Stories from the Field: Most Significant Change (MSC) Synthesis

Challenge Program on Water and Food (CPWF)

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Contents

List of Tables

Executive summary

In January of 2007, a number of people working with the CGIAR Challenge Program on Water and Food (CPWF) were invited to tell stories about the "most significant change" (innovations or partnerships) they had observed as a result of CPWF activity. This paper aims to pull together some of the threads emerging from these stories, weaving them into a fabric that gives insight into CPWF approaches and achievements.

The most significant change (MSC) technique was developed to more effectively monitor and evaluate complex participatory rural development programs in which there is diversity in both implementation and outcomes. It has been referred to as "monitoring-without-indicators" (MSC does not make use of pre-defined quantitative indicators) or "the story approach" (answers to important questions about change are felt to be most readily found in stories of who did what, when and why).

Authors of CPWF MSC stories included Theme Leaders, Basin Coordinators, Project Leaders and Principal Investigators. Most stories were based on experiences in "first call" Competitive Grant Projects. Others emerged from Basin Focal Projects or Small Grant Projects. Authors of stories were self-selected. A total of 54 MSC stories were submitted. These stories were compiled and sent for analysis and screening to key CPWF leaders.

Two categories of stories were requested – one on "the most significant technical development/advance" and the other on "the most significant partnership change". Within the former, there are stories on technical innovations, institutional and policy innovations, and information and knowledge management. Within the latter, stories were submitted on field-level partnerships, basin-level partnerships, and capacity-building.

Some MSC stories focus on only one of the above categories. Many, however, discuss to a greater or lesser degree the interrelationships among categories, e.g., how an institutional innovation enabled widespread use of a new technology. More than half of the stories are also linked to a specific production environment, e.g., dryland, irrigated or rice-based, salt-affected, or aquatic. These are predominantly stories about technical innovations, and the institutional innovations and partnerships contributing to their success. The remaining stories tend to focus on conceptual frameworks, information and knowledge management, and institutional and policy innovations not closely tied to any particular technology.

Looking at the stories as a group, some common threads emerge:

- Many stories described the development and initial adoption of new technologies. The fact that no stories described widespread technology adoption is not particularly surprising. At the time the stories were submitted, the CPWF was only two years old. The changes described in these stories might be interpreted as steps along "impact pathways"[1] that will ultimately lead to widespread adoption and impact.

- A large proportion of stories described the development of intermediate products. These include conceptual frameworks, enhanced stakeholder capacity, partnership arrangements, and information or knowledge that influences research priorities. It would be helpful to locate these intermediate products on "impact pathways" so as to better understand their true significance.

- In many instances, CPWF projects were described as building on foundations laid by previous research initiatives. Such value-added research can be enormously efficient, representing a wise use of resources. Other stories made little mention of the foundations from which "significant change" emerged.

- There were a number of stories on institutional innovations. Many of these highlighted the close, complementary relationship between institutional and technical innovation. In several instances, technical change was only possible because of complementary institutional change.

- Although some stories looked closely at downstream and cross-scale consequences of innovation, others stories did not. Such stories might be considered as missing a chapter.

- Relatively few stories were submitted on policy innovations, although most acknowledge the potential importance of research in informing policy decisions.

- For the most part, a good case was made that CPWF projects had accelerated research along "impact pathways" faster or farther than would have been the case without CPWF involvement.

If we were asked to name a single lesson emerging from the combined MSC stories, it would be the importance of interpreting significant change in the context of "impact

[1] Impact pathway analysis has been used at least since the early 1990s. It is ". . . based on program-theory evaluation from the field of evaluation, and the experience of the German development organization GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit GmbH)." (Douthwaite et al, 2003).

pathways". These portray the logical sequence of events whereby threads of research and development, involving multiple interrelated stakeholders, evolve and progress towards a "tipping point" of generalized adoption or application of an innovation. Impact pathways provide a context for understanding the importance of building on earlier achievements, the value of intermediate projects, the lessons to be learned from early adoption, the distance remaining to reach a tipping point, and the steps required to do so. Impact pathways reveal the whole cloth, produced when threads of research and development are woven together.

In general, the CPWF MSC stories combine to tell a tale of accomplishment and progress of substantial breadth and depth. And these stories continue to be written, in action if not necessarily on paper. The next round of storytelling promises to be enormously interesting.

Background

In January of 2007, a number of people working with the CGIAR Challenge Program on Water and Food (CPWF) were invited to tell stories about the "most significant change" (MSC) they had observed as a result of CPWF activity. They were guided by two questions, posed to establish the stories' domain and time frame of interest. These were:

- "What has been the most significant technical development/advance made by your CPWF project / theme / basin since the start?"
- "What has been the most significant partnership change (significant in terms of making scientific progress and/or developmental impact more likely) that has taken place since the start of your CPWF project (or theme or basin)?"

This paper aims to pull together some of the threads emerging from these stories, weaving them into a fabric that gives insight into CPWF approaches and achievements.

CPWF

The CPWF is an international, multi-institutional research initiative that brings together scientists, development specialists, and river basin communities in Africa, Asia and Latin America. It seeks to create and disseminate international public goods (IPGs) to achieve food security; reduce poverty; improve livelihoods; reduce agriculture–related pollution and water-related diseases; and enhance environmental security. The CPWF has a clear objective: "To increase the productivity of water for food and livelihoods, in a manner that is environmentally sustainable and socially acceptable."[2] Increased water productivity – producing more food with less water – is seen as the hinge on which all else turns.

MSC [3]

The most significant change (MSC) technique was developed to more effectively monitor and evaluate complex participatory rural development programs in which there is diversity in both implementation and outcomes. It has been referred to as "monitoring-without-indicators" (MSC does not make use of pre-defined quantitative indicators) or "the story approach" (answers to important questions about change are felt to be most readily found in stories of who did what, when and why).

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[2] Full proposal submitted by the CPWF at the CGIAR Annual General Meeting, Washington, DC, October 2002.

[3] This section draws on Rick Davies and Jess Dart, 2005. "The 'Most Significant Change' (MSC) Technique: A Guide to Its Use". www.mande.co.uk/docs/MSCGuide.htm

In the MSC technique, stories are collected from those most directly involved with the change process. These stories are elicited by asking the kinds of simple questions such as those shown above. Respondents are asked to describe why they consider a particular change to be the most significant one. The stories are then analyzed and filtered up through the levels of authority typically found within an organization or program.

MSC has been found particularly useful when change takes unexpected forms, reasons for change are as important as its direction and extent, program activities feature participatory methods, or traditional indicators are difficult to identify or measure.

Stories and authors

Authors of CPWF MSC stories included Theme Leaders, Basin Coordinators, Project Leaders and Principal Investigators. Most stories were based on experiences in "first call" Competitive Grant Projects. Others emerged from Basin Focal Projects or Small Grant Projects.[4] "First call" Competitive Grant Projects are the result of the CPWF's first call for proposals, announced in late 2002. Project selection was based on compatibility with CPWF objectives, congruence with CPWF priorities, scientific merit, quality and institutional mix of the research team, degree of stakeholder participation, likely impact on beneficiaries, and value for money.

Authors of stories were self-selected. Not all Theme Leaders, Basin Coordinators, and Project Leaders and Principle Investigators chose to submit a story. Of 33 "first call" Competitive Grant Projects, 19 are represented in one or more stories. Of the nine benchmark basins, all but one are represented. There is, however, a relative abundance of stories from the Indus-Ganges, Limpopo, Mekong and Nile basins. All five CPWF themes are represented. A total of 54 MSC stories were submitted.

After submission, stories were compiled and sent for analysis and screening to key CPWF leaders. These included the CPWF's five theme leaders, who provide scientific leadership for the Program, and the management team member responsible for gender, institutions and participation oversight. This group selected those stories they considered to be the most significant, and provided reasons for their choices.

The stories are not a comprehensive audit of CPWF impact. They do not provide a detailed, systematic and comprehensive accounting of the progress that can be attributed to CPWF activities. In fact, most of them are brief, rarely extending beyond 2-3 pages,

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[4] Project categories are described in more detail in the CPWF web site www.waterandfood.org/

and in some of them the link between CPWF work and the "most significant change" of interest is less clear than would be desirable. Rather than a check on accountability, the stories should be seen as an opportunity for learning.[5]

Categories

Two categories of stories were requested – one on "the most significant technical development/advance" and the other on "the most significant partnership change". Within the former, there are stories on technical innovations, institutional and policy innovations, and information and knowledge management. Within the latter, stories were submitted on field-level partnerships, basin-level partnerships, and capacity-building. All of these categories are, of course, linked.

Technical innovations affect how plants or animals grow, how water is used in agriculture, and how it flows across a landscape. When properly designed and widely adopted, technical innovations can lead to increased farm-level and basin-level water productivity, with more food being produced with less water.

Institutional and policy innovations can influence peoples' incentives for using technical innovations. Sometimes technical change is not even possible unless accompanied by complementary institutional change. Institutional and policy innovations can also influence access to water by different uses and users. Basin-level water productivity can be increased by providing incentives to reallocate water towards high-productivity uses.

Information, the product of research, is in itself a raw material or resource that can be harnessed and used to foster technical, institutional or policy innovation. Partnerships, by bringing people together in innovative ways, can be an important means of generating and sharing information.

Some MSC stories focus on only one of the above categories. Many, however, discuss to a greater or lesser degree the interrelationships among categories, e.g., how an institutional innovation enabled widespread use of a new technology.

Apart from the above categories, more than half of the stories are also linked to a specific production environment, e.g., dryland, irrigated or rice-based, salt-affected, or aquatic. These are predominantly stories about technical innovations, and the institutional innovations and partnerships contributing to their success. The remaining

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[5] The CPWF might wish to undertake such a "detailed, systematic and comprehensive accounting of progress", using methods other than MSC.

stories are consolidated into a "cross-environment" group. These tend to focus on conceptual frameworks, information and knowledge management, and institutional and policy innovations not closely tied to any particular technology.

The distribution of CPWF MSC stories across categories, basins and production environments is shown in Annex 1.

About technical innovations

Most CPWF MSC stories dealing with technical innovations have one thing in common – a focus on water productivity for improved livelihoods. This is in accord with the CPWF objective, "To increase the productivity of water for food and livelihoods, in a manner that is environmentally sustainable and socially acceptable". This emphasis is visible in stories from all four production environments.

Two stories, however, cut across environments. These describe the formulation of an overall crop water productivity conceptual framework, designed as a way to systematically distinguish between technologies that truly increase water productivity from those that only re-distribute it among users. The framework was developed in response to a proliferation of CPWF and non-CPWF projects claiming to have identified "water-saving" technologies.

The first story lays out the issue.

