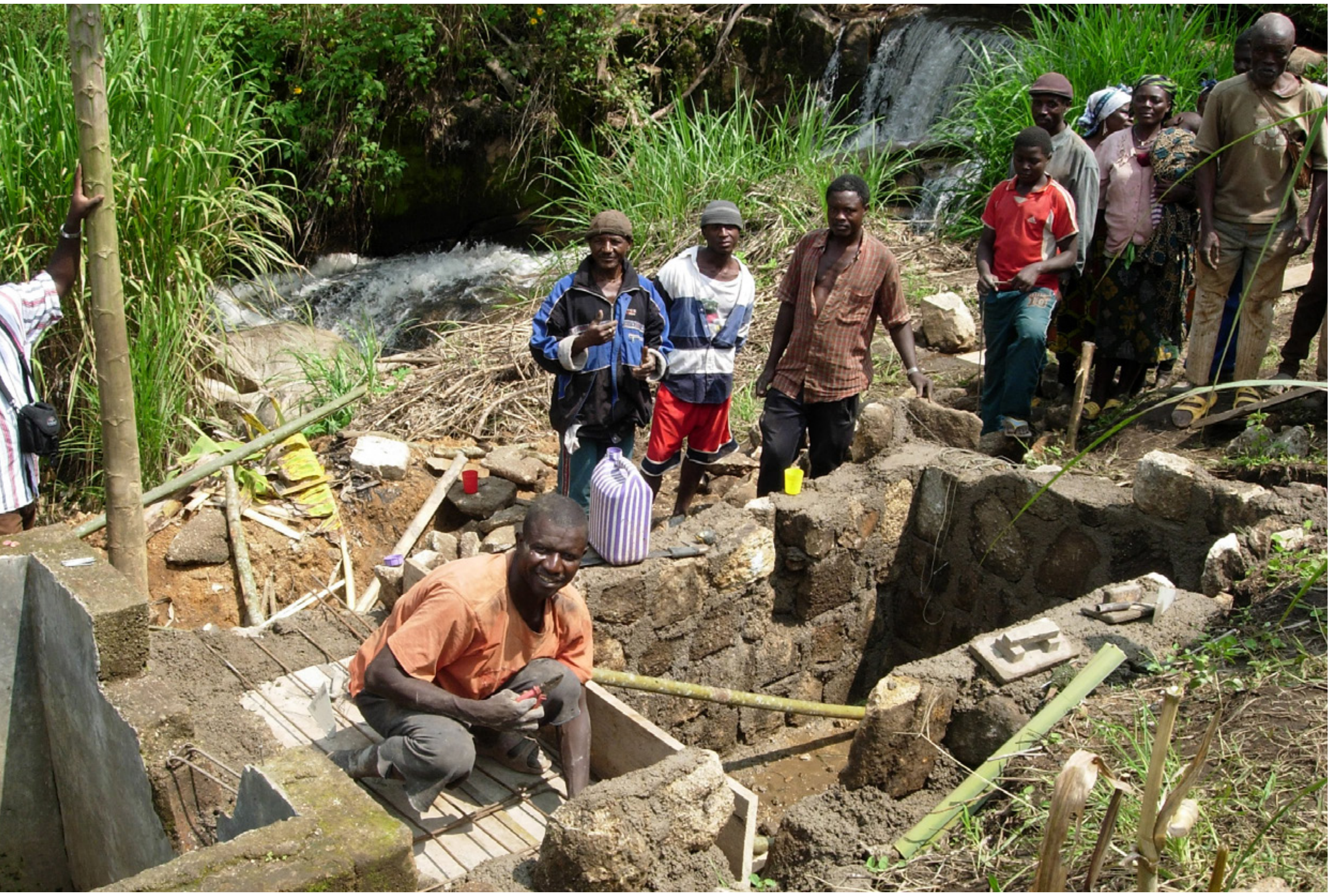


This micro-hydro plant in Cameroon leaves the river intact and floods no land. It can also be built and operated by local people (unlike megadams). Photo: Terri Hathaway

Finding Solutions to Adapt to Climate Change

While human beings have been adapting to environmental change for millennia, climate change is bringing bigger and faster changes than most human societies have had to deal with. Key changes that pose the greatest challenges for adaptation include increases in temperature, more extreme storms and worse flooding, ongoing changes in intensity and duration of precipitation, new health and disease challenges, and major changes to key ecosystems.

National adaptation plans the world over are largely state-driven and purely top-down in terms of their decision-making approach, while climate change is experienced locally and can only be effectively addressed by engaging local groups and institutions.

Local agencies, especially civil society organizations, are often best suited to improving adaptive capacities within vulnerable communities because they are closest to the problem. At the same time, a local organization may not have the necessary resources and expertise to conduct detailed assessments of climate risks. Engagement with local or regional experts and government agencies that do have the resources and expertise is thus an important piece in developing adaptation options.

In any case, resilience strategies should be an integral part of research, development, planning, training, capacity building, and project implementation.[30] This chapter describes some of the key principles of climate resilience and offers suggestions on how you can work with your organization to develop adaptation activities and sustainable solutions. It also includes a series of case studies of successful adaptation solutions by sector.

PRINCIPLES OF CLIMATE RESILIENCE

Climate resilience can refer to actions that either reduce climate impacts or respond to climate impacts. More specifically, resilience deals with reducing the vulnerability of natural and human communities to climate change impacts by strengthening their ability to deal with both ongoing and one-off disturbances generated by climate change (for instance, through improving local food security or energy access).

When developing an adaptation project or a development project with adaptation components, it is important to keep the following principles of climate resilience in mind, in order for the project to be sustainable and for local communities to be resilient to major climate-related impacts (adapted from the Institute for Social and Environmental Transition).[31]

Access Rights and Stewardship

It is important for local community members to control local natural resources. For instance, securing the land rights of indigenous populations allows them to increase their ability to adapt to the pressures of climate change. Sometimes with the support of pro bono lawyers, your group can work with community members to clarify their rights and entitlements to use key resources and ensure that these do not exclude specific groups from access to critical resources or support systems. Successful stewardship of natural resources also involves community monitoring of infrastructure projects and citizen science. This helps in building resilience as communities are more aware of project functions and associated risks. Communities that play a central role in the operation and maintenance of irrigation systems can also help build resilience.

Adaptive Capacity: A core principle for strong adaptation and resilience is improving the adaptive capacity of the affected community and those involved. This concept can mean being resourceful, responsive and having capacity to learn from past experiences. It is essential that civil society groups and other institutions involved in climate adaptation activities have a strong and locally driven understanding of the vulnerability of the poorest and most at-risk communities. Poor governance and weak institutions are often cited as the main drivers of vulnerability, and lack of local participation and investment in community-based climate adaptation strategies are significant barriers to a community's adaptive capacity. Your group can help by bridging the gap between government and local communities at an early stage. For example, local and transboundary civil society groups established an Early Flood Forecasting system for rivers in the flood-prone Assam in North East India, which has helped to increase the climate resilience of vulnerable communities.[32]

Diversification and Decentralization: A resilient system is one where key assets (such as water and energy sources) and functions are physically distributed so that they are not all affected by a climate-related event or natural disaster at any one time (spatial diversity) and have multiple ways of meeting a given need (functional diversity). For instance, a diversified and decentralized energy portfolio allows a state, province or country to be more resilient to extreme climate events that might shut down a source of energy in one region but would have a limited impact on other areas. In the water sector, diversified cropping patterns and ecological farming practices can help farmers weather droughts, floods or mismanagement of systems. Riverine fisheries supported by free-flowing rivers aid in nutritional security in times of stress.

