknowledgements

Citation
Nguyen-Khoa, S., Huber-Lee, A., van Koppen, B., Peden, D., Andreini, A. and Smits, S. 2008. *Multi-purpose Water Systems: Topic 2 synthesis paper.* CGIAR Challenge Program on Water and Food, Colombo, 13 pp.

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Multi-purpose Water Systems: Topic 2 synthesis paper
The authors are grateful to the following people for their feedback on various drafts of this document: C.T. Hoanh, Nancy Johnson, Ruth Meinzen-Dick, Laurence Smith and Malcolm Beveridge.

CPWF Topic Synthesis Papers
In the second phase of the CGIAR Challenge Program on Water and Food, activities will be organized around Basin Development Challenges and Topics. Basin Development Challenges are water and food problem areas of recognized importance in a river basin area. Topics are subject matter areas selected to support research on basin challenges. Topics play two roles: to ensure the quality of science in research on basin development challenges, and to facilitate the development of international public goods.

The process of jointly defining basin challenges and topics began with stakeholder surveys, and consultations with Basin Coordinators, Basin Focal Project teams, Phase 1 Theme Leaders, and external experts. This process culminated in a series of one-on-one interviews with key basin stakeholders from research, development and policy arenas.

In their present form, the priority Topics are as follows:

- Improving Rainwater Productivity
- Multi-purpose Water Systems
- Water Benefits Sharing for Poverty Alleviation and Conflict Resolution
- Global Drivers and Processes of Change

The four synthesis papers describe these priority Topics: their present status, how they evolved, what was learned about them in Phase 1, and the kinds of research likely to be needed on each topic in Phase 2.

These papers are not the final word, however. Basin challenges and topics will continue to be re-defined. Topics are intended to support and serve the basins: as research on basin challenges unfold, the content of individual topics may be modified. Whole new topics may emerge and other topics dropped.

I wish to thank Theme Leaders who have put tremendous effort into these papers, as well as others in the CPWF community, who together have made this document possible.

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Rationale

Overall importance of the issue

The pressure on water resources is increasing worldwide because of population growth, economic development, patterns of urbanization and migration, biofuels and increasing impact of global climate change on temporal and spatial distribution of water. Growing competition affects the poor most and risks jeopardizing the better sharing of benefits of water use for poverty alleviation and rural development.

Moreover, poor people cannot afford to purchase inputs to enable them to invest in agriculture that uses less water or uses water more productively and sustainably. These drivers are leading to more acute competition between alternative uses of water, especially for the poor (who often include women), a lack of water for some activities and conflicts over water allocation.

Therefore pro-poor water development in areas where water resources are still largely underdeveloped, as in sub-Saharan Africa, and more equitable allocation and management of water resources is urgently needed to satisfy the multiple objectives of food production, ecosystem conservation and poverty alleviation in rural (and possibly peri-urban) areas, whilst meeting the needs of growing cities and industry.

Most water infrastructure and management systems are used for multiple purposes, even if they are designed for a single or primary use. This includes domestic use of irrigation systems (Yoder 1983; Meinzen-Dick 1997), livestock (Peden 2007), fisheries and aquaculture in irrigation systems (Petr, 1985; Nguyen Khoa et al. 2005), agricultural (i.e. including crops, livestock, fisheries and home gardens) and small-scale industrial use of potable systems (Moriarty et al. 2004) and agroforestry (CA 2007). While infrastructure development and managing water resources have primarily been designed for crop production or domestic uses, these diverse activities can greatly improve economic productivity of water and other benefits at a relatively low cost in terms of water consumed (CA 2007). Smith (2004) also cites multiple use benefits as one of the four main mechanisms by which irrigation development can contribute to poverty reduction.