"*The challenge to produce more food with decreasing water availability has led to the notion that crop water productivity (WP) needs to increase. However, the debate on how to increase WP is confounded by different definitions and spatial and temporal scales of analysis, and poor understanding of what constitutes a "real" water saving. For example, water savings at the field level . . . do not always translate into water savings at a regional level (where the losses at the field level can be captured and reused elsewhere in the system). Furthermore, merely increasing water productivity may not solve the dual challenges of increasing food production . . . and saving water.*" (1)[6]

The "significant change" lies in the development of the conceptual framework itself (shown in Annex 3) which ". . . *provides a systematic means of identifying potential interventions that can increase food production while saving water, at a range of scales from the plants to region. The framework is based on generic principles that can be readily applied across cropping systems, environments and spatial scales. It will assist CPWF projects that aim at improving crop water productivity.*"

[6] Numbers in parentheses refer to the number of the MSC story. A list of stories is given in Annex 2.

The “generic” principles in question are as follows: enhancing marketable yield of crops per unit of water transpired by the crop; reducing outflows of water from the domain of interest and atmospheric depletions other than crop stomatal transpiration; increasing non-irrigation water inflows into the storage pool; and increasing the size of the storage pool in time and space. Each principle is accompanied by examples of how it can be applied in practice.

A complementary story describes how the development of this conceptual framework was accelerated by a series of back-to-back meetings among scientists from the CPWF and from the Comprehensive Assessment of Water Management in Agriculture (CA) – all of whom were working on crop water productivity. (13)

Remaining CPWF MSC stories on technical innovations were tied to specific environments: dryland, irrigated or rice-based, salt-affected, and aquatic.

In dryland environments

There are thirteen MSC stories on technical change in dryland environments. Of these, two focus on germplasm, four on rainwater harvesting, one on farmers’ strategies for adaptation to climate change, and three on wetland management and small irrigation. In addition, three complementary stories describe the role of partnerships in developing and adapting new technologies.

Germplasm and participatory varietal selection

Both stories about germplasm focus on Eritrea. Interestingly, neither story discusses drought tolerance (as might be expected in narratives about a dryland, drought-prone environment) but rather disease resistance. Nonetheless, both describe efforts to increase yields with the limited water available.

The first story focuses on lentil, the production of which is limited by disease pressure. Through participatory varietal selection, one particular line of disease-resistant lentil was chosen by both men and women farmers. Seed is being distributed, village seed production is being organized, and plans are being made for scaling out.

“*Lentil is an important cash crop in Eritrea but production is seriously limited by biotic stresses, the most important being wilt and rust . . . In 2005 a high-yielding lentil line (ILL 7978) . . . was identified. It yielded, under rainfed conditions and without additional inputs, nearly three times more than the local check. It was not affected by wilt and rust . . . and being small seeded, was the most preferred by farmers . . . In 2006 the line was added as check in the initial participatory lentil trials planted in three* *villages . . . the line's superiority was confirmed when it ranked first in [test villages]. During farmers' selection, the line received the highest or amongst the highest score by both men and women.*" (8).

The second story is similar to the first. Once again participatory varietal selection was used to identify a disease resistant variety, this time for wheat. Initial adoption, local seed production and plans for scaling up and out are the outcome.

"*Yellow rust . . . is a serious threat to wheat production in the highlands of Eritrea . . . Most cultivars in most wheat growing areas of the highland are highly susceptible to this disease, especially if rainfall is favorable . . . for the past two years [the project] has been exposing farmers to resistant material . . . Farmers selected for resistance against the disease, plus other agronomic characters such as earliness, plant height, spike length, spike density, grain size, and grain yield . . . In 2006, twenty resistant genotypes with attractive agronomic attributes were selected by a total of 131 farmers (51 females and 80 males) from 8 villages in 4 locations . . . Farmers . . . requested seeds of the selected genotypes.*" (7)

A complementary story describes how partnerships between farmer groups and research institutions facilitated progress.

"*In 2006 researchers from the Ministry of Agriculture and the University of Asmara, seed technologists, extension agents, and farmers worked closely together to establish village-based seed enterprises and to implement field activities. This made it possible to establish integrated sites in farmers' fields, where several activities were implemented by different institutions and disciplines.*" (14)

Water harvesting

The four stories on water harvesting describe a range of practices being tested and adapted in three different basins.

The first story comes from the Limpopo. It tells how farmers in a drought-prone area of Zimbabwe, through community organization and participatory methods, became interested in and began to adopt water harvesting practices (some of which had been around for decades). These practices, which include tied-ridges and planting basins, were complemented by the introduction of improved sorghum varieties. The story ends with a call for capacity-building, investment in scaling up and out . . . and more research.[7]

"*Persistent rainwater shortages . . . in the region have led to food shortages. Research and development efforts from Chiredzi Research Station . . . engaged with some of the communities in the surrounding*

[7] A complementary story describes an emerging partnership among CGIAR Centers, NARES, farmers, extension workers, local leaders, retailers, policy/decision makers, and NGOs. This partnership is said to be key to the adaptation and use of new sorghum varieties, fertilizer, and water harvesting practices. (9)

areas since 1981 and covered aspects of soil and water conservation techniques including tied furrows, pot-holing, mulching, planting dates, moisture tolerant varieties and crops, growth durations and fertility. Farmers' level of appreciation and desire to participate and adopt/adapt was notably absent or very low before . . . [but with participatory approaches] . . . farmers are clamoring to participate . . . to a point that the R&D teams are beginning to feel overwhelmed by the demand . . ." (11)

Two interrelated stories come from southern Uganda, in the Nile basin. They tell of extension efforts on soil and water conservation, compost use, water harvesting, and organic farming. Water harvesting practices feature water storage pits rather than tied/ deepened furrows. Diversification of agroecosystems into fruits and vegetables was part of a strategy that benefited about 90 farm families.

"*Subsistence farmers formed three groups of thirty members each . . . They trained in soil and water conservation . . . We provided practical demonstration [sic] in water harvest, soil moisture retention and soil erosion reduction . . . We also helped established communal plant nurseries . . . We provided "on farm advice", responding to individual needs and addressing the interests of even the most timid participants. We also introduced the use of polythene to line water storage pits fed from surface run off, covered with wood logs and soil spread over to allow growing of vegetables with shallow roots.*" (51, 54)

The story concludes with a suggestion that these practices be extended to neighboring villages. Little is said, however, about the feasibility of extensive use of compost on large areas, or utilization or marketing of high value diversification crops.

A story from Rajasthan in India puts a very different spin on "water harvesting". In this story, harvested water is not immediately exploited for agriculture, but rather is used to recharge groundwater reserves. In this way water that otherwise would be been lost to evaporation or run-off is preserved for future use within the community.

"*Eighty recharge systems were constructed in the villages, with four models: rooftop rainwater harvest through recharge pits; through dried hand pumps; through dug wells; and through deep bore. Water recharge structures were made in three village johads (crescent-shaped earthen check-dams) with the consent and participation of the community. A system has been developed whereby the bore wells nearest to the johads have been calibrated and the water level measured both before the onset of the monsoons, after the monsoons, and once in 15 days during the monsoon. For comparison, measurements will also be taken from the tube wells which are in the village . . . We already have got promising results from the water recharge in Village Dughera. Here it was observed that one tube well near the johad has an increase in water table by 2-3 feet. This has been very encouraging for the villagers . . ."* (53)

So far, around 3000 people are said to have benefited. Presumably, the observed increase in groundwater levels represents a positive, long-term trend, not just an ephemeral change associated with one or two rainfall events. The story does not discuss possible reductions in water availability for downstream water users.

Adaptation to climate change

The sole story on adaptation to climate change starts with farmers in South Africa and Ethiopia claiming to perceive long-term changes in rainfall and temperature patterns. As a consequence, they begin to take up farming techniques that improve the capacity of their farm systems to cope with increased climate variability and drought risk. (Curiously, no mention is made of water harvesting practices.)

"*[The] majority of farmers in the Limpopo [South Africa] . . . and the Nile Basin [Ethiopia] . . . are aware of long-term changes in precipitation and temperature. In response to higher temperatures and decreased rainfall, farmers have developed different adaptation strategies to mitigate some of the negative impacts . . . They range from irrigating more, changing crop varieties or crops, shifting planting dates, to stopping farming as an activity and instead investing in livestock. Farmers adopt different adaptation strategies in response to changes in rainfall and temperature changes. While adoption of a new crop variety is the main strategy used to adapt to rising temperatures, water harvesting schemes and increasing irrigation is the primary adaptation strategy to decreased precipitation.*" (39)

The question arises as to why only about half of surveyed farmers have changed their practices. Reasons for non-adoption are said to include lack of information, lack of credit, and lack of access to water. It is suggested that these constraints to adoption can be addressed through suitable policy changes. Note that "adaptation to climate change" is taken to mean "adoption of practices to increase agroecosystem resilience". These are the same practices often used to manage risk in drought-prone climates, regardless of whether these climates are perceived as changing.

Wetland management and small irrigation

Of the three stories on wetland management and small irrigation, two come from the Limpopo and one from the Andes basin. "Wetlands" in this context are understood to be relatively low-lying areas where water and soil tend to collect. Compared to surrounding dryland areas, they typically have deeper soils with more moisture.

One of the Limpopo stories describes an effort to generate information on trade-offs among alternative uses for wetlands. Alternatives include crops (rice and maize), livestock, fisheries and others (e.g., collecting reeds for making mats).

"*In our research we are . . . integrating disciplinary analysis (for hydrology, socio-economics, agronomy, and ecology) [in a framework] . . . that allows analysis of tradeoffs in wetland environments. Data has been gathered and is used to quantify tradeoffs among wetland uses . . . As the project progresses farmers are more open to changing management of wetlands. They are experimenting with different methods of water management to suit the crops they grow . . . Hydrological analysis is used to quantify the changes in water balances brought about by this management while socio-economic and livelihoods analysis is used to quantify the livelihoods benefits such as food and income.*" (25)

In principle, trade-off analysis can also produce information on the value of environmental uses of wetlands, or downstream and cross-scale consequences of changes in wetland management. This particular chapter, however, has not yet been written.

" . . . *What we have not been able to do in this project . . . is to focus on global benefits and tradeoffs. This is an important area of the research as it is evident that there are cases where positive tradeoffs at local level result in negative tradeoffs if a wider (more global) system boundary is considered . . .*" (25)

Of the two stories on small irrigation, the first tells about the introduction of drip irrigation in Zimbabwe. Drip systems were successful in increasing water productivity but not labor or land productivity. Furthermore, smallholder farmers often lacked access to even the small amounts of water needed for drip irrigation. In some instances, the introduction of drip systems caused problems for downstream water users. In this context, strategies for distributing drip systems were revised and improved.

