Tackling change

Future-proofing water, agriculture, and food security in an era of climate uncertainty

P. McCornick, V. Smakhtin, L. Bharati, R. Johnston, M. McCartney, F. Sugden, F. Clement and B. McIntyre

IWMI
International Water Management Institute

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RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security
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Photo: Nana Kofi Acquah

Future-proofing water, agriculture, and food security

Photo: Matthew McCartney

In 1950 the global population was just over 2.5 billion. Now, in 2013, it is around 7 billion. Although population growth is slowing, the world is projected to have around 9.6 billion inhabitants by 2050. Most of the population increase will be in developing countries where food is often scarce, and land and water are under pressure. To feed the global population in 2050 the world will have to produce more food without significantly expanding the area of cultivated land and, because of competition between a greater number of water users, with less freshwater. On top of land and water constraints, food producers face climatic and other changes which will affect food production.

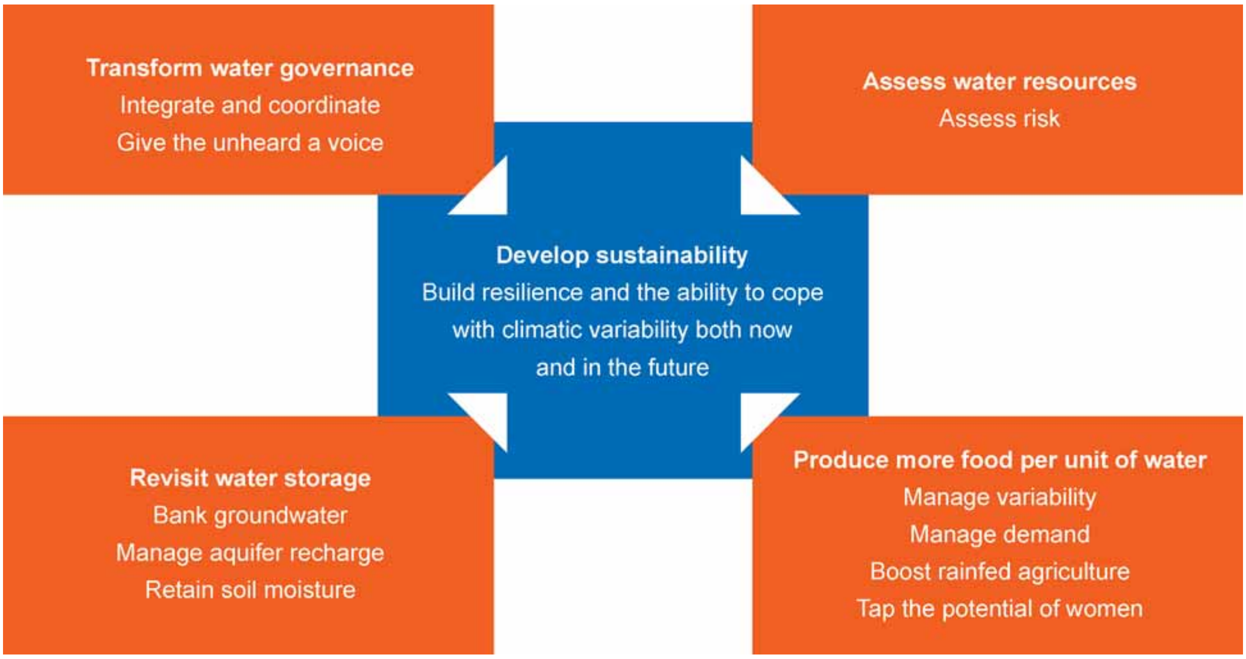
There remains great uncertainty as to how climate change will affect any given locality, but it seems likely that it will have a profound effect on water resources. Projected rises in average temperature, more extreme temperatures, and changes in precipitation patterns are likely to alter the amounts and distribution of rainfall, ice and snow melt, soil moisture, and river and groundwater flows.

Now and in the future, agriculture and food security depend on managing water – a finite resource, but variable in time and space.

Adapting water management to potential future changes in climate emphasizes the need to:

- Accept existing climatic variability as a given measure and improve understanding of variability, and improve understanding of the impacts of climate change on variability
- Rethink water storage, emphasizing underground opportunities to minimize the impacts of variability and utilize the storage continuum
- Improve understanding of the role of natural ecosystems in variability
- Improve understanding of how humans influence variability
- Develop and manage water resources fairly – share water, land, and food in a cooperative manner and in a way that does not leave vulnerable groups disproportionately burdened by the impacts of variability

Adapting water management to climate change



Adapting water management to climatic variability is not something that can be done in isolation. Water underpins sustainable development. There is broad consensus that adapting to climate change is best addressed in the context of sustainable development. Depending on local contexts, needs, and interests there are opportunities for improving water management that help adaptation to climatic and other change, and simultaneously advance development. These opportunities usually integrate and apply the best and most promising approaches, tools, and technologies to help vulnerable rural communities build resilience and develop sustainably.

Change is nothing new. But the people, communities, and societies that cope best with change of any kind are resilient and able to adapt. The more resilient they are, the more they are able to manage climatic variability, diversify their livelihoods, and reduce risk. Building resilience now will bring benefits regardless of specifically how and when climate change plays out on the ground.