Improving the design and management of agricultural water storage and delivery systems to specifically take into consideration multiple uses and users has been identified as one of the major opportunities to increase water productivity (Molden et al. 2007). It is critical to include support of ecosystems and the services they provide, as this represents the ability to withstand rapid change – resilience – for both ecosystems and poor and marginalized people (Falkenmark et al. 2007). Recognizing the diversity of water uses and users is also critical in alleviating poverty and enhancing social equity including gender equity. The consideration of "productive uses" for domestic (Castillo & Namara 2007) and human health (Boelee & Laamrani 2004) purposes can raise the social and economic status of marginalized communities and socially disadvantaged people such as women, fishers and the landless (Bruns & Meinzen-Dick 2000). Although indirect economic benefits of "non-productive" uses may not be easily quantifiable, they represent a substantial contribution to social benefits that enable MUS to make better use of the water available.

Despite the high potential of multiple water use systems (MUS) in optimizing the use of water, successful experiences are documented only in grey literature, with little peer-reviewed research articles or books (CA 2007, Peden et al. 2007). In addition, conventional sectoral approaches to water management show serious deficiencies, including a lack of consideration of both blue and green water. There are three potential areas of focus.

First, understanding and sustaining traditional resource management systems that incorporate multiple uses of water resources, and which typically offer diverse and resilient livelihood strategies to poor groups, even though there may be gender imbalances. Second, designing and managing water systems for multiple uses from the outset, and third rehabilitating existing 'single use' systems for multiple uses. Each of these has the potential to make major impacts on poverty alleviation and ecosystem conservation. In all cases, both green and blue water are considered in the landscape. This calls for the development of cross-sectoral and transdisciplinary approaches that improve our understanding of the benefits and water demands of alternative water uses including aquatic ecosystems.

Contributions from Phase 1

CPWF Phase 1 has contributed to a growing body of research on the management of multiple water use systems under various agroecological, economic and socio-political contexts. New tools and approaches have been developed and many of these are ready for testing and validation during Phase 2, in the specific context of multiple use systems.

Research by projects such as Multiple Uses of Water (PN28), Small Reservoirs (PN46) and SCALES (PN20) has made visible the often unseen but important uses and users of different types of water systems. Other CPWF projects have contributed to improving the conceptual and empirical understanding of the impacts of livestock, aquaculture and other uses on water quality, availability, productivity and equity in select basins, (e.g. Nile Basin Livestock Water Productivity (PN37), Coastal Resource Management in the Mekong (PN10), Improved fisheries productivity and management in tropical reservoirs (PN34) and Basin Focal Projects across the 10 Phase 1 basins).

There has been considerable progress in the development of multi-stakeholder governance platforms and negotiation support tools for water management and upscaling through local government. PN28 has identified technological and policy innovations for multiple use systems, and it has piloted a methodology for addressing institutional challenges at multiple scales (Van Koppen et al 2006; www.musproject.net). In addition, as a result of MUS projects efforts, South Africa has adopted the multiple use services approach, which was also broadly endorsed at the World Water Forum in Mexico in 2006.

PN37 research addressed MUS through the entry point of assessing and increasing agricultural water productivity through better livestock management. Increasing the water productivity of livestock can enable maintenance of current levels of production with substantial reduction in water use making more water available for other human needs and ecosystem services.

In some cases, there may be opportunities to replace livestock services with less water costly alternatives. For example, 70% of the cattle in highland areas of the Blue Nile basin are kept for provision of farm power. If conservation agriculture could enable reduced cultivation, fewer oxen would be needed for crop production, thereby reducing the amount of water needed for production of animal feed (Peden et al. 2007).

Opportunities to take pressure off of MUS imposed by livestock involves adoption of three strategies: Improved feed sourcing that provides nutritionally adequate and palatable diets based on water productive vegetative material; improved animal husbandry, health, genetics and nutrition that reduces the amount of water needed to maintain unproductive herds; and water conservation practices that reduce contamination and degradation of surface water on which people depend for other uses.