Villagers along the Teesta River in Bangladesh at a community-building workshop in Sikkim, India. Photo: Samir Mehta

Flexibility: Because climate change implies a future of uncertainty, flexibility is a core underlying principle that applies to essentially all areas of adaptation: infrastructure, projects, institutions and governance. Faced with such an uncertain future, your group can promote "no-regrets" strategies that address key development priorities and are justified even if climate change was not an issue. For instance, if water resources seem to be declining, reducing demand through increased efficiency may be a more flexible (and precautionary) solution than building a dam, at least until there is more certainty about how much water will be available.[33]

Good Governance: Decision-making processes should follow widely accepted principles of good governance, chiefly: transparency, accountability and responsiveness. Your group can urge your government to recognize that the community groups that are most affected have a legitimate claim for being involved in decision-making processes. Decision-making processes should also be transparent, representative, timely and accountable; include avenues for affected parties and different interest groups to provide input including complaints; and ensure that dispute resolution processes are accessible and fair.

Information Flows: Your group can assist in collecting and disseminating accurate and meaningful information to households, businesses and the public so that they can make judgments about risk, vulnerability and adaptation options.

Redundancy: In order to prepare for emergency situations, governments and institutions should be equipped to provide various service delivery options. Your group can assist in this by channeling aid and funding to disaster-stricken communities. This concept of redundancy also includes the presence of buffer stocks (for example, local water or food supplies) that can compensate for the loss of critical resources and support systems if resources or service flows are disrupted.

KEY RECOMMENDATIONS FOR CIVIL SOCIETY GROUPS

Selecting/Designing Sustainable Solutions

If you are in charge of developing a project or program, ensure that it follows the *Principles of Climate Resilience* (see above) and also meets the following specific criteria:

- Helps vulnerable groups: The most vulnerable groups or sub-groups within a community have the greatest need to increase their adaptive capacity; therefore, activities that meet the needs of these groups should be emphasized.
- Number of beneficiaries: Balance the first criterion with a goal to benefit as many people as possible.
- Sustainable "no-regrets" solution to climate change: The proposed activities should take into account the impacts of climate change in the long-term and bring benefits even in the absence of climate change impacts.
- Grounded in sound science and local context: As much as possible, ensure that the project marries both bottom-up (vulnerability analysis) and top-down approaches (climate science projections).
- Political feasibility: While you want a project that ideally receives political and financial support, encountering political opposition should not be seen as an insurmountable barrier or a limitation on innovative thinking.

Lake Chad, once the fourth largest lake in Africa, has lost 80% of its surface area in the past 30 years due to dams, diversions, and shifting climate patterns. It can now be crossed on foot. Photo: Cédric Faimali

- Cultural appropriateness: Adaptation projects and activities also need to respect the local culture to be feasible. Otherwise, you may find that changes are not widely adopted. Similar to the previous criterion, this should not rule out change, as deeply rooted behaviors may be part of the problem.

- Long-term cost effectiveness: Less costly solutions should be preferred for obvious reasons; however, cost effectiveness should be considered over the long term, as adaptation solutions will by their nature often only pay off in the long run. Cost assessments therefore need to take into account not only the immediate implementation costs of the project, but also the avoided future costs of climate impacts.

- Greenhouse gas emissions: While reducing the carbon footprint may not be a priority for local development of poor and vulnerable populations, low-carbon development should be pursued whenever possible.

When you have come up with an appropriate project, make sure that it has community support and ownership, and determine that you share a common, clear definition of the impact that you are hoping to achieve. Make sure that your solutions will not create secondary challenges or future problems. Make a plan and timeline for designing, funding, launching, managing, and handing over the project to the community. There are number of resources for this in *Appendix 1: Key Resources.*

Ensure Solutions Address the Needs of the Most Vulnerable:
Projects that tamper with or destroy natural resources – such as major river engineering projects – should be evaluated for how they will affect the adaptation capacity of the most vulnerable. Further, because poor communities often do not perceive adaptation as something new or separate from how they have always been living with their environments, the following practitioner's perspective in working with the most vulnerable populations on climate adaptation can be useful:

- Learn from what exists: A sensitivity to natural adaptation patterns is required to learn how a specific community experiences climate change and what natural adaptation methods could be built upon for climate adaptation.

- Customize solutions: Adaptation processes differ across geographic, physical, and cultural contexts. Synergy among practitioners from similar contexts can lead to new solutions for specific communities.

- Link to livelihoods: For communities living in poverty, meeting basic needs is a priority. Adaptation processes that directly enhance local livelihoods more easily become community-driven, and hence sustained.

- Create local knowledge paths: Challenges of convincing a community to adopt an unfamiliar adaptation solution can be overcome by developing village-to-village mentorships. A community that has proved the efficacy a new adaptation process would be the best knowledge agent for others facing similar climate risks.

You can find a wealth of resources around solutions that have worked on Practical Action's website: www.practicalaction.org/climate-change.

TYPES OF SOLUTIONS BY SECTOR

The following sections present specific adaptation solutions in the water, energy, food and conservation sectors, and case studies where they have been successfully implemented. They include examples from both "supply-side" management, which includes increasing capacity (such as building new structures) and changing operating rules for existing structures, and "demand-side" management, which includes managing demand and changing institutional practices.

WATER SECTOR

Climate change will bring huge and complex challenges to the water sector, and a great variety of adaptation strategies will be needed to tackle them. Climate change will impact the amount and quality of water that is available. Water supplies will become less predictable. Water-related extreme events will become more frequent. Reduced water availability will pose an ongoing threat to ecosystems.

The area of hyper-arid land increased by 100% between the 1970s and 2000s.

Over the past several years, there has been an increase in interest in demand-side techniques, as certain supply-side strategies such as building more storage reservoirs or large water diversions have proven to increase some problems of adapting to a changing climate – for instance, they can evaporate great amounts of water due to higher temperatures, and pose a greater risk of damage or failure from more extreme floods. Decentralized local storage options generally provide greater accessibility and flexibility for local water users. While many regions will need greater water supply, many bodies such as the World Bank continue to promote hard-path, large-scale infrastructure as an adaptation response rather than more resilient strategies, such as some of the examples presented in this chapter (see "World Bank's IDA and Climate Resilience" on next page). Climate adaptation strategies and alternatives to large water storage from dams vary greatly and encompass a variety of approaches including better water management strategies, small-scale water storage, and alternative agricultural practices. Some of these examples are described below.

Rainwater Harvesting and Groundwater Recharge

Around the world, community groups have developed locally practical rainwater harvesting systems. These systems will be of increasing importance in a changing climate because they can be more accessible and dependable than a centralized large water storage facility, especially for the rural poor who are located in remote regions. Unlike large infrastructure projects that often bypass the rural poor, small-scale rainwater harvesting projects are managed locally, and are simple and cheap to build and operate. Local people can be easily trained in such technologies, and construction materials are usually locally available. Rainwater harvesting is convenient, because it provides water at the point of use and farmers have full control of their own systems. It can also help to increase soil moisture levels and groundwater through artificial recharge. Its main limitation is the availability and amount of rainfall.[34]

Man stands next to a johad, or small dam, built to impound rainwater in India. Photo: Patrick McCully

For example, in Thailand many rural people collect rainwater for drinking and cooking in large jars near their houses. More than 10 million rainwater jars have been built in Thailand. The jars come in various capacities, from 100 to 3,000 liters, and are equipped with lids, faucets, and drains. The most popular 2,000-liter jar holds enough rainwater for a six-person household during the dry season, lasting up to six months.