Photo: David Brazier

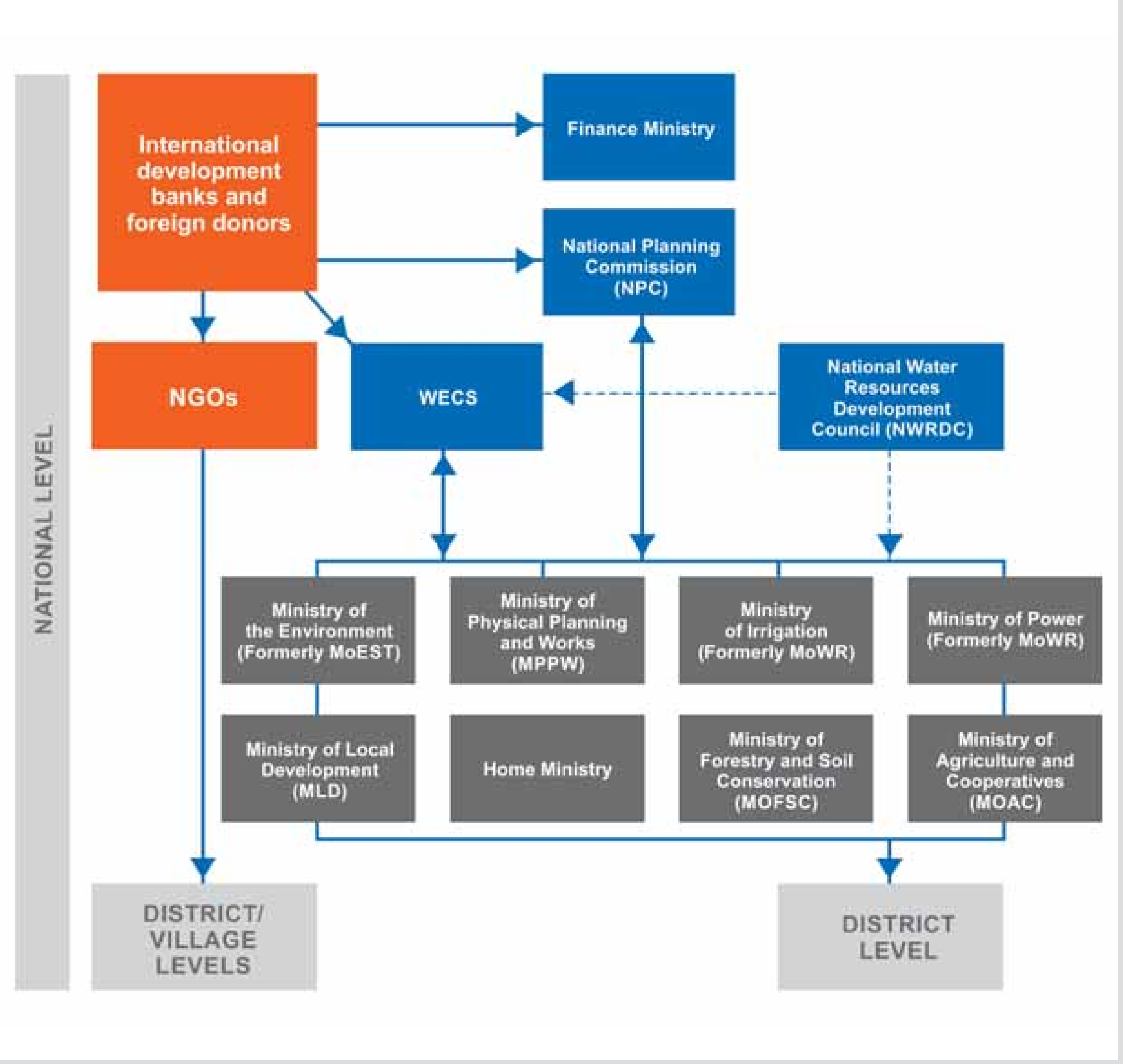
Transform water governance

Photo: Faseeh Shams

Unraveling the multiplicity of interests and issues in water and ensuring equity in accessing water resources is enormously challenging. Social, cultural, governance, and political issues can hamper or advance adaptation to climate change just as they can hamper or advance development. Technical solutions by themselves are of no practical value unless they are supported by people with the power to make policies and to ensure that policies are implemented through appropriate governance and institutional processes.

Institutions involved in adapting water management to climate change in Nepal

The institutions governing water in any situation can constrain or advance adaptation to climate change. To gain a comprehensive understanding of the institutions potentially involved in adapting water management to climate change in Nepal, IWMI scientists mapped the many agencies concerned. The Water and Energy Commission Secretariat (WECS), the designated clearinghouse for water and energy issues and coordinating water policy, does not currently have formal authority to formulate and implement policy, or develop inter-agency plans. Other ministries, such as irrigation, energy, environment, agriculture, and livestock can approve projects without coordinating with WECS. The map of governance helps understand the complexity of implementing strategies to adapt water management to climate change in Nepal. Although WECS has to involve and convince relevant ministries before proceeding with policies or plans, the institutional arrangements hamper progress.



Source: Bartlett et al. 2010


Photo: Vladimir Smakhtin

Integrate and coordinate

Improving water governance through integrated water resources management is widely promoted as a critical need throughout the developing world. Realizing such approaches has had varying degrees of success, often requiring a pragmatic solution suited to the particular context.

Nationally

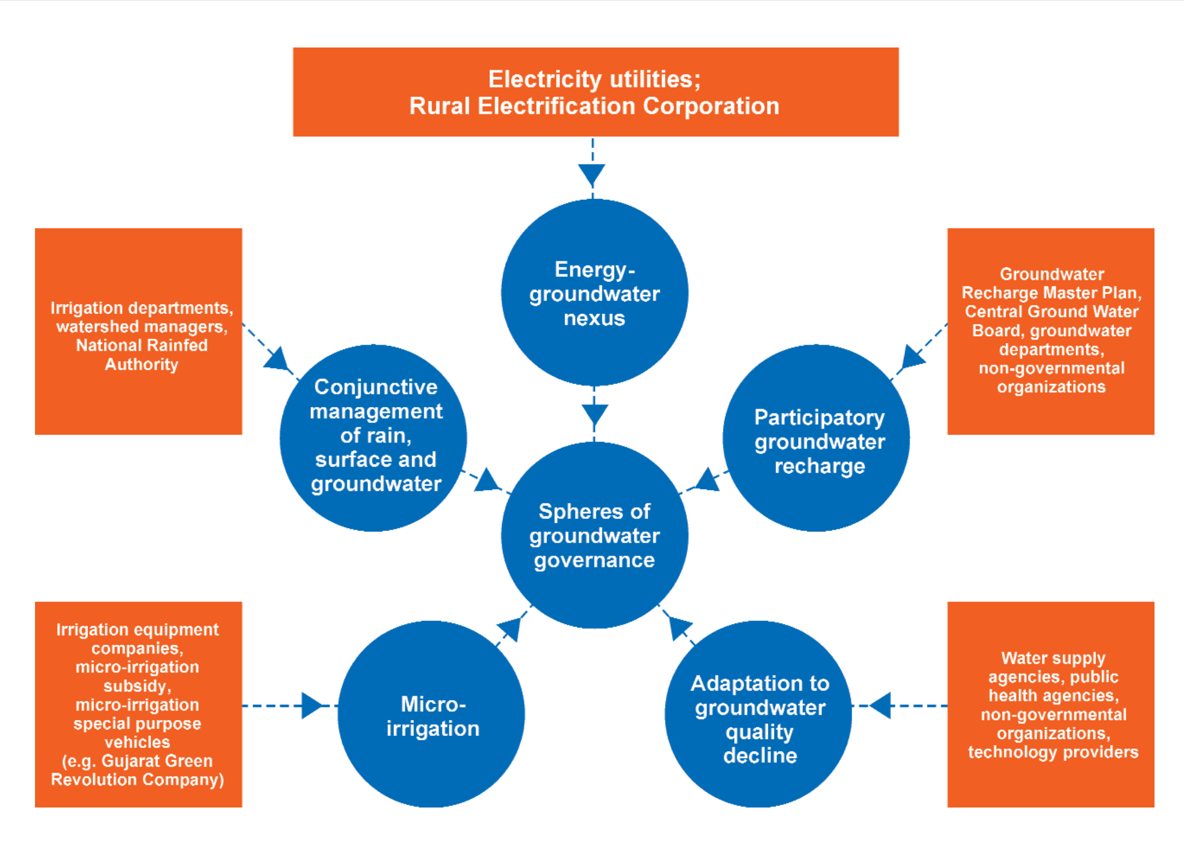
It takes time for governments to establish coordinating mechanisms for bringing multiple agencies in both the public and private sectors under one umbrella. In 2005, for example, the Indian Government produced a master plan for groundwater recharge. Recharging groundwater is important for adapting water management to current and future climatic variability in the country. For the plan to be successful, however, the major players will need to coordinate their roles and integrate their actions.

Locally

At the local level, effective adaptation depends to a large extent on the institutions – formal and informal, local and district – which plan and manage individual and collective action on water resources. These institutions channel funds, information, and technologies into rural areas and facilitate or impede action. The power relations within these institutions, who can participate and who can make decisions, determine who ultimately benefits. Adaptation policies and strategies approved at the national level may not be put into practice at lower levels, or may be put into practice, but not in the way intended. Water management institutions are often not

Multiple players in groundwater in India

The success of the Indian Government's master plan for groundwater recharge will depend on cooperation among those involved and an integrated strategy.