"*The results show that although drip kit distribution programs in the study area have achieved some of their objectives and save around 50 % on water use . . . drip kits are under-performing due primarily to poor access to water. Many of the poorest farmers share water resources with other irrigators and with other, higher priority uses, such as livestock watering and domestic use. It is therefore not suitable to offer drip kits to the poorest of the community without improving their access to water at the same time*" (24)

The second story on small irrigation comes from the Andes. It describes the experiences of several families who tapped a mountain-side water source, brought it to their farms in a closed pipe, and used it to irrigate feed and fodder crops, and trees.

"Alfonso and Olga could not produce enough to feed their family on their one-hectare farm. The region where they lived was semi-arid . . . After visiting farmers who made innovations with water harvesting

and micro-irrigation under similar conditions, Alfonso proposed to two neighbors that they tap a water source high up in the mountainside, some two kilometers from their farms . . . [Alfonso explained] how his neighbors and he worked endless weekends, and they invested about $600 in hoses and assorted materials. Most recently, they had dug storage ponds of about 10,000 liters each that they lined with clay. Now, they were experimenting with micro-irrigation. "Once I had water, I could grow that small plot of alfalfa. With the alfalfa, I could have cuy (guinea pig) . . . just the cuyes, we have already paid back our $200 investment in materials [sic]. Now I can stay home with my family. With the manure, I've planted 75 mango and avocado trees. My farm has become an oasis . . ." (49)

The story suggests that water harvesting in the mountains might be similarly feasible for many thousands of farm families. The story says little about whether other users (including the environment) were already using this water.

Significant changes and the role of the CPWF

Based on the above, two questions come to mind: In each story, what precisely was the "significant change" and what was the CPWF's role in making it happen?

As a rule, the "significant changes" described in these stories are early steps in technology selection, adaptation and adoption. Although few farm families are said to have benefited so far (the numbers range from less than 10 to a few hundred), the future is typically portrayed as full of promise. At times, however, the stories themselves raise doubts regarding the likelihood of widespread adoption.

Some stories (for example, on drip irrigation in Zimbabwe) describe research that is sensitive to the downstream, cross-scale and equity related consequences of technical innovations. Others, however, do not take account such consequences into account.

In general, projects are described as building on and adding value to prototype technologies or improved germplasm developed in earlier research. The CPWF is often portrayed as having accelerated the development and dissemination of innovations, beyond what would have been the case without CPWF involvement (Table 1).

Table 1. Selected significant change stories for dryland environments

Story	Kind of change	Commentary
Disease resistance varieties (7, 8, 14)	In technology selection and initial adoption	Participatory varietal selection leads to farmer selection of improved lines, and then to seed production and scaling out.
Water harvesting and related technologies (11, 51, 53, 54)	In technology selection and initial adoption	Farmers adapt and finally begin to adopt water harvesting and related practices, some of which have been locally known for decades. Key is participatory research and knowledge sharing among farmers.
Adaptation to climate change (39)	In technology selection and initial adoption In understanding and awareness (policy)	Farmers perceive changes in climate and begin to adopt practices to increase agroecosystem resilience
Analyzing trade-offs among alternative uses for wetlands (25)	In understanding and awareness (research priorities)	Information on costs and benefits associated with different uses for wetlands
Drip irrigation systems (24)	In understanding and awareness (policy)	Drip irrigation systems may not be suitable for smallholder farmers when they lack access to water and when these systems lead to conflict with downstream water users
Small irrigation in the Andes (49)	In technology selection and initial adoption	Three farmers tap a mountain-side water source and introduce micro-irrigation

In irrigated or rice-based environments

There are seven MSC stories on technical innovation (and complementary partnerships) in irrigated or rice-based environments. These are defined as cropped areas with irrigation <u>or</u> areas dominated by rice-based systems regardless of whether they are irrigated. (Salt-affected areas are discussed separately). Of these stories, four focus on germplasm, two on ecosystem services and IPM, and one on groundwater.

<u>*Aerobic rice*</u>

Two stories describe changes associated with the development of aerobic rice systems (rice grown under non-flooded and non-puddled conditions, like wheat or maize). Aerobic rice varieties were first developed for temperate areas in China where water scarcity rules out production of lowland puddled rice, or where the possibility of flooding makes growing maize or cotton excessively risky. Aerobic rice can be produced with less water than puddled rice, and with less risk than maize or cotton.

The initial story is divided into two parts. First, CPWF research confirmed that aerobic rice can in fact produce high yields while using relatively little water.

"*Using a combination of well-designed field experiments, monitoring farmers' performances, and crop growth simulation modeling, we confirmed that aerobic rice yields of 3.8-5.6 t ha-^{1} are obtainable with groundwater tables deeper than 2 meters, with only 2 to 3 supplemental irrigations (150-225 mm) and rainfall of 115-670 mm . . . lowland rice in the same environments produced 6-9 t ha-^{1}, but required 900-1,300 mm of combined rainfall and irrigation water with groundwater tables of 20 to 30 cm depth. Moreover, it was experimentally demonstrated that aerobic rice can withstand prolonged flooding.*" (3)

Then, the CPWF initiated research to develop aerobic rice varieties suitable for the <u>tropics</u>, unlike the <u>temperate</u> varieties developed in China.

"*The project builds on work in northern China, where breeders have produced temperate aerobic rice varieties with a [high] yield potential . . . and that use only 50% of the water used by traditional, irrigated lowland rice varieties. The project aims to develop aerobic rice varieties for the tropics and crop-soil-water management practices for growing tropical . . . "aerobic rice" that combines drought resistance of upland rice with high yield characteristics . . .* " (Bouman et al, 2007)

The excitement of the story lies in its future prospects: Imagine China with 5m ha of aerobic rice. How much water could be used for purposes other than rice production?

"*With increasing water shortage in traditional rice-based cropping systems, field conditions will become more aerobic (less flooded conditions) with adoption of alternate wetting and drying, aerobic rice, and upland crops. This will have major implications for sustainability . . . and ecosystem services . . .*" (3)

A complementary story focuses on opportunities for extrapolating aerobic rice technologies beyond China. First, it tells how the CPWF Impact Project, through the use of modeling and GIS, was able to identify unexpectedly large extrapolation domains for aerobic rice.

"*Potential extrapolation domain (ED) areas for aerobic rice are calculated using Homologue and Weights of Evidence modeling that look for similar agro-ecological and socio-economic conditions to those found in project pilot sites. The analysis shows highest probability areas are all in Asia. In India, the extrapolation domain is largely centered on the rice-wheat systems in the Indo-Gangetic basin. In Thailand and Burma the areas are centered on rainfed lowland areas. The analysis finds large areas that are suitable climatically in Africa in Zimbabwe, Mozambique, Madagascar, Burkina Faso and Nigeria, and in Latin America, in Brazil, Bolivia and Venezuela.*" (Bouman et al, 2007). Annex 4 shows aerobic rice ED areas in Asia.

It then goes on to describe how partnership arrangements, in part inspired by the results of previous extrapolation domain analysis, were developed to facilitate testing of aerobic rice technology in South Asia. By making use of existing networks (and with the assistance of special project funding obtained from the Asian Development Bank (ADB)) partners were able to increase research efficiency by avoiding duplication of effort.

"*The partnership . . . between STAR [the network developing aerobic rice technology] and the ADB project [to support aerobic rice testing in South Asia] . . . ensures that no work gets unnecessarily duplicated, that resources are optimally utilized, and that results and ideas get shared in early stages of development. The ADB project could make a 'flying start' and benefit from STAR's experiences.*" (4)

Upland rice in Laos

Two other stories portray the potential gains from introducing new rice varieties into farming systems in the uplands of Laos.

"*Upland, traditional glutinous rice, commonly grown under slash-and-burn system, yields an average of 1.5 tons per hectare. Introduction of improved non-glutinous upland rice varieties has clearly demonstrated that yield can be increased up to 2 t/ha . . . using farmers' standard practice . . . Yields can be boosted to 4 t/ha with production inputs.*" (15)

This opportunity seems somewhat less compelling than that for aerobic rice. Research is just now beginning and the knowledge base is thinner. Moreover, as admitted by the stories' authors, opportunities for widespread adoption may be inherently limited. A ". . . *preference of Laotians for glutinous rice [may limit] wide adoption of non-glutinous rice cultivars.*" (15).

A complementary story on partnerships makes it clear that the introduction of new varieties will be done through participatory varietal selection, reducing the likelihood that materials unacceptable to farmers will be chosen. Interestingly, the source of the improved germplasm is the neighboring province of Yunnan, in China.

"*A platform for multi-institutional collaboration for evaluating improved rice technologies was established in Laos. The platform facilitated the importation of seeds of improved rice varieties from Yunnan for testing and evaluating [sic] on-station and on-farm under the Lao upland conditions. Seeds of improved varieties developed at YAAS were distributed in small quantities to more than 300 Lao rice farmers for testing and evaluation.*" (16)

Ecosystem services and IPM

System ecology was the focus of the next two stories. The first of these tells how researchers from the Comprehensive Assessment of Water Management in Agriculture and from CPWF Theme 1 joined forces to develop an assessment of "Rice and Water". Through a joint workshop, they became aware that rice fields produce more than rice – they also produce ecosystem services.

". . . *rice production was only one of the many ecosystem services provided by rice landscapes. Rice fields seem to provide very unique, but often unrecognized, ecosystem services such as providing a habitat for birds, fish and other animals, recharging groundwater, mitigating floods, controlling erosion (through terraces), flushing salts from the soil, providing water filtration, sequestering carbon, and regulating temperature/climate.*" (2)

They concluded that it is important to take account of ecosystem services when studying changes in water management and hydrology.

". . . *there is little understanding on how water scarcity (or other major hydrological changes such as increased flooding and salinization) will affect the other ecosystem services from rice landscapes and what options exist to safeguard valuable ecosystem services and minimize damage to the environment with major hydrological changes.*" (2)

The next story tells how a community of farmers in Rajasthan learned to control insects by surrounding cotton fields with a trap crop, "ladies finger" [sic]. Thinking that crop damage was in part due to water stress, some farmers had begun to increase the number of irrigations. Farmer testing showed that higher cotton yields could be obtained with fewer irrigations as long as the trap crop was also planted.

"*The logic was that since the pests which attack cotton and ladies' finger are the same, the introduction of a trap crop will reduce the attack of sucking pests. The farmer used two irrigations in the model plot, whereas the control plot had three irrigations . . .*" (52) Yields were higher in the "model plot" with the trap crop, despite having less water applied. Higher yields from less extracted water resulted in increased field-level water productivity.

Groundwater management

The final story focuses on groundwater. It begins with a recognition that groundwater depletion and groundwater governance are overwhelmingly complex, and that many stakeholders are keenly interested in groundwater management but that few of them command have the necessary range of expertise.