India has a long history of community water systems, and in recent decades a rainwater harvesting movement has been underway, especially in the driest parts of the country. Villagers in Rajasthan, for example, have built or restored thousands of water-harvesting structures, with the help of NGO Tarun Bharat Sangh. Known locally as *johads*, these small rock or earthen dams are built across seasonal water courses to capture monsoon rains, restrain soil erosion, provide irrigation water, and restore the groundwater. Along with other water-conservation structures and strategies, they have brought water back to more than 1,000 villages and revived five rivers in Rajasthan. *The Hindu* newspaper summed up this remarkable water harvesting work in Rajasthan: "The poor should not always have to pay a price for the government's constant search for ineffective mega-solutions and critical neglect of micro-problems. The people only need to be given a sense of hope to achieve the impossible."

Several examples of community-centered small-scale water systems exist throughout India, especially in the biodiversity hotspot of the Western Ghats. These are not just one-off success stories, but a mainstay of many drinking water and irrigation systems. For

CATEGORIES OF ADAPTION MEASURES IN THE WATER SECTOR[1]

Adaptation Measures	Examples
Planning and implementing new investments	Reservoirs, irrigation systems, rainwater harvesting, groundwater recharge facilities, levees, water supply, wastewater treatment, desalination plants,
Adjusting operation, monitoring, and regulation practices of existing systems to accommodate new uses or conditions	Pollution control, environmental flows in dam operation, ecosystem restoration
Working on maintenance, major rehabilitation and re-engineering of existing systems	Dams, barrages, irrigation systems, canals, pumps, rivers, wetlands
Making modifications to processes and demands for existing systems and water users	Water conservation, pricing, regulation and legislation, basin planning, funding for ecosystem services, consumer education and awareness
Introducing new water-conserving technologies	Biotechnology, drip irrigation, wastewater reuse

World Bank's IDA and Climate Resilience

By Peter Bosshard, Policy Director for International Rivers

The World Bank's International Development Association (IDA) is the most important source of development finance for the world's poorest countries. Donor governments are currently negotiating their contributions to the IDA. A new round of finance is supposed to support goals such as inclusive growth, gender equity and climate resilience.

Despite a commitment to climate resilience, the World Bank has accelerated its push for large dams, which could increase climate vulnerabilities in many regions. In March 2013, World Bank management proposed to make large regional infrastructure projects an additional focus of future IDA projects, including the Inga 3 hydropower dam on the Congo River (cost: US$10 billion) and the Mphanda Nkuwa and Batoka Gorge hydropower schemes on the Zambezi (expected total price tag: $8-9 billion). The Bank argues that such projects could "catalyze very large-scale benefits to improve access to infrastructure services," while ignoring the fact that these projects could also undermine IDA's commitment to climate resilience.

In a letter to donor governments, International Rivers and several partner groups argued that reducing climate vulnerability requires flexible, decentralized and diversified energy and water infrastructure. As climate change makes rainfall less predictable, putting all our eggs into the basket of large, centralized reservoirs increases vulnerability to climate shocks. Already, Sub-Saharan Africa is the world's most hydro-dependent region. World Bank and IMF experts have recommended that this dependence be reduced in the interest of climate resilience.

According to research by the Intergovernmental Panel on Climate Change, the Zambezi exhibits the "worst" potential effects of climate change among major African river basins. In spite of this, the Mphanda Nkuwa and Batoka Gorge dams, which the World Bank proposes to fund, have not been evaluated for the risks of reduced annual streamflows, more extreme floods and extended droughts that are associated with a changing climate.

Representatives of the community that would be affected by Inga 3 on the Congo River (with International Rivers' Rudo Sanyanga, lower left). Photo: International Rivers

In March 2013, governments rejected the World Bank's proposal to add regional infrastructure initiatives to the focus topics of future IDA projects. The World Bank could take this decision as an opportunity to change direction and prioritize decentralized, renewable technologies with a better potential to reduce poverty in Africa. The Bank's new leadership has, in theory, the best intentions around clean energy and say they are accelerating large dam development because they want to reduce GHG emissions. However, they are doing so without considering climate adaptation. International Rivers and partner organizations will continue to monitor the IDA and other World Bank financing mechanisms.

instance, the Chauka system of water harvesting increases fodder and protects biodiversity. Integral to these is community ownership of grazing lands and a central role in decision-making and management.[35]

These and other initiatives that harvest rainwater also help recharge groundwater. In the dry state of Maharashtra, India, for instance, the NGO Watershed Organization Trust, aided by the German government, worked directly with villagers to form village watershed committees to restore their watershed, improve crop yields, and increase water availability. Through building check dams and hillside contour trenches, banning grazing on hillsides, and planting trees and grasses, groundwater aquifer levels rose by three meters, in spite of several drought years. Irrigated acreage doubled, and water trucks delivering water during the dry months were no longer needed.[36]

In Kenya, more than 500 sand dams have been built in the Kituï District to store rainwater and restore groundwater, similar to the check dams in India. Sand dams are a simple, low cost technology that can be built by local people using easily available materials. A sand dam is a low wall (2-4 meters high), typically built across a seasonal sand river to store water when


A community builds a sand dam in Kenya. Photo: Excellent Development

it rains. The RAIN Foundation reports that some Kituï sand dams have been in operation for 25 years. This strategy has also been successfully implemented in the Borana zone of southern Ethiopia by Action for Development, and several Ethiopian NGOs have been trained to construct similar sand dams in other regions.

Sand dams to restore groundwater have been constructed in Kenya, Ethiopia, Angola, Zimbabwe, Japan, India, Thailand, the US, and Brazil, providing water to thousands of people.

Africa has great potential for developing more rainwater harvesting. About a third of Africa is considered suitable for rainwater harvesting, according to a study by the United Nations Environment Programme (UNEP) and the World Agroforestry Center, which states that: "As we look into what Africa can do to adapt to climate change ... rainwater harvesting is one of those steps that does not require billions of dollars, that does not require international conventions first – it is a technology, a management approach, to provide water resources at the community level."

Artificial Glaciers

A retired engineer in India's Ladakh region has found a way to make artificial glaciers. In this cold desert region, the only source of water is glaciers, whose waters flow into Ladakh too late in the summer for farmers to use. Chewang Norphel has developed a way to create artificial glaciers that bring water to the fields in spring.

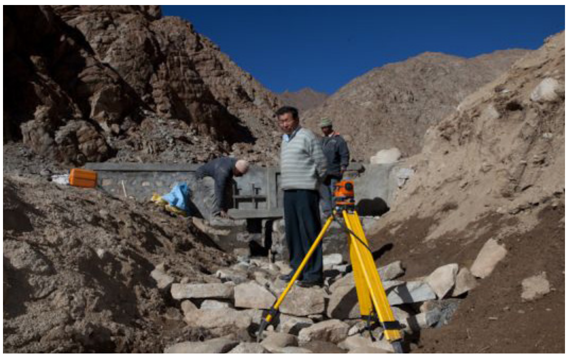
Norphel's glaciers are easy to build. First, the workers channelize glacier water into a shallow pool in the shadow area of a mountain, hidden from sunlight. Half-inch-wide iron pipes are placed at its edge. As the water keeps collecting in the pipes, it freezes. As more water seeps in, it pushes out the frozen blocks, and is frozen in turn. These frozen blocks create a clean, artificial glacier. The shallow pools melt faster than natural glaciers, and the water can be used for spring planting. By 2012, Chewang Norphel had built 12 artificial glaciers; the largest is 1,000 feet long, 150 feet wide and 4 feet deep, and can supply water for a village of 700 people.