PN34 research addressed rehabilitating existing ‘single use’ irrigation reservoirs for improved fisheries productivity. Maintaining aquatic ecosystem integrity through improved fisheries management is an important, but often overlooked alternative in maintaining water quality for domestic purposes, particularly drinking water. Improved fisheries management in Indian irrigation reservoirs has, besides improved water productivity from fisheries, helped to control eutrophication and therefore directly contributed to improved water quality for downstream users.

Of particular note, a community of practice around MUS has emerged via the CPWF MUS Project. The MUS Group (see www.MUSGroup.net for additional information) brings together both practitioners and researchers around MUS Issues, including the dissemination, advocacy, and sharing of results.

Major gaps

Despite the significant progress made during Phase 1, further development in the following research areas is urgently needed.

ASSESSING THE ACTUAL AND POTENTIAL BENEFITS AND COST OF MULTIPLE WATER USE SYSTEMS

The potential and actual benefits and costs of multiple use systems need to be assessed for different systems in various contexts. MUS are characterized by non-linear and complex causal relationships between interconnected and interdependent water uses and users. The conceptual, methodological and empirical understanding of complementary and alternative water uses must improve, including consideration of demand management. This includes the valuation of incommensurate social and ecological benefits and costs, such as water demands for ecosystems and for social equity. For example, clear but rarely quantified tradeoffs can exist in using water storage reservoirs for both downstream purposes (irrigation, capture fisheries and other key ecosystem services) and for reservoir fish stocking purposes that can also benefit the poor. Fishing also provides an example where the security of the location and the physical accessibility of the water resource have implications for access by more vulnerable groups including women, the elderly and others with restricted mobility.

Overall, it is recognized that the assessment and valuation of water for multiple uses and users is difficult and fraught with uncertainties (Costanza et al. 1997), especially in developing countries. A key element of what defines social equity and values depends on the ethical understanding of the role of water. Unless these ethics are examined and understood, there is high potential of reinforcing existing power structures. Results and valuation may be crude, with qualitative estimates likely complementing quantitative assessments. This should not impede efforts toward the assessment and valuation of multiple water uses that support multi-objective decision-making (Hermans et al. 2006).

IMPROVING THE TECHNICAL PERFORMANCE OF MULTIPLE WATER USE SYSTEMS

Multiple use systems present major technical challenges because the different uses of water often have very distinct quality, quantity and timing demands. Demands further depend upon the site of use and related water sources, such as homestead-based uses, migration uses by nomadic pastoralists, communal uses, field-based uses, or direct uses from open water bodies. For example, at the household and community level, some water needs may take predominance over others, based on existing power and gender relations. Demands are also gendered: women invariably prioritize water supplies to homesteads, while water needs for agriculture depend on the gendered organization of farming. Another aspect is that demand for water can change spatially. For example pastoralists migrate with seasons and water availability.

Depriving water access in only one place for a short period of time may undermine the entire year-round pastoralist migratory pattern making use of water at other times in other places impossible. For example, access to water in the dry season near irrigation systems and wetlands enables livestock to survive stressful times so that they can move to distant pastures during more favorable times. Thus competition for water near the irrigation system will impact water use over a much larger area. In addition water uses differ in terms of their impacts on water quality, quantity and availability to other users. Some activities like livestock, aquaculture, and certain industries may consume relatively small amounts of water but can have large impacts on the quality of remaining water. With such contexts, clear opportunities exist for low cost, technically less challenging and more pro-poor multiple water use systems such as low input aquaculture in multi-purpose ponds on-farm.

One of the outcomes of the CPWF Small Reservoirs project (PN46) is the recognition that its tool box requires technical options for improving livestock management. PN37's experience in Nakasongola, Uganda, demonstrates that improved upslope pasture management can increase water quality and reduce turbidity and sedimentation providing more secure and longer lasting domestic water and that upslope pasture and animal management must be fully integrated with pond (valley tank) design, management and including maintenance of riparian vegetation and adoption of watering troughs (Mpairwe et al. 2008). A key technical requirement for improving performance of MUS is to fully integrate livestock management with other water uses.