Source: Shah 2009

tailored to handle dispersed smallholder water management arrangements. Small-scale private irrigation, for example, tends to neither come under the remit of irrigation departments, which tend to deal with large-scale canal irrigation, nor under agricultural departments, which are concerned with rainfed farming.

Basin-wide

The boundaries of river basins transcend administrative and national boundaries. Worldwide, water management at all scales increasingly considers water resources in basins and watersheds according to natural boundaries. Yet management decisions and implementation of interventions are more often than not through national administrative arrangements.

Tensions between managing water within natural boundaries and managing water within national borders proliferate. Competing interests – political and economic – between countries, while widely deliberated, are challenging to resolve. A key aspect of adapting to climate change is that countries in transnational basins plan and work together much more than they have done in the past.

One transnational option for the Blue Nile, for example, is for Ethiopia, Sudan, and Egypt to cooperate in a scheme to store water in the upper reaches flowing through the highlands of Ethiopia where evaporation is low. This would reduce the need for storage in Lake Nasser, Egypt, where evaporation is high. However, such a scheme requires far more collaboration between the nations than has occurred in the past.

Managing climate change necessitates cooperation in the Blue Nile Basin

The Blue Nile is an important shared resource of Ethiopia, Sudan, and, because it is the main tributary of the Nile, Egypt. There is great uncertainty about the likely impacts of climate change in the basin. Some models indicate more rainfall and some less. How changes in temperature and rainfall will affect river flows and, hence, how much water is available for irrigation and hydropower is even less certain.

Under the auspices of the Nile Basin Initiative countries in the basin have agreed to collaborate. However, there are still tensions. Formal mechanisms to develop the basin's water resources cooperatively are limited. Despite the potential benefits of cooperation and joint management, countries continue with unilateral plans for development. In the absence of integrated planning, much of the currently planned investment in water storage is likely to underperform and intended benefits may not be fully realized.

Source: McCartney et al. 2013a

Planning

Planning and managing adaptation programs at the watershed scale need to take local vulnerability, and local culture and social organization into account. At this scale, it is in many cases possible to overcome barriers posed by competing interests and to make plans that are mutually beneficial. At larger

Lack of integrated planning endangers livelihoods in the Mekong Basin

In the Mekong Basin, the growth of commercial farming and uncertainty as to how much water will be available as the climate changes raises deep concern about how much water will be available for maintaining aquatic ecosystems and the livelihoods of people who depend on them. A recent IWMI study found that in Cambodia and Laos natural ecosystems buffer food security. Although rice provides calories, foods from natural ecosystems provide nutrition – fisheries provide 50 percent of the protein – and foods such as wild fruit and vegetables, frogs, snails, and insects diversify diets and provide micro-nutrients.

Plans for adaptation need to be integrated so as to safeguard aquatic ecosystems. For example, any proposed changes need to consider the value of fish. In some areas of Cambodia the value of fish in the rice-fish agricultural system can be higher than the value of rice. Intensification of rice production could negatively impact the fish catch unless measures are taken to manage irrigation and the use of pesticides.

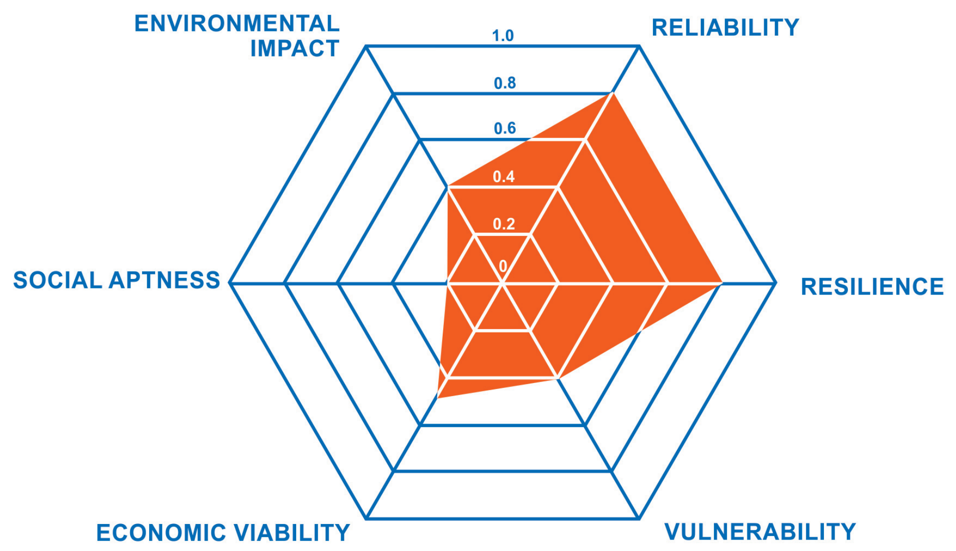
Source: Johnston et al. 2010

scales, adaptation planning requires going beyond water to consider links to other sectors – it needs to be part of overall development planning rather than a separate activity.

Clearly, adaptation options for individuals and communities at the local level depend on the context, such as the particular environment. In many cases though, opening up opportunities for local adaptation needs action by higher level authorities. This has implications for national level adaptation planning. Government plans that support building water storage facilities or putting in place community-managed irrigation systems

Assessing the need for water storage

IWMI scientists developed an analytical tool to evaluate the need for water storage and its likely effectiveness under existing and possible future climate conditions. This has been applied in sub-Saharan Africa, the Volta Basin, and the Ethiopian part of the Blue Nile Basin. The tool considers reliability, resilience, and vulnerability, and the economic, social, and environmental aspects of water storage options for different areas. The results can be shown in a manner that illustrates the trade-off between the key characteristics of a storage option.



Their analyses showed that throughout sub-Saharan Africa, the greatest need for storage was in the Sahelian zone, the Horn of Africa, and southern Africa, with local hot spots of need in southern Angola, Rwanda, Burundi, and Uganda, as well as in Malawi and Mozambique. In Ethiopia and Ghana, the greatest need was not in areas with the least rainfall as might have been anticipated, but rather in the areas with the highest population densities. Based on changes anticipated for a 'middle impact' climate change scenario, the effectiveness of storage will most likely decrease in both the Volta and Blue Nile basins. The analytical tool provides an initial step in more rigorous approaches to assessing investment in agricultural water storage.

Sources: McCartney and Smakhtin 2010; McCartney et al. 2013b can help rural communities and households adapt. In Nepal, for example, where livelihoods and the economy depend heavily on agriculture, planning concentrates on encouraging agricultural practices that are less water intensive, rehabilitating water infrastructure, expanding water storage and irrigation, and making water management more equitable.

Invest wisely

Planning investments also needs to take climate change into account. Investments can range from large dams and irrigation schemes, inter- and intra-basin transfer, or reforestation, to water pricing systems and water management techniques. New infrastructure or technologies may bring benefits, but these benefits may be significantly less compared to those that would accrue in the absence of climate change. Introducing technologies or building new infrastructure may affect ecosystems or may increase the risk of water-related diseases. Failing to introduce technologies or build new infrastructure, however, may also have significant implications. Rigorous analysis of proposed infrastructure or technologies helps decision-makers invest wisely and avoid unintended consequences.

Weigh up costs and benefits

In Africa and, to a lesser extent, Asia, insufficient capacity to manage existing climatic variability lies behind much of the prevailing poverty and food insecurity. These continents are projected to experience the greatest negative impacts of climate change. New schemes can help manage climatic variability now and in the future by, for example, storing water in reservoirs that can be used for irrigation during dry periods. Assessment and modeling approaches used by IWMI enable countries which have limited planning capacity to envision the likely outcomes of adaptation strategies under various scenarios, and to consider alternatives and trade-offs. Models can help planners envisage the upstream and downstream effects of irrigation and hydropower schemes on agriculture, socioeconomics, and the environment under different climate change scenarios.