Norphel says his artificial glaciers are a better solution than large dams, which bring enormous financial burdens and environmental and social hazards. Big reservoirs also evaporate water more quickly in the bright mountain sunshine. As the Himalayan glaciers melt, the artificial glaciers will stop being an effective solution – but for now, it's an ingenious local solution for water harvesting.

Flood Management

Flood management in a time of climate change must focus on improving flood-coping mechanisms and flood-preparedness. Some key areas that must be addressed include sustaining and improving natural systems' ability to absorb floodwaters; improving dam management and instituting clearly defined and transparent dam operating rules that are stringently enforced; improving the maintenance of existing flood infrastructure rather than spending money on new dams and embankments; and producing transparent disaster management plans intended to be implemented in a participatory way. Community networks like River Basin Friends in India's Brahmaputra Basin provides an excellent example of people-powered early flood-warning systems (described on page 35).

In Europe, a number of rivers are being "de-engineered" to restore their floodplains. The six countries through which the Rhine flows have been taking steps to restore its floodplain ecosystems. In 1998, the International Commission for the Protection of the Rhine adopted a 20-year Action Plan on Flood Defense. Key components of the plan include the removal of embankments and restoration of river and floodplain ecosystems, and improved flood mapping, education, warning and evac-


Chewang Norphel watches over construction of a shallow pool, which will hold an artificial glacier in the Ladakh region of north India. Photo: Ecofriend.com

Finding Water Through Demand Management in Southern Africa

Southern Africa water experts agree: water demand management can reduce water consumption by at least 30% in most cities. Moreover, these savings can be achieved with no noticeable reduction in quality of service, nor at any long-term cost to consumers. In fact, some cities in the region have already achieved significant reductions through demand management. Windhoek, Namibia achieved 33% reductions through pricing strategies, appliance upgrades, water re-use and other measures. The cost of these savings was less than one-tenth the cost of developing new sources being considered at the time, such as piping water from the Okavango River 700 kilometers away.

A 12-point water conservation program in the city of Hermanus, South Africa reduced water demand by 32%. The program included measures such as promoting water-wise gardening, improving the metering system, removing thirsty alien vegetation from water catchment areas and conducting water audits in schools and homes. Revenue from water sales increased by 20% despite the decreased demand. Because water "produced" through conservation and managing demand can be 65-80% less expensive than water developed through new infrastructure, water is now more affordable to the poor.

Farming in southern Africa consumes more water than any other sector by a wide margin: 80% in Mozambique and Zimbabwe, 66% in Namibia and 60% in South Africa.[37] By contrast, the domestic and industrial sectors typically account for less than 15% each. If South African irrigators – and especially large-scale agribusinesses that use the most water – could improve efficiency by only 20%, water available for urban or industrial use would be doubled.

Another area of water use that needs further examination in southern Africa is the coal industry. A Greenpeace report, "The True Cost of Coal in South Africa," notes that for every unit of electricity produced, the new Kusile coal plant will use 173 times more water than wind power. Coal requires a huge amount of water to mine as well as burn in power plants, and has the added problem of polluting groundwater sources. As water grows increasingly scarce in South Africa, farmers fear they will begin to lose water rights to the national utility, which has precedence over other users for water.

uation systems. More natural floodplains are also being restored for Austria's Drau River, France's Loire River, and Germany's Elbe River, which experienced major floods in 2002 and 2013.

Green Infrastructure

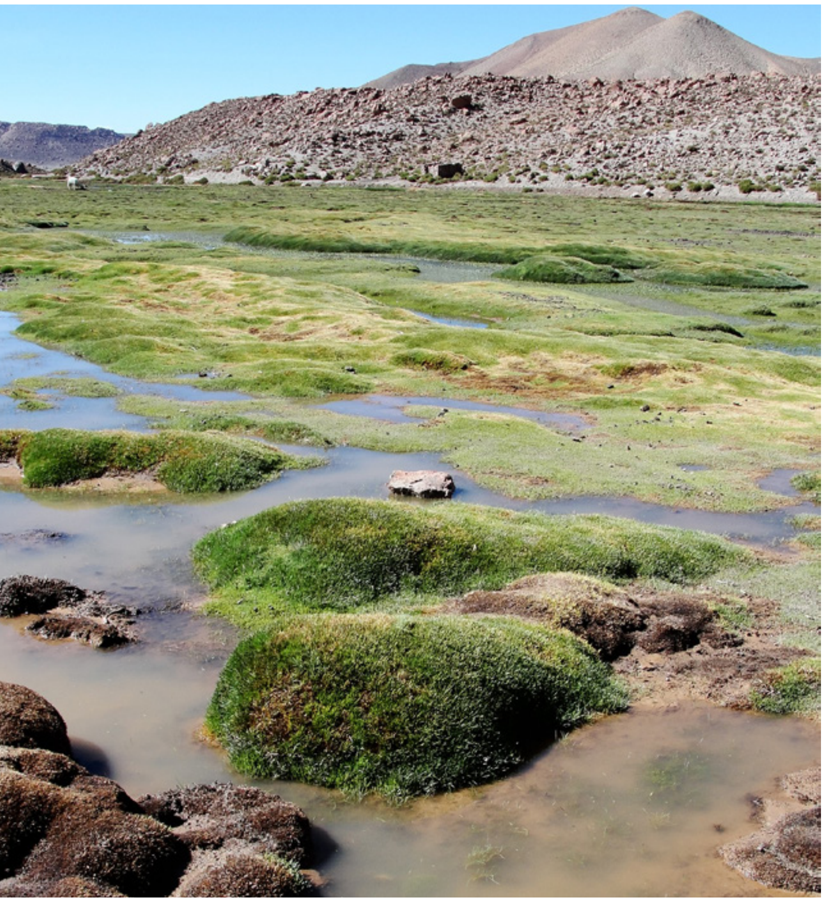
Because the approaches we have used for centuries will not solve the new water challenges we face with climate change, experts around the world are promoting "green infrastructure" for addressing floods and water management. This approach, which relies on natural greenways and wetlands to absorb floodwaters, is a cost-effective and flexible way for local governments to deal with the impacts of climate change. It has three critical components:

- Protect landscapes like forests and small streams that naturally sustain clean water supplies.
- Restore degraded floodplains and wetlands so they can better store flood water and recharge streams and aquifers.
- Replicate natural water storage systems in urban settings, to capture rainwater and prevent stormwater and sewage pollution.

In Peru, the environment ministry and local organizations have developed several adaptation measures, including the storage of water in highland wetlands (*bofedales*), storing water in small-scale reservoirs, improving irrigation practices (including expanding drip irrigation), the introduction of drought-resistant crops, and studying the potential effect of preserving native forests on groundwater storage.