The integration of domestic uses, crops, aquaculture and livestock can lead to diversified production and efficient re-use of water, with the added advantage of recycling agricultural by-products and nutrients on farm. Such systems are also conducive to integrated pest management as fish consume harmful insects, thereby reducing the need for pesticides. Research is needed to help establish water quality demands, estimate the value of such ecosystem services, and design efficient systems and practices for meeting the requirements based on outcomes of risk assessments (Qadir et al 2007).

IMPROVING THE MANAGEMENT AND GOVERNANCE OF MULTIPLE WATER USE SYSTEMS

When different people use water, the challenges in achieving effective water management to realize equitable benefits are great. The definition of equitable depends on the ethics of the people involved and the overall aims of the CGIAR, which is rural poverty alleviation. This aspect needs to be considered in the context of governance of water at all scales. Communities have been facing these issues for centuries with different degrees of success, yet relatively little is known about how they do it, especially about how they handle conflict. The participation and engagement of the different water users is critical to identify and implement solutions that optimize the use of water and the distribution of its benefits.

At local level and for individual systems, MUS call for multi-stakeholder dialogues, helping stakeholders to express their priorities and jointly reach a certain level of agreement on the use and management of scarce water resources (Moss et al. 2003). The ability of local communities to manage their water sources to accommodate multiple uses and users is key, as this capacity is the foundation for communities, water use associations, and the agencies and organizations that work with them will also be critical to achieving success.

There is a need to look at more than local communities and also look at people who move from place to place and only need water for short periods. Community water management should be undertaken in a gender sensitive way, ensuring that needs of all users are given appropriate attention. In terms of scale, the issue is not only household, community, watershed and basin scales, but also the interactions among places having similar scales. Research on the emergence and performance of collective action and the participation of the poor in the management of multiple use systems, at the interface of customary arrangements and public interventions, must further develop.

For natural water bodies and at a whole catchment level, polycentric governance arrangements with improved vertical and horizontal integration and coordination between existing agencies are necessary. Integrated water management is often impeded by bureaucratic divisions between, for example, domestic water use, irrigation, livestock, and fisheries. Addressing this limitation will require concerted efforts among decision makers across sectors and at multiple scales and awareness of multiple uses and users by wealth status, gender, main livelihood strategy, and ethnicity, through forging innovative policies and institutional linkages.

CREATING AN ENABLING POLICY ENVIRONMENT

Whether looking at MUS at household, community or catchment level, there is a need to create an enabling environment. This environment can only happen with a good understanding and recognition, also legally, of traditional resource management systems that may or may not incorporate multiple uses of water resources, and which typically offer diverse and resilient livelihood strategies to poor groups.

Objectives

The goal of Topic 2 is to increase the socio-economic and ecological benefits of water systems in order to enhance the productivity and resilience of livelihoods and ecosystems in developing countries. To maximize their impact, Topic 2 research projects will focus on MUS design and management for multiple uses and multiple users' groups reflecting the various ways in which rural households use water in their diverse livelihoods strategies.

Topic 2 objectives range from the characterization and diagnostic of MUS costs and benefits, the assessment and management of multiple use water demands in terms of quantity and quality, to the identification of adequate system design, operation and management, the evaluation of tradeoffs to support water allocation decision-making and governance, and the promotion of enabling policy contexts.

This research will support CPWF researchers at the catchment and local level by improving knowledge and assessments of MUS technologies, management approaches, costs and benefits across all scales, and in particular at local and catchment levels. The development of integrated water management institutions will be encouraged through careful engagement with the relevant water authorities at the relevant levels.

Planned outputs and tools will include:

- Investment strategies for infrastructure development and rehabilitation that accommodates multiple water needs

- Effectiveness of various tools, including formal and informal water rights, maintenance of environmental flows, water charging and prohibition of certain activities in managing water demand

- The design of a diagnostic framework and identification of appropriate gender-sensitive indicators of performance

- The identification of appropriate combinations of water uses based on case studies and empirical evidence. The impact of water use ethics on competition for water will be considered here.