"*One of the key constraints to proper groundwater management . . . is the lack of inter-disciplinary capacity within existing structures for developing, utilizing, allocating and safeguarding water resources. Typically, the development of groundwater is within the hands of technical staff, with little knowledge of environmental and socio-economic impacts. Allocation of groundwater . . . may be controlled by politicians, legal advisors, with the help of economists or simply driven by open market mechanisms. Safeguarding of the resources and the associated health and livelihood benefits (in the lack of pro-active and institutionalized controlling mechanisms), is driven by environmentalists, self-driven activists, NGOs with support from international donors and local to global coverage media.*" (34)

The answer, it is suggested, lies in capacity-building, carried out in areas where groundwater problems seem most intractable. Since groundwater issues show considerable similarity across countries, a CPWF capacity-building program was developed with international participation. The result is an " . . . *an innovative and unique concept of inter-disciplinary capacity building cum knowledge sharing, action research, policy dialogue and awareness raising through media coverage within groundwater governance.*" (34)

Significant changes and the role of the CPWF

In each of the above stories, what was the "significant change" and what was the CPWF's role in making it happen?

As with stories on dryland environments, authors did not identify "significant change" in terms of the widespread adoption of a new technical innovation. Instead, they identified as significant any kind of change that was perceived to increase the likelihood that a technology might be widely adopted in the future. In other words, these were stories about impact pathways.

The stories mostly described intermediate changes: in awareness and understanding (from new information), in the research agenda (reflecting investment in new opportunities), and in the ability of stakeholders to deal effectively with complex problems (through capacity-building). Only one story focused on technology adoption as such and even here adoption was in its very initial stages.

For the most part the role of the CPWF was clear – all projects were part of the CPWF and, in most cases, it was clear that the change would not have occurred without CPWF involvement (Table 2).

Table 2. Selected significant change stories for irrigated/ rice-based environments

Story	Kind of change	Commentary
Confirmation of aerobic rice performance (3)	In understanding and awareness (research priorities)	Information on aerobic rice yields and water use in water-scarce temperate areas of northern China
Aerobic rice germplasm development (3)	In understanding and awareness (research priorities)	Research program launched to develop aerobic rice varieties suitable for tropical areas
Aerobic rice extrapolation domains	In understanding and awareness (research priorities)	Information from modeling and GIS on extrapolation domains
Partnership for aerobic rice testing in South Asia (4)	In partnerships	Partnership for aerobic rice testing in South Asia
New upland rice varieties for Laos (15, 16)	In understanding and awareness (research priorities)	Research program launched to introduce improved upland rice varieties
Water and rice – ecosystem services (2)	In understanding and awareness (research priorities)	Information on ecosystem services provided by rice fields
Cotton in Rajasthan (52)	In technology selection and initial adoption	Effective trap crop convinced farmers additional irrigations were not needed for pest control
Capacity-building in groundwater governance (34)	In stakeholder capacity	Inter-disciplinary capacity building/ knowledge sharing, policy dialogue and awareness regarding groundwater governance.

In salt-affected environments

Water management and salt-tolerant germplasm

There are four MSC stories on technical innovations in salt-affected environments. These stories, all of which discuss CPWF work in the Mekong and Ganges river basins, feature various combinations of innovative water management methods and salt-tolerant germplasm. Curiously, all stories deal with areas where salt problems derive from proximity to the sea. No stories were submitted on secondary salinity in dry irrigated environments.

The first story comes from an area in Orissa where salinity is a problem in both rainy and dry seasons, despite plentiful rainfall.

"*The villages where the work was done have problems of soil salinity due to ingression of seawater during high tides through surface channel, creeks and river during the wet season while the rice of shallow saline groundwater creates salinity problem during the dry season . . . Although the average annual rainfall is around 1558 mm, the distribution of monsoon rain during the crop growing season is highly erratic.*" (5)

The "significant change" was the introduction of salt-tolerant rice varieties suitable for the dry season, and crop diversification featuring sunflower. The rice varieties were chosen by farmers using participatory varietal selection methods involving both men and women.

"*With the introduction of new varieties namely SR26B, Pankaj, and Lunishree, rice yields increased and additional/expanded dry season rice crop allowed farm households to grow enough rice for the year. Farmers said "we no longer think about whether we will have enough to eat the next day . . . Sunflower, a crop which has tolerance to salinity, was introduced after rice. Farmers used to leave the fields fallow after rice. Now, farmers would like to double the area planted to sunflower.*" (5)

Farmers are said to be using participatory methods to address second generation problems such as stem borer in rice and access to improved seed.

A second story comes from Khulna District in Bangladesh. It shows what can be done by combining improved rice germplasm and innovative water management practices in coastal saline areas. Here the salinity problem is caused by salt intrusion in rivers.

"*About 1 million ha of coastal saline soils have been monocropped with low-yielding (about 2.5 t/ha/yr) traditional rice during the wet season (aman season) from July to December. Most of these lands remain fallow in the dry season from January to June (boro season) because the lack of enough good quality irrigation water as river water becomes saline after January.*" (31)

The significant change was to harvest fresh river water in the wet season, store it in field channels, and use this to grow dry season rice. The simultaneous introduction of improved rice germplasm allowed a maximum harvest from the limited area that could be irrigated from the stored water.

It should be noted that the CPWF project did not actually discover this water management practice, but rather built on technologies developed in an earlier project.

"*The DFID-IRRI project PETTRA tested growing HYV rice during aman and a novel water management that allows cultivation of HYV boro rice with irrigation from non saline river water during November to January and water stored in field channels from February to April. [The CPWF project] further developed and refined the said technologies, selected suitable HYVs for each season . . . provided training on coastal water management and HYV rice production,[and] seed production and preservation to male and female farmers . . .*" (31)

Another example of a CPWF project building on earlier advances comes from coastal areas in Bac Lieu Province, Vietnam. The story centers on water allocation between rice farmers (needing fresh water) and shrimp farmers (needing saline water). Who is to get what kind of water, when?

"*Prior to 2000, with the aim of boosting rice production for export, the Vietnamese government invested in water management infrastructure (embankments and sluices) to protect Bac Lieu Province from salinity intrusion. The intervention adversely affected the livelihood of people in the west of the protected area who needed brackish water to raise shrimp . . . In 2001 demand of aqua-products for export increased significantly, and conflicts between shrimp culture and rice culture became serious due to different water quality requirement: saline water for shrimp and fresh water for rice...*" (29)

The answer is said to have emerged from an earlier project. It involved zoning of rice vs. shrimp areas and controlling water quality and quantity to each through an elaborate system of water control.

"*[A previous] project proposed a land zoning scheme and the associated sluice operation procedures that would accommodate both rice intensification in the eastern part and shrimp culture in the western part of the area and the shrimp (dry season) – rice (rainy season) systems in the transitional area. Change in water quality due to sluice operation predicted by hydraulic and salinity model were analyzed to identify the most suitable option.*" (29)

This approach appears to have been successful. "*From 2002, the local government adapted land use zoning in the revised land use plan. Sluice operation procedures were adopted and water quality monitoring was established. Farmers adjusted their production systems according to the zoning.*" (29)

The contribution of the CPWF project was two-fold: to further develop models to forecast the consequences of additional water resource development, and to develop technologies to intensify and diversity production within both rice and shrimp zones.

"*[CPWF] work . . . involved refining the hydraulic and salinity models . . . used to compare different water development scenarios (e.g. excavation of new canals and dredging old ones) . . . and to find the impact of sluice operations of the surrounding province on Bac Lieu and vice versa. It also improved production systems in each of the "land use zones" by implementing agricultural and aquaculture experiments with farmers, which have very much stabilized due to the preliminary land zoning.*" (29)

A complementary story describes how partnerships with NGOs, local governments and development agencies enabled the CPWF project to achieve success. (6)

Significant changes and the role of the CPWF

In each of the above stories, precisely was the "significant change" and what was the CPWF's role in making it happen?

In three of the four stories, the change being described involved adoption of new technologies: salt-tolerant rice varieties, diversification crops, dry season irrigation using water stored in canals, and so on. One story also included an institutional innovation – rules governing sluice gate operation and water allocation between rice and shrimp farmers. Finally, one story emphasized partnerships.

The significance of the technical and institutional change reported in these stories would be more visible, however, if more information were made available on the pace and extent of adoption. It makes a difference if ten farmers or ten thousand farmers are using a new practice, and whether adoption is unfolding quickly or slowly.

Once again the role of the CPWF was reasonably clear. Projects were part of the CPWF and, in two cases, were able to make rapid progress because they built on strong foundations laid by previous projects. In most cases it is apparent that the change would not have occurred (or, in the case of Vietnam, might have occurred far more slowly) without CPWF involvement (Table 3).

Table 3. Selected significant change stories for salt-affected environments

Story	Kind of change	Commentary
Salinity in Orissa from seawater intrusion (5)	In technology selection and initial adoption	Salt-tolerant rice varieties and crop diversification with sunflower increase water productivity
Dry season rice in Bangladesh vulnerable to seawater intrusion (31)	In technology selection and initial adoption	Dry season rice production using freshwater stored in field channels that had been "harvested" from the river in the rainy season.
Water allocation between rice farmers and shrimp farmers in Vietnam (29)	In initial adoption of institutional innovation In technology selection and initial adoption	Zoning of rice vs. shrimp areas and controlling water quality and quantity to each through sluice gate operation
Partnerships on water allocation in Vietnam (6)	In partnerships	Partnerships with NGOs, local governments and development agencies enabled the CPWF project to achieve success.

In aquatic environments

<u>*Property rights, collective action and technical change*</u>

Three MSC stories focus on aquatic environments and fisheries. Two of these stories come from flooded environments in the Ganges and Mekong basins while one comes from a dry area in the Volta basin.

In the lower Ganges basin, substantial areas of agricultural land in floodplains and deltaic lowlands are subjected on a regular basis to seasonal flooding, which may last for several months. Most of these lands are used during the dry season for irrigated agriculture but cannot be cropped when flooded. Although floodwaters perform ecological and environmental functions (e.g., flushing of silt, revitalization of wetlands), they typically are not utilized in ways that contribute directly to the livelihoods of the poor.

Substantial untapped opportunities exist to use floodwaters for aquaculture. Doing so, however, requires that flooded areas be fenced off for community management of fisheries. Governance is important because community fishing during floods must alternate with crop production on individually-owned fields during the dry season. A CPWF project in Rajshahi, Bangladesh, was successful in catalyzing community action to fence off 100ha of floodplains for stocked fish. Fish yields increased substantially, in part because harvesting was coordinated at the community level.

"*Harvesting was carried out by eight groups of beneficiaries using a well-planned method, using 16 non-motorized boats, which has increased the overall harvest . . . During low water level periods, villagers are still able to harvest fish by using small scale fishing gears (push net, pole and harpoon).*" (30)

Fish consumption is said to have increased dramatically, with income from fish sales tripling in value.