In China, local governments and NGO partners are restoring wetlands and lakes for natural flood control, as well as wildlife habitat restoration. In 1998, a flood in the Yangtze Basin breached 2,000 embankments, inundated 28,500 square kilometers of agricultural land, and left 2.5 million people homeless. The disaster prompted Beijing to pass a Flood Control Act that signaled a shift from a dependence on structural flood control to greater use of non-structural measures. One such project, managed by WWF-Beijing and local governments, is a restoration initiative that will restore 20,000 square kilometers of wetlands in central China. In addition to flood protection, the project will also improve fisheries and give a boost to migratory birds. Wildlife species have begun to return to restored areas.

From 1999-2008, floods affected almost one billion people in Asia, 28 million in the Americas, 22 million in Africa and four million in Europe.



Highland wetlands in Chile. Photo: Javier Ignacio Acuña Ditzel

ENERGY SECTOR

Many forms of electric power production are extremely vulnerable to climate change. Extreme weather events threaten infrastructure, and drought threatens hydropower production. Changing wind patterns could reduce wind-power potential, while increasing clouds could interfere with solar power. More robust design specifications for energy infrastructure projects that allow structures to withstand more extreme conditions and accommodate incremental changes over time can be more climate-resilient. Local, diversified energy systems like micro-hydro plants and wind and solar systems, while vulnerable to climate change individually, can form a resilient energy network if developed together and with back ups.

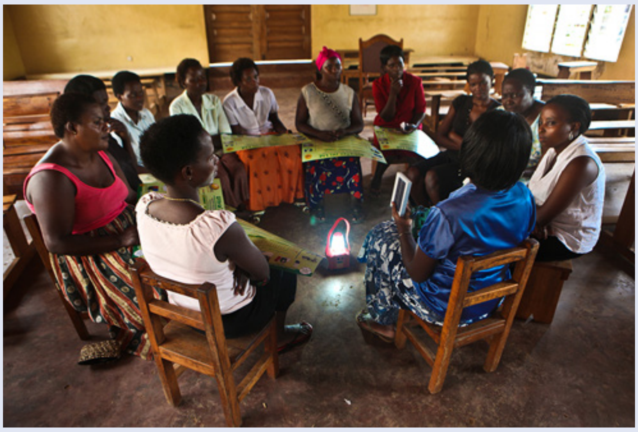
In a report on energy sector vulnerability and adaptation to climate change, the Asian Development Bank (ADB) makes the following recommendations for energy sector planning for adapting to climate change[38]:

- Introduce climate change vulnerability and adaptation considerations to criteria used for selecting and prioritizing projects.
- Develop sector-specific and country-specific screening tools to identify proposed projects at risk.
- Incorporate budgets for specific adaptation interventions, including estimates of the likely costs, risks, and benefits of adaptation action and inaction.
- Adjust zoning regulations for energy infrastructure (for example, to avoid flood or permafrost zones).
- Design flexible energy infrastructure (for example, use more robust design specifications that could allow structures to withstand more extreme conditions).
- Incorporate climate change indicators into energy planning and budgeting.

ENERGY NEEDS AND DECENTRALIZED RENEWABLE OFF-GRID SOLUTIONS[2]	
Cooking	Biogas from small scale digesters; solar cookers; clean stoves and clean fuels
Lighting and other small electric needs	Small hydropower; biogas from small digesters; small biomass gasifiers and gas engines; wind turbines; solar home systems; solar LED lanterns
Power generation for productive uses	Small, micro and in-stream hydro and electric motors; biomass power generation; biomass gasification
Water pumping for home use and irrigation	Mechanical wind pumps; electricity from micro to small hydropower; solar PV pumps; treadle pumps
Heating, cooling and refrigeration	Biogas combustion; solar crop dryers; solar water heaters; cooling through small electricity systems

Climate Change Adaptation in Uganda

By Geoffrey N. Kamese, Senior Programme Officer, the National Association of Professional Environmentalists (NAPE), Kampala, Uganda



A Solar Sister training in Uganda. Photo: Solar Sister

Uganda is one of the world's least developed countries and highly vulnerable to the impacts of climate change. According to Uganda's National Adaptation Programme of Action (NAPA), the country has been experiencing an average temperature increase of 0.28°C per decade between 1960 and 2010, with the months of January and February being the most affected, averaging an increase of 0.37°C per decade. The frequency of hot days in the country has significantly increased, resulting in severe drought and water scarcity among many communities who are increasingly becoming water stressed. This has in turn resulted in communities generating and regenerating knowledge, practices and innovations to enable them to adapt to the changing climatic conditions in the country.

The Ankole region in Uganda is one of the most seriously affected by climate change and is among the most water stressed in the country. The water stress in the region has mainly been due to prolonged dry seasons and unpredictable rainfall. As an adaptation strategy, many rural communities have constructed both surface and underground rainwater harvesting tanks; this is in addition to the numerous small dams that are located in different parts of the region mainly to provide water for livestock. The communities contribute finances, materials and labor for construction. Some support also comes from NGOs and the local government. For some very poor communities, water tanks have been constructed using mud and wattle and other low-cost materials. These rainwater tanks provide safe water for drinking and for other uses at the household level, as well as water for small-scale irrigation.

While there has been effort and some success towards the implementation of community adaptation projects, a lot is still required. The impacts of climate change in Uganda have been devastating and become increasingly complex and difficult to address with indigenous knowledge. Many adaptation strategies today require large amounts of money, yet such funds have not been appropriately disbursed. Adaptation funds are essential to, among other things, support sizeable water storage tanks, facilitate the provision of drought-resistant crops in some places and flood tolerant crops in others, provide appropriate energy technologies, and raise awareness among communities on the impacts of climate change and key adaptation strategies. Unfortunately, while the government of Uganda has put in place a climate change policy, there is no specific budget in place to address climate change impacts. Climate change is considered to be a cross-cutting issue, and it often does not receive the attention it requires. There has also not been sufficient support from the international community to support adaptation activities in poor countries. All these present a major challenge toward the implementation of community adaptation projects.

Adaptation to climate change impacts in least-developed countries is critical and must be addressed by development planners. First and foremost, we need greater recognition of the importance of community participation in the planning and implementation process of large development initiatives. The guiding principle in any development process should be to improve the livelihoods of the people, to sustain development in the community, and above all to respond to community energy and water needs. In the case of large dams, planners must recognize that access to water is a fundamental human right that must be respected at all times. It is also imperative that governments, dam planners and financiers respect and address the energy and water needs of the communities as key strategies to adaptation. Governments and financiers must identify and support energy options that can be easily owned by the people not only to ensure energy security but also to ensure community energy sovereignty.

For more information on NAPE, see: www.nape.or.ug

In practice, however, according to the South Asia Network on Dams, Rivers and People, the ADB is funding and supporting large hydropower projects in the Indian Himalayas, one of the most vulnerable regions with respect to climate change, without using any of these criteria.

Hydroelectric power is often touted by industry groups as a reliable source of base-load energy, as well as an effective source of peaking power, since it can be turned on and off quickly. However, as we saw in Chapter 2, it can also be very vulnerable to climate change, as its performance is dependent on water inflows to reservoirs and a predictable hydrological cycle. While both large-scale hydropower and small-scale decentralized renewable energy projects (such as wind, solar, micro-hydro, and biomass) can provide adaptation, mitigation, and poverty-alleviation benefits, decentralized and distributed renewable energy sources are more likely to support livelihoods, and increase local autonomy over energy sources.[39]

DECENTRALIZED OPTIONS	BENEFITS OVER LARGE HYDROELECTRIC DAMS
Solar (community lighting systems, portable solar PV, lights, village solar pumping systems, and solar water heaters)	Direct access, no grid connection needed, is locally managed and/or owned.
Wind pumps (home use and irrigation)	Provides relief from water stress and energy for water pumping in otherwise energy-deprived areas, energy source diversification.
Micro-hydro	Local watershed conservation, local management, overcoming energy equity issues of large hydropower, and empowerment of local livelihoods.
Biomass (straight vegetable oil systems and biogas from small-scale digesters)	Direct access, no grid connection needed, locally managed, and diversification of a range of local energy sources.