- The assessment of costs and benefits of different water uses, factoring in water ethics and including their distribution across scales and respective tradeoffs at community and catchment scales to inform investment decisions

- The promotion and support of scientific and technological innovation

- Monitoring and evaluation of existing and new MUS; adaptive management

- Supported and informed water resource allocation decisions

- Innovative governance and policies for multiple uses and users of water, including re-use.

Scope

The MUS topic includes natural and managed water resource use systems at various scales with emphasis on local and catchment levels. A water resource use system, including both green and blue water, can be a natural water body (lake, floodplain), an agricultural field (e.g. rice field), a water supply system, groundwater, an irrigation scheme and its command area as well as the whole catchment. It encompasses biophysical and human components. The assessment and management of MUS at basin, regional and national scale will exploit synergies with Topic 3 'Water and benefit sharing', and at the global scale with Topic 4 'Global drivers and processes of change'. The effect of improving rainwater management (Topic 1) will be integrated into community and catchment analyses in this topic, MUS. Please see the framework below that illustrates the interactions between topics, with Topic 2 expressed in more detail.

Multiple uses of water include productive uses as well as non-productive uses - for example domestic use (drinking, cooking), human and animal health, and ecosystem services: provisioning, supporting, regulating and cultural services – recognizing that distinctions between productive and non-productive uses, consumptive and non-consumptive uses of water are often difficult to establish and boundaries may be imprecise and variable. In addition, the "non water-use" impact of an activity on water quality and quantity has to be factored in. For example, animal pathways create point sources of sediment flows into domestic water reservoirs, but the animal use of the pathway is not a use of the water that is degraded. Fisheries, besides being a key productive water use of aquatic ecosystems, also provide an important regulating service to aquatic ecosystems and can have a positive non water-use impact on water quality.
Framework for Topic 2: scope, focus and key objectives

Note: This framework does not aim to be comprehensive but rather to show the key factors, relationships and interactions that Topic 2 proposes to analyze.

The geographical scope of the MUS topic are rural areas of developing countries in the CPWF river basins (Volta, Nile, Limpopo, Ganges, Mekong, Andean System) where the issue of MUS has been identified as a priority to achieve the Basin Impact Challenges put forward by each basin.

Key Research Areas

Key research areas focus on the characterization of MUS, the management of water demand and the integrated assessment of water quantity and quality demands that can accommodate ecosystems services, fisheries, domestic use and human health as well as crop, aquaculture and livestock production. Design, management and water demand and supply management, and allocation innovations will be sought along with supporting governance mechanisms and enabling policies. The working definition of MUS, under development in conjunction with the MUS Group1, distinguishes use across scales: people's preferred sites of multiple or single end-uses at the lowest scales, and, as relevant, communal abstractions, storage and conveyance of water resources for uses at the next higher community-scale, up to basin scale.

Characterization of MUS and identification of factors of success

MUS can be extremely varied, hence the need for a characterization framework for clarification. Not all experiences have been successful. Existing knowledge and experience will be used to draw lessons and insights to identify constraints and sustainable benefits of such systems, including the limits of production, and guide further implementation. Multiple water use systems will be characterized by their ecological, technical, spatial and social aspects and their respective boundaries. This includes biophysical, geomorphological and engineering factors, as well as socio-cultural, economic and institutional factors. The definition of ecological and social boundaries of MUS within a catchment framework will facilitate cost-benefit analysis across scales, and serves to capture upstream-downstream interactions.

Water users will also be characterized by community, activity and sector such as crops, fisheries, livestock, domestic use, ecosystem services, and within all of these contexts power relations are important. Respective outcomes will be assessed and analyzed in relation to patterns of interactions of the water resource system, its users and uses, and the governance and policy environment - See Appendix: Framework for Topic 2, drawing from institutional analysis frameworks (Oakerson 1992, Smith et al. 2005, Ostrom 2007).