This story provides an example where the success of a technical innovation – fencing off of flooded areas for aquaculture – depended on the prior success of an institutional innovation – adjustments in property rights allowing alternation between community management of fisheries and individual management of crops.

The introduction of this institutional innovation in Bangladesh is said to have been inspired by a parallel experience in Can Tho city, Vietnam, in the Mekong basin. A separate story describes how a farmers' organization agreed to enclose flooded agricultural fields for use in aquaculture, following community-developed rules. The story was said to be significant because, "*[It] showed that collective action in fish farming is possible and* *can be successful . . . The farmers managed to establish a well-functioning system of rules and regulations concerning duties, and sharing the costs and benefits of the aquaculture project . . . In addition, savings for future self-management of the project have been included and farmers are well prepared to manage their financial needs on their own in the future . . . These regulations were established and revised in a participatory manner at regular meetings.*" (32)[8]

A story with some similarities to the above was submitted from northern Ghana in the Volta basin. It begins with the observation that fishing in community dugouts is an indigenous practice that can help meet the protein needs of rural communities. Many dugouts are said to be ineffective in this role, however, because of low fish yields caused by predation of stocked fish by carnivorous species. Another problem is that dugouts sometimes simply accumulate silt and dry up. Technical solutions are straightforward – modification of stocking methods, and desilting of dugouts. The principle reason why these innovations were not being used was said to be lack of dialogue between different water users, and unclear property rights for harvested fish. An institutional innovation – water users' associations – helped overcome these constraints.

"*Formation of water users' associations encouraged dialogue on emerging water use rights and improved sharing and sense of ownership of proceeds from harvested fish. These have encouraged community participation in protecting dugouts from frequent drying through desilting and tree planting.*" (10)

Significant changes and the role of the CPWF

The MSC stories on aquaculture show an intensely close relationship among property rights, institutional innovations (typically involving community-level collective action) and the successful adoption of technical innovations.

As was noted in the context of salt-affected environments, however, the significance of the changes reported in these stories would be more visible if further information were made available on the pace and extent of adoption. As written, the stories describe the experiences of relatively small numbers of people. Only through scaling up and out can the innovations – changes in property rights fostering collective action, in turn facilitating technical change – be called truly significant. Another way of making the stories more realistic would be to highlight previous research and development efforts that served as a foundation. In these kinds of stories, it is common for someone else already to have written a preceding chapter (Table 4).

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8 Another story gives an account of how NGOs helped a CPWF project select research sites, establish local collaboration, uncover existing data, build stakeholder capacity, and (perhaps for the future) scale out an undefined set of technical innovations. (33)

Table 4. Selected significant change stories for aquatic environments

Story	Kind of change	Commentary
Aquaculture in the lower Ganges (30)	In initial adoption of institutional innovation In technology selection and initial adoption	Alternation between community management of fisheries and individual management of crops, allowing community management of fisheries during floods.
Aquaculture in Vietnam (32)	In initial adoption of institutional innovation In technology selection and initial adoption	Alternation between community management of fisheries and individual management of crops, allowing community management of fisheries during floods.
Waters users associations in northern Ghana (10)	In initial adoption of institutional innovation In technology selection and initial adoption	Clarification of property rights for fish harvested from dugouts, facilitating proper re-stocking and de-silting practices

About institutional and policy innovations

Six CPWF MSC stories talk about institutional and policy innovations. Five of these focus on institutional innovations aimed at increasing water productivity, reducing poverty and improving equity. Of these, four stories discuss interactions among upstream and downstream communities, while the fifth talks about water systems for multiple uses.[9] The remaining story gives an example of how research was able to inform and influence policy decisions. A number of stories mention this as a possibility, but only this one goes into some detail about the process whereby this occurred.

Institutional innovations - upstream and downstream

The first story about upstream – downstream interactions describes the development of a conceptual framework to better envision such interactions. In particular it emphasized the notion of "reverse flows", or ways in which downstream communities can influence upstream populations. The value of the framework lies in how it changes the way researchers think about, plan and evaluate research (Annex 5).

"*The framework has been successful in communicating not only the upstream-downstream relationships within catchments but also that these one way flows can become two way flows. The reverse flows can take*

[9] Three other stories have already been presented that describe how institutional innovations – changes in property rights and the use of collective action by communities – facilitated technical change in aquatic environments.

many forms and people interpret them in a range of ways from a direct financial flow such as payment for environmental services (PES) or an indirect flow of labor from lower to upper in search of income earning opportunities. The framework gets people thinking about the catchment as a system that is based upon but more complex than water flowing downstream." (17)

The second story introduced a forum called a "conversatorio", used to facilitate discussion among communities, NGOs and government authorities in the Andean basin. The case in point involved a forum involving upstream and downstream communities, upstream and downstream NGOs, a national NGO, and research institutes. Through discussion, the communities and NGOs became aware that the best way to solve downstream problems of water quality might lie in upstream actions to conserve land and water or to treat wastewater. Among these actions was the institutional innovation of "payment for environmental services" or PES.

"*In one watershed, the NGO was mainly focused on the lake at the bottom of the watershed, while in the other it was an NGO from the páramos of the uppermost part. Bringing these two together, through the support of the national NGO, has led to a strong collaboration and to new perspectives on the importance of linking upper and lower parts of watersheds. In addition to their links with each other, the wetland NGO now works in upper areas and the páramo NGO now has contacts with the irrigation districts of the lower part of its watershed . . ."*

"In a prioritization exercise to determine what topics would be addressed in the "conversatorio", fisher communities gave priority to problems faced by upstream communities because they recognized that by working with those communities to solve their problems of unsustainable agricultural expansion, they would indirectly be solving their own problems of water contamination . . ."

"The realization that upstream issues were important also spurred the downstream NGO to try and influence policy makers to take action in upstream areas. One area is land use regulations in páramos. The NGO is supporting the idea of environmental service payments for adopting sustainable practices in appropriate areas. Another area is water treatment. None of the water treatment plants in the rural communities is working and this is a major source of pollution downstream." (20)

The above story shows PES being applied in the field. A broader view of PES was developed in a project inception workshop, described in a third story. It is interesting that advances were being made simultaneously in both the theory and practice of PES.

"*Theme 2 [of the CPWF] hosted a project inception workshop for payment for environmental services (PES) approaches to contribute to equitable and sustainable management of soil and water in upper catchments in Nairobi, Kenya from 27 to 28 June 2006. The workshop was assisted by Theme 2 project* *leaders, members of MSEC, MIS and AfNet (a consortia of soil scientists working in Asia, Latin America and Africa), and experts of PES in Australia, North America and Africa*."

"*They discussed how to integrate water and soil management thinking in the landscape scale, and how the technologies being developed by the projects have the potential to produce environmental services at the watershed level. As a consequence, several soil scientists became interested in the socio-economical concept of PES and how they will be able to apply it to their projects. The participants have also been motivated to write joint proposals for PES case studies*." (18)

While CPWF scientists in the Andes were exploring PES, their colleagues in the Mekong were working on ways to foster and inform watershed-level stakeholder negotiations on water allocation. Their story tells how "companion modeling", a combination of gaming and simulation modeling, helped water users understand the consequences of making alternative investments in water infrastructure, for example, large upstream dams vs. small strategically-located weirs.

It was especially helpful in showing who would benefit and who would not from different interventions. In some instances, seemingly attractive investments in water development turned out to benefit only a few large water users. Armed with this information, water users were able to influence policy decisions on water development.

"*Three months later, the . . . representative was about to present a project to the . . . council which looked much more like his initial suggestion (a single reservoir above the village) than the agreed upon collective option of small weirs negotiated during the . . . exchange. But this was shelved and ten months later the . . . representative and the leader had finally collaborated to design a new project . . . favoring the powerless people who do not have access to water*." (26)

This story showed how role-playing games, combined with computer simulations, place people in a virtual world in which they can act and talk without concrete consequences, thereby helping mediate among different actors and fostering the development of generally-acceptable strategies. The question, of course, is the extent to which the process can be generalized and widely applied.

Institutional innovations - multiple use systems

The sole story on multiple use systems (MUS) is in some ways surprising. It does not portray the development of such systems, not does it document how they have improved water productivity and equitable access to water resources. Rather, it describes the political processes underway to scale up and out this innovation.

Yet the innovation is in itself very interesting.

"*Virtually all people use water for a multiplicity of domestic and productive purposes. Poor people living in upper catchments are particularly likely to rely on a wide range of water-dependent activities for their livelihoods. This "multiple uses of water" strategy increases their welfare – and also tends to increase water productivity . . . Unfortunately, most water supply systems have been designed with a single use in mind, e.g., irrigation or direct consumption. Not infrequently, they are simply unable to cope with the demands (volume of water required or the timing of water delivery) that may be placed on them by the "multiple uses of water" strategies often preferred by poor households. The answer may lie with water supply systems that are multiple-use by design . . . women's participation in [designing MUS systems] enhances institutional and financial sustainability of multiple use water services, and improves water efficiency and equity at low incremental cost.*" (Harrington, et al, 2006)

The story itself focuses on changes in national and institutional priorities that favor the expansion of MUS.

"*The governments of Colombia, South Africa, Zimbabwe, and Thailand have taken up recommendations of PN28 and have adapted a national policy towards planning and implementation of multiple water uses. The government of South Africa has drafted national guidelines for multiple water use services and is testing these in pilot-projects with local governments. In Zimbabwe there is a proposed law incorporating MUS . . . Dialogue with global water sector leaders in both domestic and productive sectors and with national and local partners has led to uptake or strengthening of multiple-use approaches (World Water Forum IV, WSP, IFAD, global NGOS, Winrock, GWP, ICID, Stockholm Water Week, Gates Foundation, etc [sic]).*" (21)

Information was not included on how changes in priorities have been translated into projects and investments.

Using research to inform policy decisions

The story on the use of research to influence policy comes from Ghana and deals with the question of safe use of wastewater in urban irrigation. The story speaks for itself.

The Accra Metropolitan Assembly (AMA) has a bylaw on "Growing and Safety of Crops" which states that: "No crops shall be watered or irrigated by the effluent of a drain which is fed by water from a street drainage. Any person who contravenes this bylaw commits an offence [and may be fined or imprisoned] . . . AMA has no systematic way and insufficient resources to enforce the bylaw . . . AMA also did not consider the benefits that can be gained from making the bylaw partial. During the Akosombo Impact Pathways Workshop [CPWF projects] PN 38/51 identified the Ministry of Food *and Agriculture (MoFA) . . . as the most important stakeholder in terms of scaling out/up of the project outputs and policy formulation . . . Shortly after the Impact Pathways workshop, MoFA organized its own multi-stakeholder and policy workshop on UA [urban agriculture]. PN 38/51 seized the opportunity to present to the Ministry ways to minimize health risks without outright banning wastewater use for agriculture. . . The presentation was well received to the extent that the greater part of the meeting afterward was spent discussing the presentation. A declaration for political support for the UPA was made by the Ministry and they concluded that the PN38/51 outputs should be used by the Ministry and the Metropolitan Assembly in the formulation of more appropriate policies on UA in the future . . . Another recent success is that WHO and FAO have given funds to continue the current work with stronger focus on the WHO wastewater use guidelines. This project aims at implementing the guidelines where MoFA will be a key partner.*" (35)

Significant changes and the role of the CPWF

In each of the above stories, precisely was the "significant change" and what was the CPWF's role in making it happen?