Building Local Economies with Solar

Solar power is becoming more and more widely available for purchase, and is relatively easy to install and maintain, making it an ideal candidate for a community-owned energy system. Many of the millions of people who lack access to electricity live in places where the sun shines steadily and connection to the national grid is a distant prospect. The price of solar panels has dropped dramatically in recent years, and while affordability remains an issue for the poorest, solar is the most cost-effective way to electrify huge swaths of the world's off-grid regions.

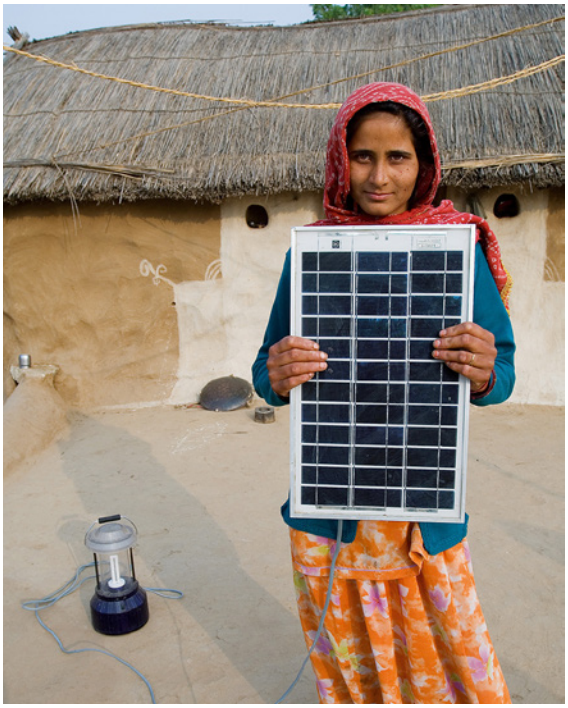
New models of distributing systems are helping get systems in place. For example, the Solar Energy Foundation has distributed over 19,000 solar home systems to rural areas throughout Ethiopia, established regional "solar centers," across the country, and is training technicians and installers.

In Rwanda, Uganda and South Sudan, Solar Sister (a social enterprise comprised of over 170 female entrepreneurs) uses a direct-sales network that allows women to build their own businesses in remote areas. By selling a variety of high-quality solar products through their networks, Solar Sisters are not only spreading solar light throughout the region, they are creating economic opportunities for themselves as entrepreneurs.

The limitations to solar include a number of bottlenecks such as training for the installation, operation and maintenance of new and existing systems, and accessing credit to pay for and install them. Scaling up distribution with national and international financial support, as well as shifting the balance of support for renewable decentralized energy sources over conventional large-scale projects, should become a much higher priority for governments and major financial institutions.

Energy Efficiency

Improving energy efficiency should be made a top priority for all nations, because efficiency measures are cheaper, cleaner and faster to install than any other energy option. For instance, in India, up to half of hydropower projects are generating at less than 50% of their installed capacity while 89% have never generated at their installed capacity. In such a situation, even without considering transmission losses, end-use efficiency and demand-side management, there is huge scope for making the existing infrastructure more efficient.[40]



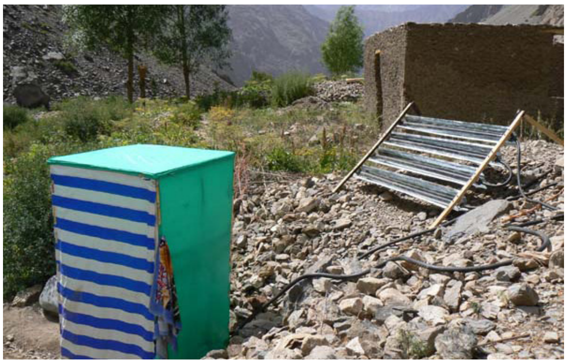
Women trained by Barefoot Solar Engineers in India electrified this village in Rahasthan. Photo: Knut-Erik Helle, justworldphoto.org

Tajikistan has been in an energy crisis since 1997. Its cold climate and poor infrastructure meant that much of the population relied on local firewood and dung for household energy. Huge amounts of wood were being burned to heat houses during the five-to-seven month long winters. With help from the German government, energy efficient products were introduced into local markets, and local craftsmen trained to produce and install efficient windows, house insulation, solar water heaters and fuel-efficient stoves. Local micro-finance programs were expanded to cover the efficient products. Household fuel consumption for cooking and heating has since been reduced by 30-50%.

Developing countries, which will account for 80% of global energy demand growth to 2020, could cut their demand by more than half using existing technologies to improve energy efficiency, according to McKinsey Global Institute.[41] Energy savings can be found even in countries where energy use is just beginning to take off. In fact, putting efficiency measures in place now for growing economies can save money to invest in other pressing needs.

Below are a number of steps that civil society groups can recommend to governments and utilities:

- Develop strong building and appliance standards and promote the aggressive deployment of energy-efficient technologies and strategies. To be effective, these standards should be mandatory and tightened regularly.
- Break the link between utility sales and revenue. Known as "utility decoupling," disassociating a utility's profits from its energy sales is a necessary step to encourage utilities to pursue a path of energy efficiency over expanding supply. Without decoupling, a utility will be more focused on energy sales rather than meeting its customer's energy needs.
- Establish standards for utilities. While decoupling in and of itself will not cut electricity demand, it does mean that utilities can provide incentives for conservation programs without losing revenue. Enforceable targets for energy efficiency for utilities (also known as a "portfolio standard") will ensure steady progress. Other strategies to help utilities limit the need for new power plants include energy conservation, distributed renewables, and tactics to manage peak demand for electricity.
- Adjust energy prices to encourage ongoing efficiency. While this can be politically difficult in poor countries, blanket subsidies discourage efficiency and may benefit mainly those who are better off. Low-income communities can be protected from higher energy prices by subsidizing basic consumption and increasing unit costs for the heaviest users.
- Focus on the energy-intensive industries such as pulp and paper, mining, steel, cement, aluminum, petroleum refining and chemicals. Adopting the most-efficient blast furnaces and boosting recycling can cut energy use in the steel industry by close to 40%.[42] Converting China's cement industry to the most efficient dry kiln technologies, as used in Japan, could cut global energy use in the cement sector by 40%.[43]
- Increase awareness among consumers, businesses, building inspectors and contractors through education campaigns, labeling of appliances, and trainings. Giving energy users feedback on how much they use and where savings can be found can lead to significant savings.
- Transmission systems can be hugely wasteful. Africa's power grids, for example, lose twice as much electricity during transmission as do more modern systems.[44] "Smart grid" technologies, which use microprocessors and software to allow information to flow back and forth to all users in the system, would reduce electrical losses through the wires and enable a larger expansion of renewables within the grid.
- Create a carbon economy. Taxing high-carbon energy sources would help encourage companies to use energy more wisely and switch to clean renewables.



