March 2003

DAMMED RIVERS, DAMNED LIES

WHAT THE WATER ESTABLISHMENT DOESN'T WANT YOU TO KNOW

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FoE Japan IRN

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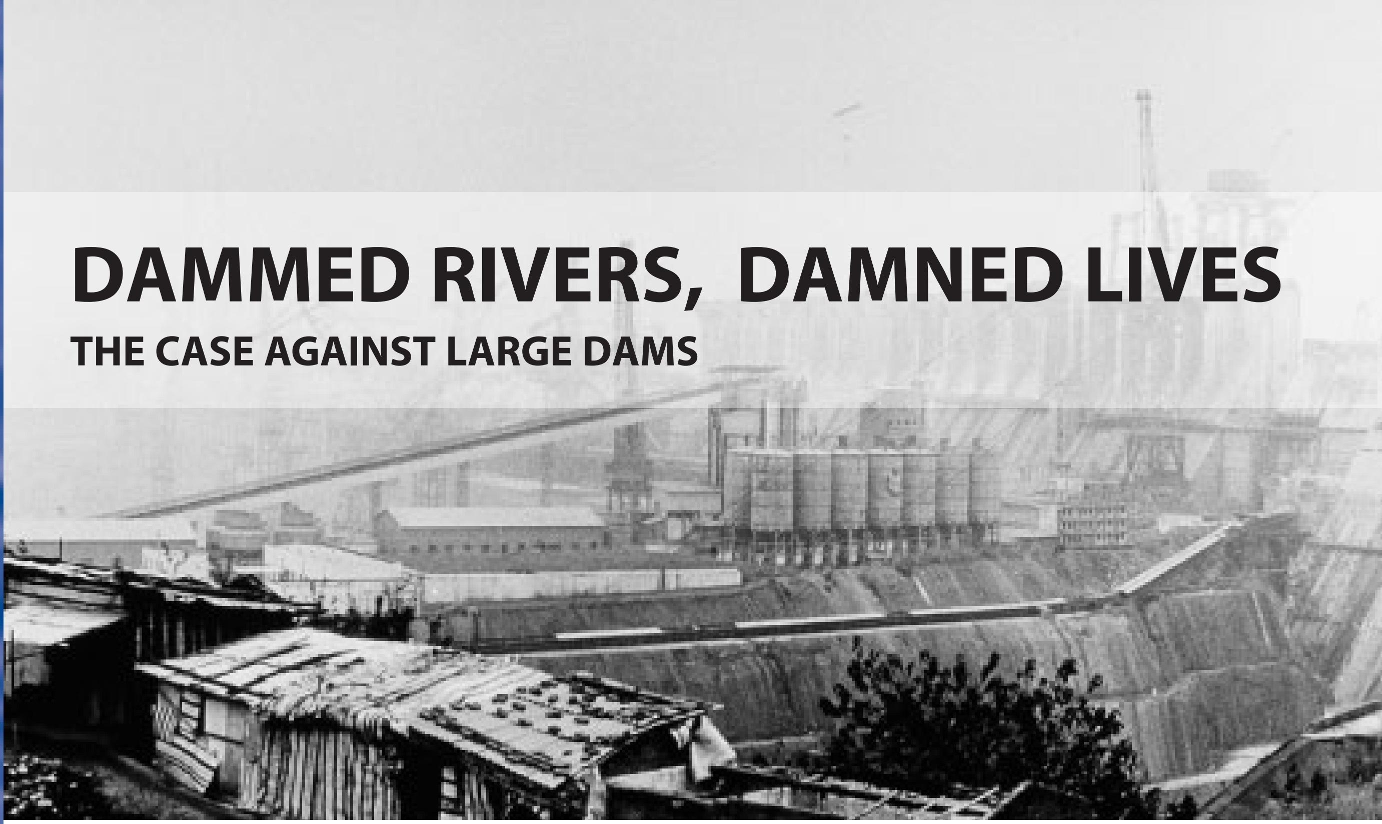
DAMMED RIVERS, DAMNED LIVES

THE CASE AGAINST LARGE DAMS



Nearly two million people will be displaced by China's Three Gorges Dam. Credit: Ben Sandler

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When Malisemelo Didian Tau first heard about plans to build a big water supply dam on her land in Lesotho, she resisted. But the dam builders convinced her that a few people would have to move away to save many people's lives. They promised Malisemelo and her community compensation, water supply, schools and new homes. But the promises have not fully materialized.

Says Malisemelo, "When we don't get enough compensation for our lands, it is the death of our children and the death of coming generations because they will have nothing to help them survive in the future."