1 The MUS Group is hosting a Symposium in November 2008 in Addis Ababa. CPWF will be participating on discussions of definitions, characterizations and research gaps that may influence the research for Phase 2.

Indicators of performance in relation to the characterization of multiple water use systems will explicitly consider social and ecological objectives of MUS such as productivity (linking especially with water productivity work in Topic 1), equity, poverty, resilience, sustainability, as well as assessment of technical performance, and costs and trade-offs of MUS operation and maintenance relative to benefits derived from the system. The identification of possible optimal multiple uses of water, includes its potential re-use, e.g. in integrated crop-livestock-fish systems, or optimizing multiple productive water uses, for example by stocking fish in irrigation reservoirs. At community, landscape and catchment scales, there is a need to consider having an optimal pattern of land and water uses – a sort of patchwork that places land and water uses in a spatially and ecologically optimal way. For example, well-managed grazing in dry-land areas can be an optimal use simply because it takes advantage of low valued water distributed over large areas and there is no other agricultural use that would be more productive and sustainable. Appropriate standards are likely to be context specific. Ex-post assessments will inform ex-ante assessment and management of future MUS.

Assessment of water demands for the different users

It follows from the characterization of MUS (see Section 4.1 above) that the distinction between systems providing water for domestic uses and those providing water for productive uses such as agriculture or small-scale industry is difficult to sustain in a multiple use perspective. Nevertheless these distinctions are still dominant in conventional water management thinking, and in the allocation of roles, responsibilities and funding to agencies. This serious deficiency calls for the development of integrated (inter-sectoral and transdisciplinary) approaches to understand the benefits and water demands of alternative agricultural water management systems, and the actual and potential size and distribution of their uses, benefits and costs[2].

Water demands will be assessed for the different use and users, notably agriculture, livestock, fisheries, aquaculture, forestry, domestic use (water and sanitation), ecosystems (environmental flows), human health. Assessments will be conducted in terms of quantity and quality of water, consumptive and non-consumptive uses and timing of water needs (e.g. seasonality, trends). Methods will address cross-scale issues recognizing potential mismatch between scales of MUS management and potential impacts on upstream-downstream ecological processes.

Given that water resources are increasingly more variable and uncertain as a result of climate change, the burgeoning human population and economic development, exploration of ways of developing water in water-rich areas and managing demand in closing basins is essential within the MUS context. Various options will be explored, including the development and utility of enshrining basic water rights in national and international water law and constitutions, water pricing and development of guidelines for prohibiting certain activities during periods of water shortage.

A complex but key area of assessing water demands revolves around forced migration, occurring especially in Africa. With increasing populations, there are mass movements of people from one place to another. For example, in Ethiopia the government pressures people to move to new production systems (agro-ecosystems) but the people lack knowledge on the sustainable management of land water resources. Environmental, economic and political refugees are also forced into new environments. Under such condition, their lack of knowledge of appropriate water management practices compounds and confounds the institutional issues mentioned. Furthermore, this movement of people is often accompanied by the loss of institutions that once provided the governing mechanism for use of natural resources notwithstanding the fact that these institutions may not have been appropriate to the refugees new environment.

Common units of measure will be identified and further developed for such a multiple water use accounting framework based on comparable indicators of water productivity from alternative and complementary uses. A critical revision of the water productivity concept is also needed in order to expand its application to multiple uses of water in relation to spatial and temporal boundaries of the water use domain. For example, a multiple use domain could be an irrigated crop system bounded by its command area, and bounded in time for a particular growing season (Molden 1997), but put in the context of a larger catchment. This is critical to consider, as developing water-harvesting systems that are used to irrigate command areas often prevent upslope and upstream users from taking advantage of water resources in the catchment areas, as they divert the water to the command areas that benefit different people. One needs to factor in the losses and marginalization caused by such systems.