A solar water heater and shower designed by the local NGO Tajik Seeds. Photo: © Robert Middleton

- Address the water-energy nexus. Coal-based thermal power plants use huge quantities of water for cooling purposes. For instance, if India continues to build all its proposed thermal power plants, the country will need 18 billion cubic meters of water, enough to grow rice for 70 million people or provide 360 million urban dwellers with an adequate water supply.[45]

AGRICULTURAL SECTOR

Agriculture is a not only a large contributor to greenhouse gas emissions, it is also by far the largest consumer of fresh water. Some 40% of the world's food is grown in irrigated soils. Water waste on irrigated farms is a major problem globally, as is the pollution of freshwater sources by toxic farm chemicals. Experts say around half of water used in irrigation is wasted through unsustainable practices such as field flooding.[46] Activists can get involved in pressing for more efficient and equitable water use for agriculture in their regions, and a reduction in water pollution from farm chemicals and runoff. Both are critical for ensuring more sustainable water supplies for all.

Activists and civil society groups can also help small-scale and rainfed farmers practice sustainable farming, which will not only help them conserve water but also allows them to adapt to climate change. The practice of agroecology – the science of sustainable agriculture – can be used to help farmers of all scales improve their water management. Agroecology supports the development of drought resistant agricultural systems (including soils, plants, agrobiodiversity, etc.). Some ways it does this is by promoting the use of green manures and compost, which can increase the soil's water retention capacity from its current average of 1% to about 5% by increasing its organic matter content.[47]

In addition to encouraging farming systems that mimic how natural systems work, many farmers in dry areas could benefit from improved small-scale water storage systems. Farm-sized rainwater harvesting and groundwater recharge techniques can help the many millions of farmers whose farms are rain-fed. Contour plowing – in which soil is plowed in curved bands that follow the shape of the land – prevents soil erosion, and allows the water to settle into the soil. Other emerging practices, such as growing food in "micro gardens" in the world's developing cities, may not be a direct adaptation response, but because it can increase food security for the poor, it is a good "no-regrets" strategy.

Promoting wild vegetables and diverse seed banks can also improve community resilience. In tropical countries, rural food security depends in part on harvesting wild vegetable and fruits. Many NGOs in India, for instance, are working towards protecting seed diversity and the wild relatives of food plants. Subsistence farming in general, where home gardens provide the majority of nutritional requirements in a decentralized manner, should be strengthened and protected in order to promote climate resilience.

In the Mekong Delta, soil and water salinization has been a problem for decades. Damage from salinity is most severe during droughts or in early/late periods of the rainy season, and with an increasingly variable climate, salinity problems will only become greater.[48] The presence of dams leads to greater coastal salinity intrusion, since dams hold back sediments that help build the delta and also alter the natural hydrological cycle.

These climate change impacts call for robust adaptation measures to promote food security in the Mekong region. Many projects in the agricultural sector, for instance, focus on increasing resilience through adaptive crops and farm management strategies. A study by the Mekong Program on Water, Environment and Resilience that examined food production strategies for adapting to coastal salinity intrusion in Mekong delta areas listed these recommendations: salinity-tolerant rice varieties, adaptive shrimp farming, adjustment of cropping seasons, soil desalinization, and improved forecasting. The study also concludes that strategies such as increasing rice production in upper and mid-delta areas could make the investment in large-scale structural measures for dealing with food insecurity obsolete.[49]

Sri Lanka has experienced drops in groundwater levels and increased sea level in recent years. Farmers there have begun testing traditional and modern rice varieties for salt-tolerance, and greater resistance to pests and higher temperatures. Forgotten types of indigenous rice offer a local solution to this increasing soil salinity. There are around 2,000 traditional rice varieties in Sri Lanka. Many are very high in nutritional value and have medicinal properties, and most are resistant to extreme drought conditions, diseases and pests. Local farmers are testing different varieties of traditional rice with help from the National Federation of Traditional Seeds and Agri Resources and Practical Action. A few varieties have proved to be hardy, salt-tolerant and high quality rice well-suited for coastal rice paddies. These are now being promoted through local farmer organizations.

Dam Re-operation for Adaptation

Existing dams were not designed with a changing climate in mind. Some existing dam and reservoir systems can be managed better to restore ecosystem services and increase adaptation benefits and restore ecosystem services. Some of these strategies are described below.

For flood management dams:

- Use of floodplains to store and convey increased flood volumes (both through natural floodplain features and man-made basins/bypasses).
- Move levees and establish new floodplains to move floodwaters around populated areas.
- Reconnect floodplains to reduce flood risks and improve environmental management (for example, the Yolo Bypass floodplain reconnection in California, US).
- Remove silt from existing dams and catchment areas for optimal storage and flood control benefits.

For hydropower dams:

- Incorporate environmental flows into water release patterns. Flows that mimic natural river conditions can restore some of the natural seasonal hydrological patterns. (for example, the Murray Darling Rivers in Australia).
- To address daily fluctuations in flows: reregulating reservoirs, using off-channel pumped storage, and coordinating operations within a cascade of dams.
- Decommission dams that have outlived their usefulness or have a proven track record of causing and incurring losses.
- Improve power capacity generation.

For water-supply dams:

- Improve the performance and efficiency of existing dam and canal-based irrigation infrastructure.
- Improve integration of groundwater and surface storage by enhancing groundwater recharge using surface water from a water supply dam reservoir.
- Link the operation of multiple dams in a cascade/
- Change water delivery arrangements
- Combine environmental with consumptive water releases to meet flow targets more efficiently and with less water. (for example, the Murray River, Australia)

For case studies, see:
www.ecologyandsociety.org/vol12/iss1/art12

Reducing Water Waste in Farming

In traditional flood or center-pivot irrigation systems, 30-50% of the water is lost to evaporation or runoff. There are many ways to reduce this loss in farming. To give a few examples: irrigation can be scheduled to better match crop water needs; less-thirsty crops can be grown; and drip irrigation can be used to curb evaporation losses. Studies have shown that drip irrigation can reduce water use 30-70%, while actually increasing crop yields, compared with traditional flooding methods.[50] In addition, conserving "green water" – the water that is stored in soils and plants – through agroecology practices (which emphasize preserving the quality and water-retention ability of soils) can help reduce water waste, as well as having other benefits for farmers and the planet.

Another low-cost irrigation option being practiced in many developing countries is the treadle pump. In Bangladesh, treadle pumps have enabled farmers to irrigate their rice paddies and vegetables at a cost of less than US$35 per system. More than 1.4 million have already been sold in Bangladesh.[51] The pump can be locally manufactured and has been adopted by millions in India, Nepal, Burma, Cambodia, Zambia, Kenya and South Africa.

One unique effort to grow a staple crop with less water has been developed for rice. Rice is one of the world's most important staple crops, but uses large amounts of water. The International Rice Research Institute estimates that if conventionally grown, it takes 5,000 liters of water to produce one kilogram of rice. Agricultural scientists have made huge breakthroughs in reducing the amount of water needed to grow rice, while improving yields. Researchers at Cornell University and the Association Tefy Saina have developed a "System of Rice Intensification" that reduces water use by 50%, increases yields by 50-100%, and does not require expensive chemical inputs or hybrid seeds. (Similar systems of wheat intensification, crop intensification, and sustainable sugarcane initiatives have been developed that can contribute to efficient water use and conservation). An estimated 90% of agricultural water used in Asia is for rice production, so the savings could be huge. Some African nations are beginning to explore water-saving rice as well.

By 2025, 15–20 million hectares of irrigated rice will experience water scarcity. The "System of Rice Intensification" can increase rice yields by 50-100% while using half as much water.