Avert climate change tipping points

Tipping points are the critical points at which climate change will trigger negative impacts. For example, global warming can raise temperatures to a point where malaria emerges in regions hitherto unaffected. In these circumstances, water storage tanks that might previously have been suitable then become unsuitable unless they are adapted so that mosquitoes cannot breed in them. The rush to develop water harvesting and storage for climate change adaptation may increase health risks for already vulnerable people. Being aware of such tipping points is the first step towards averting unintended consequences.

Photo: Sanjini de Sillva

Weighing up the costs and benefits of irrigation and hydropower schemes under climate change in the Volta Basin

To help planners in the Volta Basin envision how irrigation and hydropower schemes may perform under a 'middle impact' climate change scenario, IWMI researchers used a dynamic regional climate model (Climate Change Simulation CCLM), hydrological model (Soil and Water Assessment Tool – SWAT), and a water resource model (Water Evaluation and Planning – WEAP). In this scenario, by 2050, average annual rainfall, mean annual runoff, and mean groundwater recharge across the basin will all decline. If, as the models suggest, average annual rainfall drops by 20 percent, water flowing through the Volta region could fall by 24 percent by 2050. This means the hydroelectric power stations that are planned and being built would generate less electricity than initially planned without considering climate change. And because the demand for irrigation water will grow, the reservoirs will also struggle to supply what is needed.

Source: McCartney et al. 2012

Dams and malaria

Adapting to change requires that water be better managed, which, in the less developed regions of the world, includes the development of new storage capacity, both small and large. The increase in the prevalence of malaria associated with the development and management of these reservoirs stems from complex interactions between people, their socioeconomic situation, pathogens and mosquitoes. The dense populations around reservoirs often coincide with high numbers of mosquitoes because of the breeding habitats created along reservoir shores. A recent study of the Koka Reservoir in central Ethiopia by IWMI and its partners quantified the impact of the dam on malaria. Although the area is known for seasonal malaria, scientists found that there were more cases of malaria throughout the year in villages close to the reservoir than in those that were further away. Both larval and adult *Anopheles* mosquitoes were much more abundant near the reservoir. The Koka Reservoir, by providing suitable breeding sites for mosquitoes, particularly in the hoof prints of livestock, increases the risk of malaria for people living nearby.

Many dams, both large and small, will be built in Africa in the near future. As well as creating benefits, these dams will bring costs, including adverse health impacts, of which malaria is the most significant. Malaria and other health issues associated with dams need to be considered in the process of planning and managing dams. Health impact assessments and participatory health impact assessments provide comprehensive, systematic approaches which include health considerations in the development and operation of dams.

Source: IWMI 2010

Photo: Nico Sepe

Give the unheard a voice

Many water management practices that have promise for adaptation are grounded in local knowledge. For example, draining rice paddies in the middle of the growing season, a strategy for using water more efficiently, originates from traditional practice in China and Japan. Rural communities have a wealth of such indigenous knowledge. This intangible asset has helped them adapt to climatic variability in the past. It is important to be aware of who contributes and who is unheard in different contexts, and to give them a voice in water governance.

Women

Women know their local water resources: those that are good quality and those that are unsafe, those that fail in dry spells and those that continue to flow. Women, because many tasks associated with water fall to them, know how to use scarce water efficiently. This knowledge is seldom recognized, although women's approaches to managing water are often locally appropriate, flexible, and usually socially and environmentally responsible. Where village headmen and elders take women's views into consideration and give them control over resources, such as in the Marma community in Bangladesh, resources are used more efficiently and productively. Instances such as this suggest that women, given opportunities to speak and participate, have much to contribute to climate change adaptation programs.

The traditional emphasis on elders and men in decision-making not only excludes women, but also discourages them from fully participating even if they are included. Quota systems for women on irrigation committees often mean women have token, not real, representation. Women are notably absent in the higher echelons of water management. An IWMI study of the performance and workings of water management associations and sluice gate committees showed the almost total dominance of men despite specific legal provision for including women.

Nevertheless, even with the odds stacked against them, in some cases women have shown that they can and do adapt to changes brought about directly and indirectly by climate change and other drivers. Fisheries cooperatives run by women in Bihar, India, overcame traditional barriers and secured permanent rights to manage land and water resources. They became powerful enough to lobby and renew their leases. Capacity building and other non-governmental organization activities with women contributed to their empowerment. Strengthening the capacity of women in managing water resources is clearly an opportunity for them to build resilience and adapt to climate change.

Marginalized groups

Economic and social stratification, including by wealth and class, and discrimination based on caste or religion, make it difficult for marginalized groups to voice their concerns, to take part in planning and management processes, and to contribute their particular expertise. Poverty and lack of voice are potent barriers to participation.

Grassroots

The lack of voice extends to local governments in many rural and vulnerable communities. Often, they know little about the climate adaptation or preparedness programs of higher levels of government or have no 'voice' in shaping those programs. There often seems to be a major gap between national programs to develop communities' resilience and what is happening on the ground.

Unequal access to adaptation funds in Nepal

An IWMI review has shown that women in Nepal have less access to land, education, information, and social networks than men, so are less resilient than men and have fewer options for adapting to changes in climate. Indigenous and Dalit women in Nepal are more vulnerable still, as they face gender and caste discrimination. Although Nepal has a strategy for targeting adaptation programs to the vulnerable, such as Dalits, women, and disabled people, this is mainly through groups. However, a study on 'unequal citizens' found that Dalit men and women have no time to be involved in group activities. Groups are dominated by men and women from higher castes. This means that although the national climate change adaptation policy endeavors to direct adaptation funds to women and marginalized groups, Dalit men and women, and indigenous communities are not accessing these funds because group members from higher castes control their distribution.