In two of the four stories, the change being described involved the development of a conceptual framework that allowed a better understanding of upstream – downstream interactions and PES. These are research products that, properly used, can accelerate the development and application of institutional and technical innovations to improve water access, productivity and quality.

The story on PES is especially interesting because it describes how an institutional innovation encouraged the adoption of new technologies (resource-conserving practices by upstream farmers). As such, it has much in common with those stories from aquatic environments where technical change was made possible by complementary institutional innovation. The story on companion modeling is also of some interest, as it describes specific mechanisms whereby better information can lead to better policy decisions on water development and water use. In both cases, however, questions remains about scaling up and out – to what extent can these innovations be generalized and widely applied in numerous watersheds and river basins? What would it take?

In most instances, it is clear that less progress would have been made without CPWF research. The case of urban agriculture in Ghana is a particularly clear case of research influencing policy (Table 5).

Table 5. Selected significant change stories for institutional and policy innovations

Story	Kind of change	Commentary
Conceptual framework on "reverse flows" and upstream-downstream interactions (17)	In understanding and awareness (research priorities)	A better understanding is gained of the complexity of upstream – downstream interactions in watersheds and river basins
Payment for environmental services (18 and 20)	In initial adoption of institutional innovation In technology selection and initial adoption	Downstream communities find ways to influence land management by upstream populations
Companion modeling for watershed level stakeholder negotiations (26)	In understanding and awareness (policy)	Gaming and modeling help inform negotiations on water allocation
Multiple use water systems (21)	In understanding and awareness (policy)	Political and institutional support expand for investment in water systems designed for multiple uses
Urban agriculture in Accra, Ghana (35)	In understanding and awareness (policy)	Political support gained for formulation of more appropriate policies for urban agriculture

About information and knowledge

Information, the product of research, is a resource that can be harnessed and used to foster technical, institutional or policy innovation. CPWF MSC stories discussing such innovations necessarily touch on questions of information and knowledge management. Some of the above stories specifically characterized "significant change" as "improved awareness" or "improved understanding" – in other words, information and knowledge.

In eleven stories, the focus was squarely on information and knowledge. Of these, six are of particular interest. These are stories about the collection, management and use of information in measuring benchmarks, establishing trends, anticipating the consequences of innovations, and setting priorities for CPWF research in basins. Three of these stories featured data management using the Integrated Data and Information System (IDIS) while the other three talked about impact pathways and Basin Focal Projects.

Information management and IDIS

The first story describes as a "significant change" the development of IDIS itself. As noted by the storyteller, "*Data and information management is and continues to be a major challenge for researchers and managers. To address this challenge, CPWF and IWMI initiated a data and information sharing initiative implemented by the Integrated Data and Information System (IDIS)*

. . . [this system] provides access to water, agriculture and environment scientific data . . . The project has developed on-line information system and tools, methods and innovative ways of combining data sets so as to permit exploration of previously uninvestigated research questions and in ways unforeseen by those initially gathering the data." (37)

One example of IDIS being used emerges from the Andes basin. CONDESAN, the entity responsible for basin coordination, "*. . . tried to collect and keep results to make them available for its members and other public, but it was not done systematically . . . Since the inception of the CPWF, this way of work had to change . . . it was necessary to compile the information in a central place. As a result, now there is a concrete inventory of data available (especially biophysical information) in CONDESAN and a database available in IDIS. As the difficulty to obtain meteorological data in the Andes became evident, so, a stochastic model was adapted to the Andes and fed with more data acquired by CONDESAN in order to produce information for any point in the Andes.*" (47)

The utility of IDIS went well beyond the management of biophysical data, however. It was also used in the Limpopo, Nile and Volta basins to manage information on African water treaties. Such information was considered essential for these basins.

"*Africa is a land of transboundary river basins. With the exception of island states, every African country has a territory in at least one transboundary river basin. Transboundary basins cover 62 percent of Africa's total land area, and virtually every basin greater than 50,000 km2 crosses at least one national boundary.*" (38)

The corresponding MSC story describes how information on these treaties was collected, managed and then used.

"*[The CPWF project] . . . provided the opportunity and resources to create what is believed to be the largest and most comprehensive collection of African transboundary agreements in existence. The collection significantly increased the known volume of African transboundary law and includes more than 150 agreements, treaties, protocols and amendments spanning over 140 years and involving more than 20 African basins . . . The treaty collection serves as a global public good available to all. It has already sparked a series of additional research projects related to the management of African transboundary waters. These include analysis of the inter-relationship between international policy and basin level agreements, the drivers of transboundary water law formation in Africa and lessons for African leaders and donors, and the impact of transboundary agreements on dam construction in Africa.*" (38)

The story then goes on to describe how this information is being used to support policy analysis by the Council on Foreign Relations, the Asia Society, the government of South

Africa, and other research institutes and government organizations. The story says little about the effect that this information may have had on policy change.

A complementary story describes capacity-building in social science to strengthen the ability of local institutions to conduct high quality research on water governance (40).

Basin Focal Projects and Impact pathways

Three MSC stories talked about Basin Focal Projects (BFPs) and impact pathways – two key areas of CPWF research.

The purpose of BFPs is to build up coherent and systematic basin-level data-sets and then use them to evaluate – at the whole basin level – water availability, water productivity, poverty and water poverty, institutional frameworks, stakeholder networks and, ultimately, the likely consequences on water productivity and poverty of introducing different sets of innovations. BFPs, then, provide a systematic framework for ex-ante assessment of alternative development strategies – including combinations of technical, institutional and policy innovations. (41)

BFPs talk about the "what if?" That is, "what would be the consequences if a certain set of innovations were to be widely adopted?" Impact pathways add a further dimension – the "how". If the widespread use of a set of innovations is likely to have favorable consequences, "how does one go about fostering their widespread use?" Who needs to work with whom, and in what sequences are research breakthroughs needed in order to maintain progress and momentum? Impact pathways are a mechanism used by the CPWF for accelerating scaling out and up, and for monitoring and evaluation.

One story discussed the theory behind impact pathways, concluding that, ". . . *this type of analysis clearly presents a comprehensive view of the intervention logic, explains how project activities and outputs will contribute to a sequence of outcomes and impacts and facilitates constructive discussion among project team leaders*." (28)

A second story described the use of impact pathways in practice, in the Volta basin. "*The Volta Impact Pathway Workshop was organized [in] . . . Ghana in January 2006 for eight projects in the basin . . . [participants] were introduced to concepts like problem tree, objective tree, project timelines and visions and network maps and matrices . . .*" (42)

Significant changes and the role of the CPWF

In each of the above stories, what was the "significant change" and what was the CPWF's role in making it happen? All stories focused on the development and use of information resources to improve understanding and awareness of research opportunities, and to anticipate the likely outcomes of different research strategies. The change, then, was in the capacity of stakeholders to make better decisions on priorities for research and development. In all cases, CPWF leadership in research was essential to progress (Table 6).

Table 6. Selected significant change stories on information and knowledge

Story	Kind of change	Commentary
Data management and IDIS (37, 38, 47)	In understanding and awareness (research priorities)	IDIS used in several basins to manage large amounts of data gathered on biophysical and socioeconomic factors
BFPs impact pathways (28. 41, 42)	In understanding and awareness (research priorities)	Information management for research planning, ex-ante evaluation, and monitoring

About partnerships and capacity-building

CPWF stakeholders were originally asked to submit MSC stories for two categories: "the most significant technical development/advance" and "the most significant partnership change". This section describes some of the stories on partnerships. Stories on capacity-building are also summarized.

Partnerships and innovation systems

For some people, research partnerships are an end in themselves, worth encouraging for their own sake. Other people view partnerships principally as a means of achieving broader ends, including better and more effective research, and faster innovation. This latter viewpoint is consistent with theories of innovation systems and learning selection.[10]

In learning selection, agents (individuals, groups or organizations) examine technical or institutional innovations, where possible adapting them more closely to their own needs.

[10] These two theories are closely related. Innovation systems theory recognizes that while one agent in an innovation system can develop an innovation, the benefit from that innovation is nearly always the result of interactions between multiple actors (Hall et al, 2001). Learning selection theory recognizes that innovation is based on individual and mutual experiential learning cycles, analogous to natural selection in the biological world (Douthwaite, 2002).

They select which innovations and adaptations to carry forward and which ones to abandon. As agents adapt and adopt, they interact with each other. They change the innovation and (more subtly) the innovation changes them (the productivity of their systems, their knowledge about processes, etc.) In a more general sense, agents, their strategies, and artefacts (e.g., "things" like seed, machinery or databases) interact with each other, generating more novelty, fuelling more learning selection, and so on in an evolutionary process. Learning selection, like natural selection, continues through numerous cycles. Unlike natural selection it can be influenced by vested interests. It can be strengthened and accelerated by:

- Stimulating variation and novelty in types of agents, strategies and artefacts. (Partnerships can expand the range of agents that interact with each other).
- Stimulating changes to interaction patterns between agents, strategies and artefacts. (Partnerships can intensify interaction among agents).
- Changing the ways that people evaluate variation and novelty, and then select what to continue to use. (Partnerships can change decision-making processes).

Partnership stories

CPWF MSC partnership stories on tend to fall into two groups:

- Field level stories – that focus on the role of partnerships in fostering the development and adaptation of specific technical, institutional or policy innovations. There are five such stories, several of which have already been mentioned in earlier sections (6, 14, 16).
- Basin-level stories – that focus on broader partnerships at the global or river basin levels.

Basin-level stories typically begin by stating the simple fact that CPWF initiatives result in new kinds of partnerships, then go on to describe the benefits that these have brought.

In the Indus-Ganges basin, for example, CPWF partnerships are said to have led to a higher priority for research on water productivity.