More emphasis will be given on the valuation of social and ecological benefits derived from water, the distribu-

2 *Note that there has been work on this issue by the partners in the MUS Group, not yet published, but will be taken as valuable input for the topic.*

tion of costs and benefits including investment and recurrent costs of managed systems, and incremental and marginal benefits of water. Approaches to incorporate uncertainty and variability in negotiation processes on how systems are designed, implemented and managed will be developed. These approaches include adaptive assessment, social learning; genuine participation and engagement of stakeholders in seeking appropriate valuation of multiple uses of water.

Improving the technical performance of multiple water use systems

Multi-purpose water systems need to accommodate various factors at end-use and community-level. The water quality required for irrigation and domestic use are not the same. Irrigating with water suitable for human consumption can be inefficient if not unsustainable, and drinking and/or bathing in irrigation water contaminated with pesticides and fertilizer is not acceptable. Providing water from a shared source for both purposes is technically challenging and must be addressed. Research to develop technical as well as institutional improvements to overcome this difficulty should be done to assure that MUS serve the people using them. One research question, especially related to water quality, is whether systems designed for MUS are more or less sustainable than single use systems.

Various means of improving the water productivity of agriculture exist. Possibilities include design of ponds and small reservoirs that incorporate fish production, use of productive crop varieties and animal breeds, fertilizer, feeds, and disease management, and also through effluent discharge strategies, effluent treatment and re-use for other purposes.

From a livestock perspective, there is no need to generate many new technologies. However, the integration of existing livestock and water management knowledge and technologies is crucial because the two sectors have rarely worked closely together with the possible exception of pastoral areas. In areas where crops are grown, agricultural water management still tends to ignore animals. The same is true for fisheries, which can provide considerable supplemental water productivity at little extra cost. Well managed fisheries in reservoirs and natural aquatic ecosystems play an important role in maintaining overall water quality for other uses, including crops, livestock and particularly domestic uses.

Management options and supporting governance mechanisms at local level

Governance challenges are inherent to any multiple water use systems. Different users have different priorities, capacities and personal characteristics. This poses important and complex challenges to management and governance of multiple water use systems. The diverse tradeoffs between sectors, activities and users will be evaluated and valued in order to identify adequate management scenarios (based on MUS characterization), including sustainable resource mobilization for operation and maintenance of managed water resource systems.

Important lessons can be learnt from communities' existing ways of management and governance, including their priorities for improvements, except in the case of refugees. There is a need to assist rural communities to get better access to water resources, improve efficiency of water use, and sustain aquatic ecosystems. Genuine participation of stakeholders will be promoted to enhance their engagement in seeking solutions to issues of multiple use of water and develop conflict resolution mechanisms where needed.

While respecting and learning from existing community practices is essential, equally important is to understand how to change existing governance mechanisms that keep the poor and marginalized people from accessing or sharing in the benefits of such systems. The heaviest transaction costs actually lie in the changes in governance. Understanding change processes will be a necessary focus of research in this sub-topic.

In many cases participation will expand into water management institutions, converting farmer's associations in irrigation systems to representative water users' associations by bringing in other users, or including representation from multiple government agencies, and creating mechanisms for negotiating between different interests. Integrated water management is often impeded by institutional and governance divisions. Enhanced coordination between respective institutions (water resources, irrigation, crop, livestock, fisheries, forestry, water user groups, environment, etc.) will be promoted via Challenge Program concerted efforts of Topics at local, catchment and basin scales (see also Section 5 - CPWF added-value). In particular current uncertainty and instability of both global food and energy markets, and climate change, prompts a need to seek to build resilience, flexibility and adaptability into the design and management of MUS.

Enabling policies and institutions at scales above community

Investment strategies for multiple-use systems and social, economic and ecological tradeoffs required to establish a national policy should be supported by public debates and be the result of a consensual approach with political support. The range of available options for policy is inevitably constrained by natural resource endowment and location, together with a host of technical, financial, environmental, social and cultural factors. Objectives (and targets etc.) are largely derived from society's values (or ethics), which can be a road block for more equitable sharing. These elements need consideration in the research undertaken regarding enabling change.