Source: Sugden et al. Forthcoming

Photo: Waterdotorg, Creative Commons

Revisit water storage

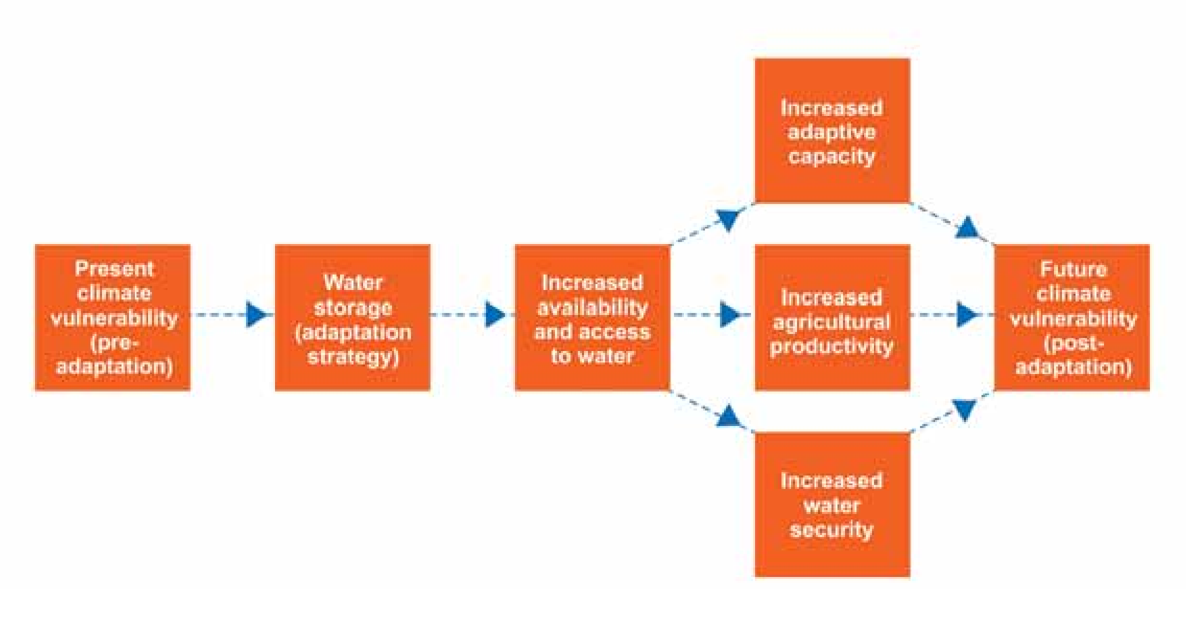

Photo: Ravinder Malik

Some of the most promising approaches to adaptation involve reinventing age-old practices, such as storing water. Storing water so that it is available when there would normally be no rain is a way to adapt to variable rainfall, significantly increase agricultural productivity, and enhance people's well-being. Water storage and distribution systems, which store water in rainy seasons for use in dry seasons and transfer water from areas where it is abundant to areas where it is scarce, help manage water deficits due to changes in rainfall or flow patterns.

Reservoirs and large dams tend to dominate current thinking about storing water. There are, however, a wide range of options for storing water, such as in natural wetlands, groundwater aquifers, ponds, and small tanks. Flexible options for storing water are among the most practical, immediate, and cost-effective responses to existing variability and future climate-induced water scarcity. Much adaptation can be done on a small scale. Covering rooftop water tanks to reduce evaporation when temperatures rise saves water and makes it available for irrigation of kitchen gardens or homestead plots. In the Indira Gandhi Canal system in India, the Rajasthan Government is subsidizing farmers to make farm ponds. These are filled from the canal once a month. Farmers can then draw water from the ponds when needed. These kinds of measures can be combined with other water-saving technologies such as micro-irrigation.

Water storage as an adaptation strategy to reduce climate vulnerability

Water storage can play a key role in both sustainable development and adaptation to climate change. Storing water may enhance both water security and agricultural productivity. However, all kinds of water storage are also potentially vulnerable to changes in climate. With less rainfall, ponds and tanks may not fill or may fill less frequently, so that they may not be able to provide enough water for irrigation.

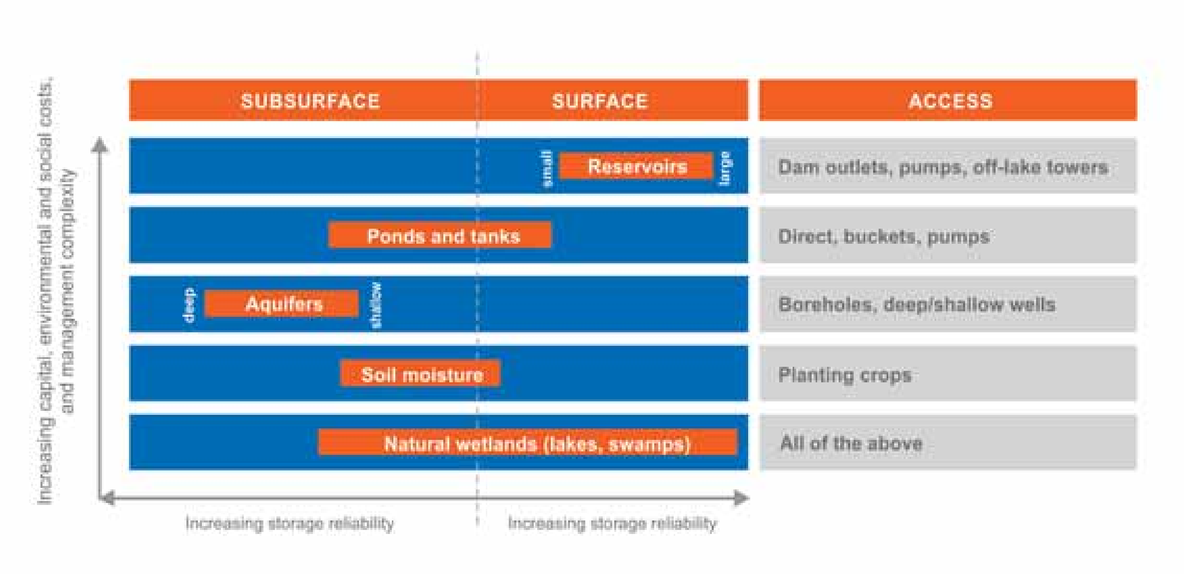


Source: McCartney and Smakhtin 2010

Photo: P. Casier (CGIAR)

Options for storing water at various scales

IWMI studies examine a wide range of options for storing water in different social and ecological circumstances and at different scales. Scientists investigate how much water a basin can store under current and increasing variability, types of storage for different situations, types of storage that will provide water when it is needed, and the advantages and disadvantages of types and combinations of water storage.



All storage options have costs as well as benefits and in any given location the extent to which a particular type will provide a reliable water supply will be different. Any water storage structure – from a small tank to a large dam – will have an effect on the natural system in which it lies. Arrangements that combine several kinds of water storage are likely to be more dependable than those based on a single type. There will rarely be an ideal combination and, in most instances, there will be trade-offs. It is important to look for ways to store water across the continuum from small to large scales and to use complementary water-saving technologies and practices.

Source: McCartney and Smakhtin 2010

Photo: Sajjad Ali Qureshi

Resurrecting traditional water storage in Sri Lanka

As water resources and agriculture are important for future food security in Sri Lanka, the government decided to restore the ancient tank storage system. Early Sri Lankan kingdoms used large above-ground tanks to collect and store rainwater. Farmers used the water stored in this way to irrigate their crops in dry periods. This meant they could draw less water from wells, and so prevent them from drying up.

Restoring the water storage system will provide irrigation water during droughts and store excess water during rainy periods. Together with other measures, such as rainwater harvesting, sustainable development of groundwater, reusing wastewater, and supporting farmers to adopt micro-irrigation technologies, this will mean farmers will be better able to cope with existing and future variability in water supplies.

Source: Eriyagama et al. 2010

Bank groundwater

Storing water underground is underused. Adaptive strategies, such as allowing shallow groundwater systems to fill in the wet season and drawing on the water to irrigate crops in the dry season, do not need large-scale infrastructure. Storing and transferring water in this way can in most years provide a few extra weeks of irrigation water. The Indian Central Ground Water Board estimated that only 10 percent of India's annual precipitation goes to naturally replenish groundwater. IWMI studies show that by encouraging the millions of farmers, households, and communities who have ponds and wells to adapt them so that they feed groundwater systems in the rainy season, much more precipitation could be saved in the ground and prevent groundwater levels falling. A reliable supply of groundwater would enable farmers to cope better with climatic variability. Farmers are likely to buy in to such schemes because they value having direct access to groundwater when they need it. Groundwater banking helps ensure that farmers and pastoralists have sufficient, reliable supplies of water under increasingly variable and severe drought conditions.