"*Starting from the kick off workshop in IGB in the year 2003, the basin coordinating unit has developed a network of partners/stakeholders from NARES, SAUs, NGOs and CG Centers who are interested in working on the challenge of producing more food with less water i.e. enhancing water productivity . . . As a result of these efforts, and the recently launched World Bank supported National*

Agricultural Innovation Project (NAIP) in India, enhancing Water Productivity has been included as one of the areas for Basic & Strategic Research. A concept note to National Agricultural Innovation Project (NAIP) with a consortium of 12 centers is submitted by us." (44)

In the Yellow River basin, CPWF partnerships have resulted in an expanded agenda for the basin coordination agency and stronger links with external sources of expertise:

"*The CPWF project has significantly improved the Yellow River Conservancy Commission's capacity from river management to a broader area including agricultural, environmental and social activities. Furthermore, both domestic and international partnerships have been built with various NARES and ARD institutions.*" (45)

CPWF partnerships are also credited with expanding the international horizons and contacts for CONDESAN, the agency coordinating the Andes collection of basins (48). In the case of the Mekong basin, the point is made that CPWF partnerships have resulted in the launch of new, innovative and exciting projects. Equally important, there has been a certain amount of co-evolution between the basin coordination agency, the Mekong River Commission, and the CPWF – each has influenced the other (43). Other basin-level partnership stories follow similar patterns (22, 36).

Storytellers were asked to comment on the key success factors with respect to partnerships. The factors most commonly mentioned are listed below. Clearly, there is considerable overlap across these factors.

- strategic cross-sectoral/ cross-scale partnerships (5 mentions)
- strengthening of partnerships between NARES, NGOs and CG Centers (research) (4 mentions)
- build on partnerships/ work from previous projects (4 mentions)
- pooling of expertise/ combined effort of relevant partners (3 mentions)
- champions who played a critical role (among implementers, and local leaders) (2 mentions)

In most stories, the cause and effect link between CPWF initiative and the development of the new partnership seems convincing. However, relatively little information is given to support the assertion that the new partnership was the cause of expanded international contacts, new information, and increased funding for research on water productivity. As additional stories are added to the mix, however, they may lend support to the claim that basin-level partnerships have been a factor in fostering innovation.

Capacity-building

There are four stories on capacity-building (CB), two of which have already been mentioned – CB to improve groundwater management in Asia (34), and social science CB to foster high-quality research by African scientists on water governance (40).

Of the two remaining stories, one describes an extraordinarily ambitious CB program in the Limpopo basin. In this program, CB is not a mere add-on to research but rather is integrated fully into all project activities.

"*Too often capacity-building is seen as add-on to research: a follow-up activity in which the main researchers are uninvolved or uninterested. As an alternative, [our] . . . approach is to integrate capacity building into research activities from planning stage onwards . . . [our project], from its inception, has integrated capacity building programs in Southern Africa in its own work.*" (23)

In fact, CPWF project research is in this case implemented by doctoral and masters students, who benefit from interaction with international scientists, project staff, and trans-disciplinary approaches.

"*Key research . . . is undertaken by six Ph.D. fellows . . . supervised by scientists from member universities and CGIAR centers . . . Each Ph.D. fellow is linked to Masters' students who undertake their dissertation projects . . . To date, 15 Masters' students have graduated and 11 are currently working on their dissertations . . . A particular benefit is the development of trans-disciplinary scientific teams for the supervision of students and the guiding of community training . . . The involvement of scientists in the supervision of research and capacity building projects at different scales, from farmer's fields to river basins, helps develop core capacity with an appreciation of the challenges and linkages at the different scales within the basin.*" (23)

The final story on CB comes from the Karkheh basin, in Iran. It describes how institutional change combined with a new focus in CB activities led to a substantial improvement in national capacity to conduct participatory action research, in ways that take account of gender specific user groups in the communities.

"*At first, training courses about participatory approaches were organized . . . While this created a lot of interest and enthusiasm it appeared to be difficult for many researchers to apply these new approaches without intensive backstopping and institutional support. Involved research institutes were testing their own technologies on-farm . . . [but these] trials were fully researcher-designed, and interaction between* *farmers and researchers were largely restricted to those farmers hosting the trials . . . In mid 2006, a special project activity on 'Participatory Technology Development' (PTD) was launched to increase farmer participation and to enhance inter-institutional linkages . . . A new research partner, the Rural Research Centre (RRC) was invited to lead the PTD activity . . . This was a timely move, as RRC had recently received the national mandate to stimulate the use of participatory approaches in Iran . . . A one-week planning workshop was conducted at RRC, using problem and objective trees and transforming the results to a project planning matrix for the whole project period. Monitoring criteria were developed and a national and two provincial PTD teams for the two project sites were formed, comprising of RRC staff and additional experts from different disciplines. To begin with, existing 'best-bet' options were introduced in four PTD pilot villages . . . [and] farmers chose those technologies they were interested in . . . The provincial PTD teams are now following up the trials and have intensive contacts with farmers collecting their views . . .*" (22)

Significant changes and the role of the CPWF

In each of the above stories, what was the "significant change" and what was the CPWF's role in making it happen? To a certain extent, stories on new partnerships describe situations where the significant change was the partnership itself. Similarly, stories on CB describe situations where the significant change was the improved ability of a partner to conduct high quality research. The expectation is that these "intermediate goods" will lead to better research, more innovation, improved outputs, and accelerated development of new technologies, institutions and policies (Table 7).

Table 7. Selected significant change stories on partnerships and capacity-building

Story	Kind of change	Commentary
Basin-level partnerships (22, 36, 43, 44, 45, 48)	In partnerships	Basin-level partnerships increase the priority given to water productivity, the range of subjects managed by basin coordination units, and the number and vigor of links with external partners
Capacity-building (22, 23, 34, 40).	In stakeholder capacity	Capacity-building enhances stakeholder ability to conduct research and development on such topics as groundwater management, water governance, and research on technical change in dryland environments

The most significant stories of all

Soon after being received and compiled, all MSC stories were analyzed and screened by key CPWF leaders. These included the CPWF's five theme leaders, who provide scientific leadership for the Program, and the management team member responsible for gender, institutions and participation oversight. This group selected eight stories considered to best illustrate those aspects of research and development that are important for CPWF success in achieving its goal. These eight stories, and the reasons for their selection, are as follows:

1. Adoption of salt tolerant modern rice varieties in the wet season and non-rice crops in the dry season significantly enhances farmers' food security and income in Orissa, India (5)

This story highlights the potential to increase food production and water productivity in salt affected areas through the development and adoption of salt tolerant varieties of both rice and other crops. Approximately 21m ha of agricultural land in Asia are salt-affected. Salinity problems undermine food security and livelihoods for enormous numbers of poor people.

2. The vital roles of NGOs, local governments and development agencies in a research project on Coastal Resources Management (6)

This story is a good example of the impact that can be achieved by identifying and truly involving key stakeholders and end users–farmers, fishers, R&D organizations including top management, district and provincial extension, NGO, local government, government resource managers, government planning and development institutions.

3. Interdisciplinary capacity building/ knowledge sharing within groundwater governance in Asia (34)

This story highlights the importance of capacity building in addressing groundwater overexploitation, as well as the role of knowledge sharing in enabling people to better understand a common problem.

4. The opportunistic presentation that may change urban agriculture in Ghana (35)

This story highlights the link between impact and networking. It was chosen because it showed the ability to build researchers' capacity to target the right policy circles, demonstrating that networks are influential vehicles that potentially bring about change.

5. The long road for participatory technology development (PTD) in Iran (22)

This story shows how proponents negotiated and struggled to seek solutions to earlier problems in order to effect change. It demonstrates an iterative approach in action.

6. INRM research supports livelihood in fresh – saline water interface environments (29)

This story shows how a project can trigger change at different scales:

- At the farm level: improved rice and shrimp farmers' livelihoods
- At local management level: increased awareness of the value of brackish water for food production (in this case, shrimp) and thus the need to include brackish water in the management of water resources in coastal areas; strong partnership involving local institutions (especially NGOs)
- At national planning level: understanding the need to shift from a rice-based to a diversified production system in order to enhance the productivity and the ecological and social sustainability of the coastal area
- At scientific level: potential for producing International Public Goods on the management of fresh and saline water interface for the production of rice and shrimp in coastal areas

7. Linking the lake and the páramo at multiple scales (20)

This story is an example of the kind of cross-scale work that is so needed and that shows the possibilities of research linking with national policy.

8. The world's largest collection of African water treaties (39)

This story was chosen because of the clear creation of an International Public Good—the database of African water treaties—that is influencing or at least being considered in the creation of national policies.

The stories chosen by the CPWF's scientific leaders show that they give priority to:

- Research on promising technologies, including adapted germplasm, with a high potential for impact
- Research that actively engages with policy during project implementation, not merely as an afterthought
- Iterative approaches that build on foundations laid by earlier research
- Research that fosters change at multiple scales
- Capacity building and knowledge sharing to understand and address pressing and complex issues, such as ground water depletion
- The development of databases and other knowledge assets as international public goods to influence basin-level changes

Threads

The above sections examined 54 CPWF MSC stories. Looking at the stories as a group, some common threads emerge:

- Many stories described the development and initial adoption of new technologies. The fact that no stories described widespread technology adoption is not particularly surprising. At the time the stories were submitted, the CPWF was only two years old. The changes described in these stories might be interpreted as steps along "impact pathways" that will ultimately lead to widespread adoption and impact.
- A large proportion of stories described the development of intermediate products. These include conceptual frameworks, enhanced stakeholder capacity, partnership arrangements, and information or knowledge that influences research priorities. It would be helpful to locate these intermediate products on impact pathways so as to better understand their true significance.
- In many instances, CPWF projects were described as building on foundations laid by previous research initiatives. Such value-added research can be enormously efficient, representing a wise use of resources. Other stories made little mention of the foundations from which "significant change" emerged.
- There were a number of stories on institutional innovations. Many of these highlighted the close, complementary relationship between institutional and technical innovation. In several instances, technical change was only possible because of complementary institutional change.
- Although some stories looked closely at downstream and cross-scale consequences of innovation, others stories did not. Such stories might be considered as incomplete.
- Relatively few stories were submitted on policy innovations, although most acknowledge the potential importance of research in informing policy decisions.
- For the most part, a good case was made that CPWF projects had accelerated research along impact pathways faster or farther than would have been the case without CPWF involvement.

If we were asked to name a single lesson emerging from the combined MSC stories, it would be the importance of interpreting significant change in the context of "impact pathways". These portray the logical sequence of events whereby threads of research and development, involving multiple interrelated stakeholders, evolve and progress towards a "tipping point" of generalized adoption or application of an innovation. Impact pathways provide a context for understanding the importance of building on earlier achievements, the value of intermediate projects, the lessons to be learned from early adoption, the distance remaining to reach a tipping point, and the steps required to do so. Impact pathways reveal the whole cloth, produced when threads of research and development are woven together.

In general, the CPWF MSC stories combine to tell a tale of accomplishment and progress of substantial breadth and depth. And these stories continue to be written, in action if not necessarily on paper. The next round of storytelling promises to be enormously interesting.