Information Systems for Farmers

Water management can be greatly improved with creative use of information technologies. In Uganda and India, farmers lacking computers are getting access to the wealth of information on the Internet by calling in their questions to a free telephone hotline called Question Box. The operators, who speak the local language, search for the answers and call the farmers back. Question Box enables poor farmers, whose only communication device may be a village phone, to connect to the wired world for information on weather forecasts, plant diseases, and more. Efforts are underway to create a model for duplicating Question Box; learn more at questionbox.org.

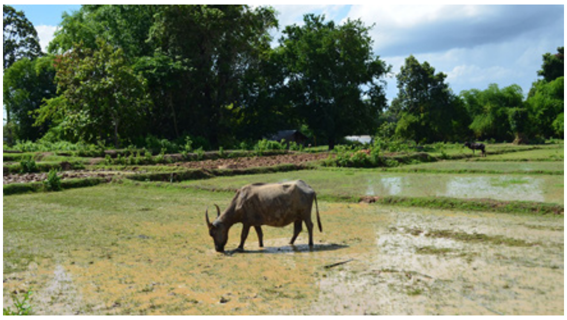
Ecosystem Services

Ecosystem services are of critical importance for adaptation to climate change. Fisheries, forest and woodland products, livestock grazing, floodplain farming, wetlands products, tourism, domestic water supply and storm-surge protection are all dependent on ecosystem services. Free-flowing rivers are more resilient in the face of climate change than their dammed counterparts, while providing a range of ecosystem services (see Chapter 1).

Ecosystem services, if well managed, can increase the resilience of natural and human systems to climate change impacts. For instance, protecting mangroves for coastal defense and floodplain management for flood defense are effective alternatives to building large infrastructure or water-intensive projects.

However, approximately 60% of all ecosystem services are being degraded or used unsustainably.[52] In addition, ecosystem degradation can trigger more disasters and reduce resilience to climate impacts, as well as reducing the ability of ecosystems to sequester carbon. There has been a sharp increase in the occurrence of natural disasters such as floods, droughts, extreme temperatures, and wildfires from 1960 to 1989, and an even more rapid increase since 1990. While this trend may not be wholly attributable to climate change, the increase in the frequency and intensity of climate-related hazards does correspond to temperature increase, and is projected to continue even if greenhouse gas emissions were to stabilize. Unless ecosystem management is prioritized and integrated into climate change adaptation and disaster risk management, the poor and their natural resources and livelihoods could become even more vulnerable to climate change impacts.

Treadle pumps have enabled more than a million Bangladeshi farmers to grow marketable produce. Photo: iDE



Rice paddies at Don Sadam Island, which is threatened by the Don Sahong Dam on the Mekong River. Photo: International Rivers

Many US communities are involved in projects to revitalize their rivers and restore ecosystem services by tearing down dams that are no longer safe or serving a justifiable purpose. In the past 20 years, through the collaborative efforts of a range of stakeholders including Native American tribes, hundreds of dams have been removed from US rivers, opening up habitat for fisheries, restoring healthier water flows, improving water quality, and returning aquatic life to rivers. Fish populations usually recover quickly. In one of the nation's biggest dam removals, the Edwards Dam was removed from the Kennebec River in Maine in 2000. Since then, fish populations have returned in astounding numbers, reviving a recreational fishery that adds $65 million annually to the local economy. In 2007, Portland General Electric blew up the Marmot Dam on Oregon's Sandy River. The river washed accumulated sediment downstream more quickly than anticipated, and Coho salmon swam past the dam the day after it was breached.

Some Latin American cities are establishing watershed trust funds to protect their drinking water supply. For instance, Rio de Janeiro in Brazil collects fees from water users to pay upstream farmers and ranchers US$71 per hectare to protect and restore riparian forests, safeguarding the water supply and preserving wildlife habitat. A public watershed protection fund in Quito, Ecuador, started in 2000 in partnership with the Nature Conservancy, receives nearly $1 million a year from municipal water utilities and electric companies. Quito's water fund has become a model for other Latin American cities.

Using Citizen Science to Save Fisheries in India

By Parineeta Dandekar, South Asia Network on Dams, Rivers and People, Delhi, India

India is second in the world in freshwater fish production. More than 75% of fisherfolk in India depend on freshwater fisheries for their livelihoods. Many millions of Indians depend on rivers for their livelihoods and nutrition; the Ganga Basin alone supports 7-8 million fisherfolk.

Unfortunately, riverine fisheries are one of India's most endangered areas. Water abstractions and dams have led to fisheries collapses in almost all of India's major rivers, severely affecting biodiversity and livelihoods. Fisherfolk, one of the poorest segments of Indian society, have been deeply impacted. In the words of an anguished fisher woman in Maharashtra, "The dam reduced us from being the king of the river, to a slave of this dam."

Though blessed with one of the richest riverine fish gene pools in the world, the contribution of riverine and capture fisheries is declining sharply and many have collapsed, despite having a great potential to grow. Climate change threatens to make the situation much worse. This is especially true for the fragile Himalayan states which are witnessing extreme impacts of climate change on the one hand and unprecedented hydropower development on the other.

Marginalized estuarine fisherfolk cross the Vashishti River in the Western Ghats (Maharashtra, India). Photo: SANDRP

Taking Action

Since 2009, tribal communities in over 32 villages in Central India have come together to work on a People's Biodiversity Register, under the Biodiversity Act of India. The People's Biodiversity Register for the Kathani River, for example, revealed that this small river had 64 distinct fish species. The local tribal fishermen had distinct names for all of these species. Following declining fish populations in Kathani, the communities, equipped with their own documentation and studies, voluntarily banned herbal fish poisons, and took an ecosystem approach to fish conservation by banning riparian tree felling, planting trees and conserving fish in riverine stretches or sanctuaries. Fish stocks are gradually improving in the river.

In the Vidarbha region of Central India, which has become infamous for farmer suicides, fisherfolk are getting organized, forming self-help groups and fisheries cooperatives. Tribal fishermen possess in-depth knowledge about fish species, breeding needs, habitats and ecology. With the help of organizations like Bhandara Abhyas Mandal, the groups have started documenting the diversity of fish and aquatic plants. Indigenous fish species found in traditional fish-rearing tanks are being documented. With the help of this knowledge, fish species are being propagated in derelict tanks by creating habitats using indigenous vegetation. Fish yields have increased dramatically following this approach.

The Indian government is exceedingly weak on protecting riverine fisheries. One of the most urgent first steps is to include the true impacts of dams on fisheries in Environmental Impact Assessments and Management Plans for dams. We also need to adopt a strong law and supporting policies to protect fisheries and local livelihoods; put pressure on dam owners and operators to compensate affected fisherfolk; adopt a national law mandating restorative environmental flows through existing dams, and undertake serious research on fish passes and ladders for Indian conditions and species. Climate change is already affecting distribution and abundance of fish species in several regions. Protecting fish diversity by addressing major issues related to dams will be a strong step in building resilience.

We also need honest and holistic cost benefit analysis of dams – analysis that accounts for the risks from climate change. Currently, the words "climate change" do not feature in environmental governance surrounding India's dams. Underperforming dams and barrages in biodiversity-rich regions need to be decommissioned. Finally, we need more protected and free flowing rivers to appreciate the range of services a healthy river can provide.

A longer version of this article can be downloaded here: http://www.internationalrivers.org/node/7758