Photo: Joe Ronzio

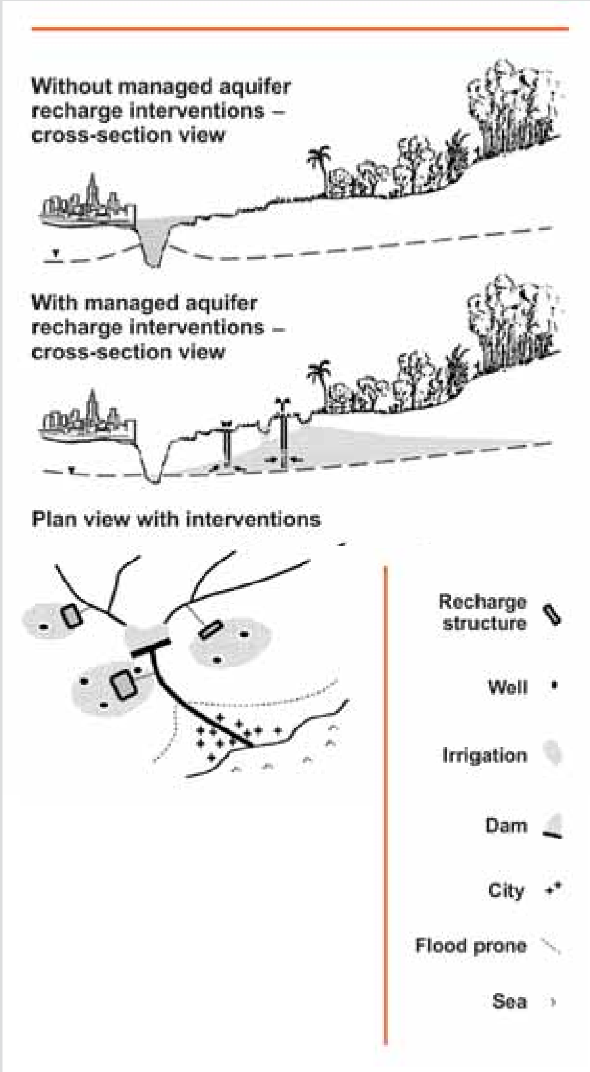
Manage aquifer recharge

In many cases, adaptation measures to reduce the vulnerability of groundwater to climatic change are the same as those needed to deal with issues such as over-allocation or unsustainable withdrawals of groundwater, or floods. Managed aquifer recharge (MAR) cuts losses from evaporation, stores water for use in dry years, and can lessen flooding in downstream areas. In dry climates MAR is increasingly common as shallow aquifers are often widespread and the costs can be relatively low, but it also has potential in humid regions.

Potential for harnessing floods for irrigation in the Chao Phraya Basin, Thailand

IWMI scientists investigated whether capturing excess runoff in the upstream reaches of the Chao Phraya Basin could avert flooding in the lower reaches. They found that peak flow above a certain level could be harvested about once in four years and used to recharge shallow alluvial aquifers over about 200 square kilometers upstream of flood-prone areas. Trapping peak flows in this way would reduce the severity and the socioeconomic effects of flooding, but would not significantly affect existing large or medium-sized reservoirs, or the Gulf of Thailand and deltaic ecosystems. Smallholder farmers in rainfed areas could use the water captured in aquifers to grow cash crops in the dry season without unduly compromising the demands of existing water users.

Such a scheme would be a way of adapting the flood-prone Chao Phraya Basin to both existing and future climate variability. IWMI scientists are currently looking at the potential for harnessing floods for irrigation in other large basins across Asia.



Source: Pavelic et al. 2012b

Photo: Akiça Bahri

Photo: Joe Ronzio

Retain soil moisture

Water held in the soil is crucial for plant growth. However, at any given locality, the soil moisture is limited and is quickly depleted by evapotranspiration. Various tried-and-tested field-scale techniques – widely referred to as soil and water conservation – can improve infiltration and retain soil moisture, thus stabilizing and improving crop yields and using rainfall more effectively. The most promising techniques include deep tillage, reduced tillage, zero tillage, and various types of planting basins.

Measures to improve soil moisture content at a small scale can also boost production or bring environmental benefits. Globally, around 75 percent of crops are rainfed, so farming practices that help retain sufficient soil moisture are important adaptation strategies where irrigation is not technically or economically feasible. For example, irrigation is often not feasible in the Laotian highlands of the Mekong Basin, where population growth is driving the change from shifting cultivation to more intensive cropping. Here, conservation farming, rainwater harvesting, and storing runoff are practical adaptation tactics.

Soil and water conservation strategies for adapting to climate change

In the West Seti Basin, Nepal, it is difficult to draw conclusions regarding future precipitation and flow trends resulting from climate change. A recent IWMI study evaluated various water management strategies: afforesting degraded land, on-farm conservation, infiltration ponds, and small reservoirs. Combining all the strategies effectively reduced surface runoff and increased percolation, thus making more water available in the dry season.

Combining strategies for rehabilitating degraded land and water resources is also an adaptation strategy in drylands. For example, applying phosphogypsum, a calcium supplement, to magnesium-affected soils can save 200 liters of water for each kilogram of cotton produced. Such water savings, when adopted on a large scale, could be important adaptation measures in dry regions where land degradation and the deterioration of water quality are widespread.

Sources: Gurung et al. 2013; Qadir et al. 2013

Produce more food per unit of water

Given that globally agriculture accounts for 70–80 percent of freshwater use, competition for water among agricultural and other water users will be an issue for years to come in many countries. The degree of competition will depend on geography and scale, and factors such as urbanization, changing demands for food, industrial development, and the relative scarcity of water in a particular season. Over the next 40 years, farmers will have to find ways to produce 60–70 percent more to feed the growing global population. They will have to do this while their share of global freshwater shrinks and while adapting to a progressively changing climate. This means making each unit of water produce more.

Poverty and food insecurity are generally highest where water productivity is lowest. Increasing water productivity is an effective way to intensify agricultural production, improve community resilience, and reduce environmental degradation. There is a considerable body of knowledge on the changes in agricultural systems and water management needed to safeguard and boost agricultural production. In Southeast Asia and Africa, farmers who have adopted the 'system of rice intensification' not only use less water because they irrigate intermittently instead of flooding paddy fields continuously, but also raise yields and benefit the environment. Nevertheless, adoption of such technologies often involves trade-offs. In this case, growing rice more intensively requires more labor, more weeding, and more attention to water management. There are very few completely win-win solutions.