The policy, investment, regulatory and institutional frameworks need to reflect these factors and at the same time be open and sufficiently flexible to allow improved approaches for MUS to evolve. Because of knowledge gaps identifying what to avoid may be easier and a preliminary step to identifying essential supporting conditions. In general it will be important to be free of any unnecessary or inappropriate bias against specific technologies or governance arrangements.

The importance and effectiveness of the following requires investigation:

- Surface and groundwater infrastructure construction and rehabilitation strategies for multiple uses and sustained investments to ensure effectiveness over time

- Integrated service delivery structures through collaborations between water users, local government, line agencies, NGOs, and private providers

- Designation, clarification and/or enforcement of property rights for common and privately owned resources Linkages between property rights regimes and public investment decisions and appraisal and compensation mechanisms

- Linkages between property rights regimes and private investment decisions, including influences on access to credit (i.e. investment and working capital)

- Management regimes or the lack thereof, community based or otherwise, for resources that remain open access

- Description of the authorities for decision-making for strategic level-planning and project-level decisions, so that responsibilities are clear

- Procedures for cross-sectoral coordination, including reconciling responsibilities under different legislation

- Avoid subsidies that can distort comparison of alternatives and unduly bias investment in single water uses

- Disclosure policies in information used in public decision-making

- Legislation and regulation requiring that a diverse set of options for water allocation and management are examined

- Environmental and social impact assessment at both strategic and project-level decision-making

- Clear and gender-sensitive descriptions of the rights and risks of affected people and the mechanisms for compensating for lost rights

- General right to form organizations that represent stakeholder interests

- Procedures for submission and processing of objections to policies or projects, including reasonable time frames for doing so, and

- Clear arbitration procedures for objections and complaints.

Achieving effective and equitable multiple use systems may require changes in informal and even more so in formal water rights regimes, especially women's rights of access to water and priority allocation of water resources for small-scale rural (and possibly per-urban) uses. Explore the different sources of water rights (state, religious, customary) but also at rights to related resources such as land, animals or trees.

CPWF niche and added-value

Water is a CGIAR system priority and a focus of the MDGs, and the Challenge Program on Water and Food (CPWF) brings together a unique collection of CG Centers, NGOs, advanced research institutes, government and the private sector to address this topic. Transdisciplinary research and analysis across sectors and scales are at the core of the CPWF.

Implementation will be supported by the close collaboration with the other CPWF Topics, e.g. with Topic 1 for improving productivity of rainfed agriculture (e.g. through agricultural diversification, nutrient cycling and supplementary irrigation), and with Topic 3 for sharing of benefits at catchments and river basin scales (e.g. the relationships between land use and river basin hydrology and water allocation). Collaboration with Topic 4 will support analysis of global drivers and externalities, and their implications on MUS outcomes and processes of change (see App., linkages with Topic 3 and 4).

One key innovation is engaging water professionals to consider implications of smaller scale processes in a trans-disciplinary context. Other areas of innovation include:

- Using empirical evidence via case studies in the relevant river basins and selected countries to enhance methodological rigor in the analysis of costs and benefits and other aspects of MUS

- The CPWF's emphasis of Phase 2 based on priorities identified by river basin stakeholders and addressed through development oriented and problem-solving approaches

- Using participatory and gender-sensitive approaches to research implementation: partnership for genuine participation and engagement in solving water related problems; networks, use of role-playing games, linkages between science and stakeholders, local partners, managers and policy-makers, and

- Fostering partnerships between researchers and users of research, and facilitating the out-scaling of the research results for investments in the basins.

- CPWF targets research impact in both science (e.g. production of IPG, International Public Goods) and development. The out-scaled deployment of promising MUS packages will be analyzed at catchment and river basin scales (the latter via Topics 3 and 4). This includes turning innovation into investable projects and exploring what the aggregate impacts of widespread introduction are likely to be.

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