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Annex 1 – Distribution of MSC stories across categories, basins and environments

Basin	**Technical innovations (22)**	**Institutional and policy innovations (5)**	**Information and knowledge (11)**	**Partnerships and capacity-building (16)**
Andes	49	20	19, 47	48
Indus-Ganges	4, 5, 30, 31, 52, 53			44
Karkheh				22, 46
Limpopo	11, 24, 25			12, 23, 40
Mekong	15, 29, 32	26		43, 33, 16
Nile	7, 8, 51, 54		50	36, 14
Sao Francisco				
Volta	10	35	42	9
Yellow	3			45
Across basins or not stated	1, 13, 39	17, 18, 21	2, 27, 28, 37, 38, 41	6, 34

Basin	**Technical innovations (22)**	**Institutional and policy innovations (5)**	**Information and knowledge (11)**	**Partnerships and capacity-building (16)**
Dryland	7, 8, 11, 24, 25, 39, 49, 51, 53, 54		50	9, 12, 14
Irrigated or rice-based	3, 4, 15, 52	35	35	16, 34
Salt-affected	5, 29, 31			6
Aquatic	10, 30, 32		28	33
Across environments or not stated	1, 13	17, 18, 20, 21, 26	19, 27, 37, 38, 41, 42, 47	22, 23, 36, 40, 43, 44, 45, 46, 48

Numbers in the tables refer to the number of the CPWF MSC story in Annex 2. Suggested assignment of projects to categories was done by the authors and should not be considered definitive.

Annex 2 – CPWF MSC stories

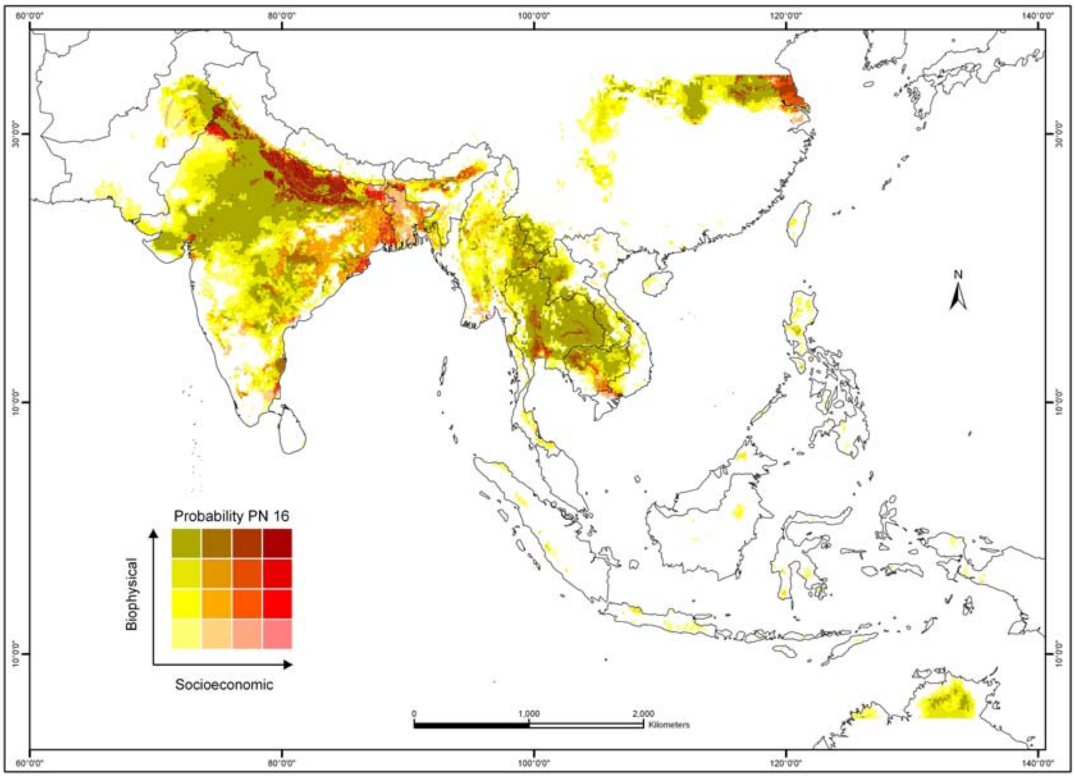
No.	Title
1.	Identifying options for growing more food and saving water
2.	Ecosystem services of rice landscapes
3.	Proof of concept of the aerobic rice technology
4.	Aerobic Rice Partnership Development in Asia
5.	Adoption of salt tolerant modern rice varieties in the wet season and non-rice crops in the dry season significantly enhances farmers' food security and income in Orissa, India
6.	The vital roles of NGOs, local governments and development agencies in a research project on Coastal Resources Management
7.	Deploying Genotypes Resistant to Yellow Rust in Eritrea
8.	New, high yielding lentil variety identified through collaboration with farmers
9.	Research staff collaborate with extension agents in adoption studies
10.	Improved productivity of community-owned dugouts for fish culture
11.	Appreciating water conservation techniques by smallholder farmers in the S.E. Lowveld
12.	Realization of Research-Extension- Farmer-Policy-Market linkages
13.	CPWF-Comprehensive Assessment Partnership in Theme 1 Crop Water Productivity
14.	Building New Partnerships between Farmers and Research Institutions in Eritrea
15.	Introduction of high yielding rice cultivars to the uplands of Lao PDR
16.	Establishment of a multi-institutional and multi-country platform technology evaluation and dissemination
17.	Theme 2 conceptual framework, especially the concept of reverse flows
18.	Payment for environmental services
19.	Deeper understanding of water-poverty relationship
20.	Linking the lake and the páramo, at multiple scales
21.	Multiple use water services
22.	The Long Road for Participatory Technology Development (PTD) in Iran
23.	Mainstreaming capacity building in food and water research in the Limpopo Basin
24.	Evaluations of low head drip irrigation kits and their distribution by NGO programs
25.	Assessing tradeoffs in exploitation of wetland goods and services in the Limpopo River basin
26.	Negotiating watershed management alternatives
27.	Theme 3 Management and Coordination: Using an impact pathways approach to identify priority interventions at Center, Discipline and CP levels
28.	Theme 3 Management and Coordination: New management structure for Theme 3
29.	INRM research supports livelihood in fresh – saline water interface environments
30.	Significant rise in fish production from the floodplains is boosting farmers' income
31.	Adoption of novel water management and High Yielding Varieties (HYV) of Rice in the Coastal Saline Environments
32.	Collective Action in Farmers' Organization
33.	Collaboration with local NGOs in Cambodia
34.	Interdisciplinary capacity building cum knowledge sharing within groundwater governance in Asia
35.	The opportunistic presentation that may turn fortunes of urban agriculture (UA) in Ghana
36.	Research and Development Partnership in the Nile Basin
37.	Improving access to water, food and environment data and information
38.	The World's Largest Collection of African Water Treaties
39.	Importance of Complementary Policies in Farm-Level Climate Change Adaptation Strategies
40.	Social Science Research Capacity Enhancement in the Limpopo and Volta River Basins
41.	Strategic planning of water resource management in basins is improved by relevant and comprehensive information
42.	The impact of the Impact Pathways and the Scaling Workshops organized in the basin on projects of the Volta

	basin
43.	The CPWF and Mekong River Commission (MRC)
44.	Strengthening of Stakeholders partnership in enhancing water productivity
45.	Better partnerships at the Yellow River Basin
46.	Capacity building at the basin and national level in Iran
47.	Biophysical data inventory and database
48.	Aguasur
49.	Creating an oasis in the dessert
50.	Knowledge Sharing and Communication Strategy in Agricultural Water Innovation Systems
51.	Water and soil management led to food security
52.	Reduction of pest incidence and water usage in cotton by introduction of ladies finger as a trap crop
53.	Improving ground water recharge through community participation and impact on adoption of water efficient systems on the small scale farmers in the area
54.	Water and organic matters improved food production

Annex 3 – Conceptual framework on crop water productivity

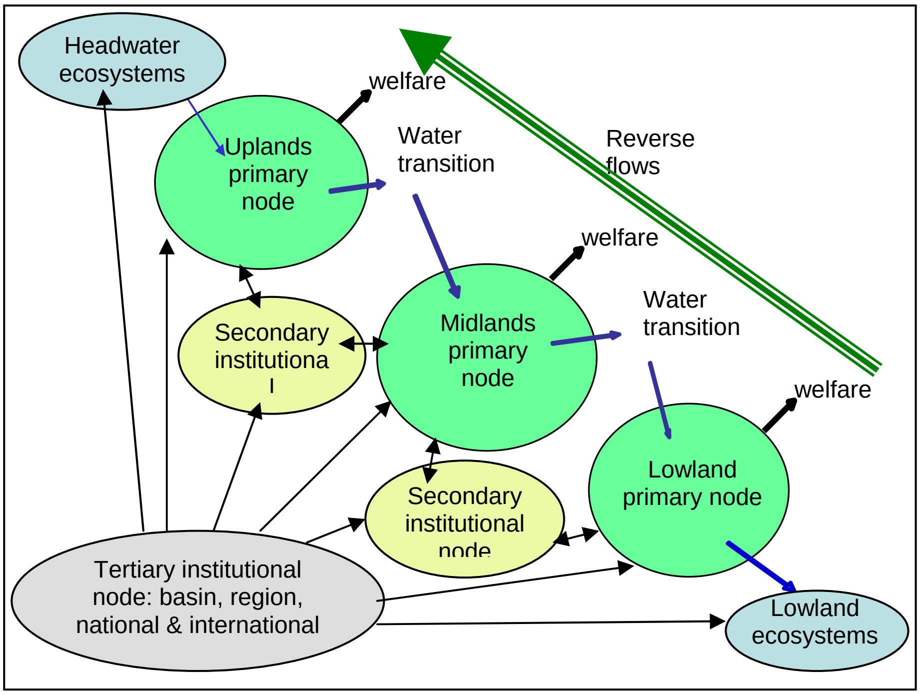
Principles to improve crop water productivity	Research approaches at different spatial scales (Plant level / Field Level / Agro-ecosystem Level)
Principle 1: Enhancing marketable yield of the crops for each unit of water transpired by the crop	• Increasing the yield or value of crop • Reducing non-stomatal transpiration
Principle 2: Reducing the outflows from the domain of interest and atmospheric depletions other than the crop stomatal transpiration	• Reducing evaporation from soil and water • Reducing transpiration from weeds • Reducing percolation • Reducing run-off
Principle 3: Increasing the non-irrigation water inflows to the storage pool	• Effective use of rainfall • Effective use of water with marginal quality
Principle 4: Increasing the size of the storage pool in time and space	• Effective use of water storage

Annex 4 – Extrapolation domain areas for aerobic rice in Asia



Source: Bouman et al, 2007.

Annex 5 – Conceptual framework on upstream – downstream linkages



Source: Harrington et al, 2006.