Regional opportunities to future-proof food security

Region	Climate change effect on food security	Adaptation opportunities
Indus-Ganges Basin	May boost or reduce food security depending on the impact of warming on evapotranspiration. Changes seasonality of flow as snow melts earlier	Store winter flows and manage groundwater recharge to supply dry-season irrigation
Karkheh Basin	May reduce food security because of significant warming	Industrialize and diversify livelihoods Store water for irrigation where self-sufficiency is important
Limpopo Basin	May reduce food security because of lower rainfall coupled with warming. Will depend on seasonality of change	Diversify livelihoods, harvest and store rainwater
Mekong Basin	Likely little impact regarding warming and rainfall, but may be affected by flooding and rising sea level	Manage storm flow, diversify livelihoods, manage water quality
Niger Basin	Possible improvement because of wetting, depending on impact of warming and also on seasonality of change	Reduce impacts of rainfall shocks and seasonality by harvesting rainwater, storing water, exploiting groundwater, and setting up early warning systems
Nile Basin	Variable from north to south, with considerable uncertainty	Reduce impacts of rainfall shocks and seasonality by harvesting rainwater, seasonal livestock migration
Yellow River Basin	May improve because of higher temperatures which extend the growing season and because of more rainfall, but depends upon seasonality of change	Diversify livelihoods Manage seasonal and inter-annual variability by harvesting rainwater, storing water, and recharging aquifers

Source: Mulligan et al. 2011

Manage variability

Regardless of national plans, policies, and strategies, farmers adapt at the local level even though in many cases they have little external support. Farmers have always lived with climate variability and have coping strategies that they can build on to adapt to climate change. They already deal with variations between seasons, and rains coming earlier or later than usual and lasting for shorter or longer periods. Following several years of low rainfall, farmers in the Upper Bhima River Basin in South-West India are already shifting from thirsty sugarcane to less thirsty soybean, an adaptation to water scarcity that also gives them a better return. In diversifying their cropping system by planting vegetables as well as rice to adapt to urbanization and developing markets, rice farmers on the outskirts of towns and cities in Southeast Asia are producing more food per unit of water and at the same time are becoming more resilient to climate change.

IWMI and other institutions have developed a wide range of technologies to build on farmers existing strategies and practices to deal with climatic variability. Combining tactics such as growing a greater variety of crops, growing crops that are more drought resistant or need less water at critical times, installing micro-irrigation, and constructing small ponds or tanks decrease the risk of crop failure, raise overall farm yields, and build resilience to changing conditions. In Madhya Pradesh, incomes of farmers who constructed on-farm ponds to irrigate pulses and wheat have risen by more than 70 percent. In Tanzania, half of the dry-season cash incomes of smallholders come from growing irrigated vegetables. In Zambia, the 20 percent of smallholders who cultivate vegetables in the dry season by irrigating on a small scale earn 35 percent more than those who do not.

Rethinking agriculture: helping farmers manage variability and reduce risk

- Improve water productivity
- Diversify production (e.g. mixed crops, livestock, aquaculture)
- Change cropping systems to less thirsty crops
- Improve water-use efficiency (e.g. drip or sprinklers to replace flood irrigation)
- Encourage small-scale affordable irrigation technologies and water management practices
- Re-invent traditional water management practices
- Diversify water storage (e.g. ponds, small tanks, reservoirs)
- Provide marketing support (e.g. access, transparency) and infrastructure (e.g. roads, electricity, telecommunications)
- Promote broad-based agricultural development that encourages off-farm rural opportunities and enterprises to supplement agricultural income
- Secure tenure for land, water rights, and access rights for common property forests, wetlands, rivers, and lakes
- Shape access to resources and services (e.g. extension, climate information services) supporting adaptation to take account of social factors (e.g. gender, caste, class) that affect vulnerability
- Develop systems to promote cooperation on water
- Improve performance and flexibility of public irrigation schemes

Source: Johnston et al. 2010

Manage demand

While farmers can be helped to adapt to climate variability and change at local level, the authority to plan and approve basin-wide projects, such as diverting water from irrigation to preserve the environment and benefit from ecosystem services, may lie in political or other spheres. Decision-makers need to understand the trade-offs, for example the benefits forgone by reallocating water from canal irrigation to environmental flows under different water allocation schemes and climate change scenarios. This understanding can help them manage demand.

Reforming irrigation management is a viable option for raising water productivity in many countries. Across the Mekong Basin, countries are building and planning large irrigation schemes. Meanwhile, existing public irrigation schemes are often inappropriately designed, and perform well below their potential because of the way they are operated and maintained. In Tanzania, community-managed irrigation schemes are boosting incomes and yields to the same extent as government-managed irrigation schemes, but at a lower cost. More food can be produced per unit of water by adapting management practices in irrigated agriculture to deal with uncertain rainfall now and in the future.


Photo: David Brazier

Understanding the trade-offs between allocations for environment flows and allocations for irrigation in the Upper Ganga Basin

A recent IWMI study examined the trade-offs between allocations for environmental flows and canal irrigation in the Upper Ganga Basin (UGB) under changing climate conditions. The study assessed the marginal increase and marginal decrease in the value of crop production within and outside the UGB for changes in the volume of surface irrigation. The assessment showed that even if canal irrigation was cut by a large percentage, it would make very little difference. This is because groundwater accounts for six times more irrigation than canal water. In the UGB, agriculture is the largest water user. Land and water productivity are very low. Improving water management, reducing water use by changing to low water-use crops, and introducing drips or sprinkler systems which irrigate more efficiently could effectively compensate for water diverted from canals for environmental flows.

Source: Bharati et al. 2012

Photo: Sanjini de Silva

Boost rainfed agriculture

Sixty percent of the world's food is produced on rainfed cropland. Supplemental irrigation – irrigation applied only at the critical stages of crop growth – combined with better soil, nutrient, and crop management can more than double water productivity and yields in small-scale rainfed agriculture. Major increases in production in the Mekong delta, for example, have been achieved by supplemental irrigation in the dry season. Simple water-lifting equipment – powered by fossil fuels, electricity, the sun, people or animals – and micro-irrigation techniques, ranging from clay pots to drippers, can also dramatically boost the ability to cope with climatic variability, and can have a profound effect on agricultural productivity. Dry-season irrigation of rice could improve yields between 70 percent and 300 percent across sub-Saharan Africa.

These kinds of approaches to boost rainfed production at local levels improve resilience and reduce risks for farmers and communities. The AgWater Solutions Project, an IWMI-led partnership, has provided practical recommendations and tools for governments, the private sector, donors, and organizations to support farmer-led small-scale irrigation initiatives in sub-Saharan Africa.

Tap the potential of women

Women comprise, on average, 43 percent of the agricultural labor force in developing countries. Female farmers produce less than male farmers, not because they are less efficient as farmers, but because they have less access than men to productive resources and opportunities. Governments are reluctant to change property rights, citizenship laws, and access to credit in ways that would open up opportunities for women. Economic stratification at the household level is critically important in shaping adaptation options, in particular regarding land tenure. The 2010–2011 FAO State of Food and Agriculture report, *Women in agriculture: closing the gender gap for development*, showed that if women had the same access to productive resources as men, they could increase yields on their farms by 20–30 percent. This could raise total agricultural output in developing countries by 2.5–4 percent.

In Bangladesh, Nepal, and India the rules and regulations that deprive women of rights to land and other resources, and formal and customary laws that assign assets and responsibilities to men means they are poorly placed to adapt to changes in climate. The gender division of work characteristic of purdah sometimes prevents Bangladeshi women growing crops even on land owned by the family.

Educating both men and women will boost their capacity to raise agricultural production and adapt to climate change. In India, men's

Opportunities for gender-sensitive strategies to respond to climate change

- Mainstream gender perspectives into national policies, action plans, and other measures on sustainable development and climate change
- Carry out systematic gender analysis, collect and use sex disaggregated data, establish gender-sensitive indicators and benchmarks
- Develop practical tools to support increased attention to gender perspectives
- Ensure consultation with and participation of women in climate change initiatives
- Strengthen women's groups and networks

Source: Sugden 2008

Photo: Jim Holmes

and women's education levels and literacy were found to affect their access to information on the weather. Since women generally receive less education and have limited access to information and opportunities, they are less likely than men to be able to acquire new food production skills. Organizers of farmer groups assume that women are 'less educated' and thus are not suitable candidates for training programs. Most of the women's contact is with non-governmental organizations. Both government and non-governmental rural development programs that target women lag behind the realities of change and still focus on traditional female sectors.

Migration spurs women to adapt

Studies in the Khulna, Jamalpur, and Bandarban districts of Bangladesh attributed an increase in the involvement of women in agriculture to male migration driven by climate change. Women were adapting to the absence of men by having to spend more hours in the fields. In taking on the burden of more agricultural work, women also gained more access and control over crops and inputs, although purchases of inputs are still largely controlled by men.

Source: Sugden et al. Forthcoming

Social and cultural attitudes are slow to change. In some countries, the groundswell of change in attitudes to gender, caste, and class is a long way off, but here and there positive changes are emerging. In communities where changing conditions, climatic or otherwise, have led men to migrate in search of work, women have been forced to become more involved in traditional male domains. The exodus of men from rural areas has steered women into taking up their husbands' responsibilities, such as in the engineering aspects of irrigation or negotiating access to canal and groundwater. More change along these lines will be important for adapting to change. Raising awareness of changes that are happening and why, and educating and informing both men and women will help. The key decision-makers in agriculture in the future will increasingly be women.


Photo: David Brazier

Assess water resources

Photo: Petterik Wiggers

In many parts of the world there are no long-term climatic data or records of river flows. In other parts the data may exist, but may be dispersed and difficult to access. This deficiency in data and information is not likely to be resolved soon and adds to the uncertainties of climate change projections. Decision-makers are faced with projections that take historical trends and extend them to a range of possible futures. The uncertainty at the global scale – on the scale of the changes and even on the direction of change – is considerable. Moreover, global models are at a scale and resolution difficult for water resources managers at local, national, or regional levels to work with.

IWMI takes models produced by the Intergovernmental Panel on Climate Change (IPCC), downscales them to the watershed and river basin level, and models temperature, precipitation, hydrological, and water resources with the most reliable local data and information available. Even at these scales there are uncertainties as to what will happen with climate change, more so when there are gaps in the data or the data for baselines are unreliable. The models provide an indication of possible changes under specific scenarios rather than define what will actually happen in reality. But, where different models point to approximately the same trends, they provide a best bet on the likely higher or lower limits of change. This means decision-makers can focus on what is most likely to happen, rather than on what is still very unclear, in order to make their agricultural systems more climate-resilient.

Assessments are a first step in developing equitable and sustainable adaptation strategies. IWMI scientists use a range of computer models – temperature, precipitation, hydrological, and water resources – to assess how current climatic variability affects water resources and how climate change might affect water resources in the future. A recent IWMI study of rainfed rice in the lower Mekong showed that even when data are limited, reasonable assessments can be done at the basin or regional scale using simple models like AquaCrop.

Analytical tools help decision-makers to understand the costs and benefits involved in proposed adaptation measures. They present scenarios that allow stakeholders and decision-makers to envision the effects of climate change on water resources. In the Mekong Basin, analyses showed that there was no observed increase or decrease in rainfall, and that temperature is rising. The construction of large storage dams on Mekong tributaries for generating hydro electricity is likely to have considerably more impact on river flow regimes than climate change, at least for the foreseeable future. The most significant effect of climate change would be the projected rise in sea level because it would transform farming in the delta region which is the most productive part of the Mekong Basin.

Shaping adaptation to uncertainty in Sri Lanka

Faced with a high degree of uncertainty about the future climate – some predictions from climate models suggest precipitation will be above normal and others suggest it will be below normal – the Government of Sri Lanka chose to tackle variability rather than projected upward or downward trends. The government took a broad approach, looking at the climate models, and the capabilities and vulnerabilities of farmers. To make agriculture more climate-resilient the government will work with farmers to resurrect traditional ways of dealing with a variable climate. This tactic will help prepare farmers for changing growing conditions in the near future and in the longer term.

Source: Eriyagama et al. 2010

Assess risk

Analytical tools can also be used to identify the communities and areas – particularly those that are major food producers – which are likely to be most vulnerable to climate change. Governments can then direct adaptation efforts to areas most at risk.

Assessments can be geared to helping target adaptation programs to areas most at risk. An IWMI study ranked basins and watersheds in the Middle and High Mountains of Nepal according to their vulnerability to climate change. Based on this assessment, the Asian Development Bank (ADB) and the Department of Soil Conservation and Watershed Management are launching a pilot program to build climate resilience in the most vulnerable areas. Measures include digging farm ponds, terracing, and building check dams for storing water. IWMI is working with ADB on monitoring the impact of these interventions.

IWMI research on vulnerability takes into account, for example, socioeconomic factors, infrastructure, and technologies in use as well as existing and projected climate variability. Planning to address hot spots of vulnerability identified in this way is more cost-effective than a 'one-size-fits-all' approach. New technologies, improved climate information services, and safety nets can help communities adapt to risks associated with increasing climate variability and extreme events.

Degree of risk to countries in the Ganges Basin from climate change

Risk	India	Nepal	Bangladesh
Rise in temperature	High	Very high	High
Glacier retreat	High	High	-
Frequent floods	High	High	Very high
Frequent droughts	High	High in some areas	High in some areas
Rise in sea level	Modest	-	Very high

Source: Hosterman et al. 2012

Identifying areas of risk in Sri Lanka

IWMI scientists developed an index to identify hot spots of vulnerability to climate change in Sri Lanka. They found that typical farming districts are more vulnerable than the rest of the country because they rely heavily on primary agriculture. Poor infrastructure, few assets, and exposure to natural hazards mean farming communities are least able to adapt and are most likely to suffer the adverse impacts of climate change. The Sri Lanka Government used the results of the study and applied them at district level as part of the national adaptation plan of action.

Source: Eriyagama et al. 2010

Photo: Nico Sepe

Build resilience

Photo: Karen Conniff

Accepting and managing climatic variability now is the best bet for managing climatic and other changes in the future. Improving water management and water productivity, and involving farmers, communities, policy-makers, the private sector, and civil society are important for encouraging the adjustments in individual behavior, technology, institutions, and agricultural and socioeconomic systems needed to adapt to a variable and changing climate.

In the short-term, adaptation in many agro-economies is likely to involve the uptake of improved agricultural and water management technologies. In the long term, however, diversifying sources of income is likely to become the main adaptation strategy. Trends in migration to urban centers, off-farm employment, remittances from abroad, and new businesses that capitalize on advances in information technology and other infrastructure, signal that adaptation to changes in climate and other circumstances is already underway. Governments could help men, women, and communities adapt to changing circumstances, including more variable and extreme climate, by delivering public services, such as sanitation, drinking water, and information about agriculture, livestock, and fisheries, more effectively.

Taking a sustainable development approach to adaptation addresses vulnerability, rather than just climate change. Promoting broad-based agricultural development to lift resource-poor rural communities out of poverty is probably the most effective adaptation strategy. The sustainable development approach builds resilience and the ability to cope with climatic variability and unforeseen circumstances both in the present and in the future. For many communities, adaptation and sustainable development will be one and the same. As incomes, livelihoods, and well-being improve, so will resilience.

Sustainable development opportunities to build resilience

- Provide secure tenure to land and water rights, and access to common property forests, wetlands, rivers, and lakes
- Diversify to spread risk
- Improve access to markets, and improve their transparency and competitiveness
- Provide financial safety nets (credit, crop insurance, and crop mortgages) to mitigate risk
- Develop emergency food and nutrition programs
- Develop disaster plans for floods, cyclones, and drought

Source: Johnston et al. 2010

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