This story would be compelling enough if it were only Malisemelo's story. But it isn't. Between 40 and 80 million people have been forced from their homes and lands to make way for dams. Most have been left further impoverished. Some of the world's most diverse wildlife habitats and fertile farmlands have been flooded beneath reservoirs. Entire river ecosystems have been destroyed.

Across the world, people are recognizing that the costs of large dams have been far too high. In the first comprehensive independent assessment of dams, the World Commission on Dams (WCD), established by the World Bank and the World Conservation Union (IUCN), stated that while dams have made an important contribution to development, "in too many cases an unacceptable and often unnecessary price has been paid to secure those benefits."

Although the rate of dam building has dropped to less than half of its peak in the early 1970s, hundreds of projects are under construction and many more are proposed. Dams continue to be promoted and funded in Southern countries by institutions like the World Bank and Japan Bank for International Cooperation. India, China, Brazil, Turkey, Iran, Laos, Vietnam, Spain, Mexico and Ethiopia are all building or planning numerous dams, which would have severe impacts on rivers and people.

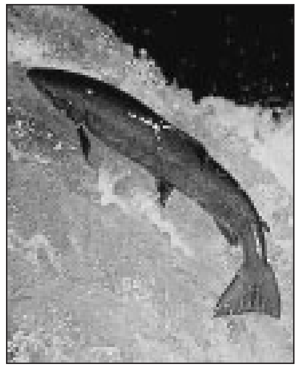
This briefing paper summarizes the social, environmental and economic impacts of dams and outlines better options for water management and energy supply.

SOCIAL IMPACTS

Some say a few people must sacrifice for the "greater common good." But what sacrifice is being asked? Millions have been forced to give up their homes and risk their food security and well-being for dams that are frequently poorly planned and unnecessary. Those forced onto resettlement sites often do not have clean water to drink or enough food to eat. They languish there, stripped of their traditional livelihoods, land and natural resources – the social fabric that binds their communities together ripped apart. Alcoholism, depression, domestic violence and disease increase.

Compensation – if provided at all – is typically inadequate. Cash compensation is rarely enough to purchase comparable replacement land. When land-for-land compensation is provided, those displaced typically receive smaller amounts of poorer quality land. Unable to subsist on their new plots, farming families frequently end up living as migrant laborers or slum dwellers.

People who resist are regularly subjected to violence and intimidation. In China, people have been jailed and beaten for protesting against poor resettlement conditions for the Three Gorges Dam, which will displace up to two million people. One of the worst human rights atrocities associated with dams happened in Guatemala in the 1980s. More than 440 Maya Achí Indians, mainly women and children, were murdered by paramilitaries because they refused to leave their ancestral lands for the World Bank-funded Chixoy Dam. Survivors of the massacre have not yet received reparations for their suffering.



Dams have decimated wild salmon populations in the US.

INDIGENOUS PEOPLE AND WOMEN SUFFER MOST

Indigenous people and other ethnic minorities have suffered disproportionately from the impacts of dams. In India, according to government estimates, 40 percent of all those who have been displaced by dams are *adivasis* or tribals, who represent less than six percent of the Indian population. Almost all the larger dam schemes built and proposed in the Philippines are on the ancestral lands of the country's five million indigenous people.

The impact of dams upon indigenous peoples is especially harmful as most of their communities have already suffered centuries of exploitation and displacement. The trauma of resettlement is also exacerbated because it severs their strong spiritual ties to their land, disrupts their cultural practices and destroys the natural resources their livelihoods depend on.

"We have lost fisheries and our vegetable gardens along the riverbanks. We live in fear and all the time we worry that water from the dam will flood our lands. Sometimes we almost drown. We want our natural river returned to us."

Ethnic Tampoun woman living in Cambodia who has suffered downstream impacts from Vietnam's Yali Falls Dam.

Women are left worse off than men, as compensation payments are usually paid only to the male heads of households. Women may also be affected disproportionately because of their greater dependence on common property resources such as grazing lands and forests. Common property is rarely eligible for compensation and rarely provided at resettlement sites.

SECONDARY DISPLACEMENT AND DOWNSTREAM IMPACTS

Those displaced by reservoirs are only the most visible victims of large dams. Millions have lost land and homes to the canals, roads and other infrastructure associated with dams. Many more have lost access to clean water, fish, grazing land and other resources.

Changes in river flow have drastically impacted the lives of millions living downstream from dams. They suffer from declines in fisheries, poor water quality and disruption of the annual floods which once irrigated and fertilized their fields and recharged their wells. In Africa, the loss of the annual flood has devastated traditional floodplain farming, fishing and grazing. Kainji Dam in Nigeria, for example, directly displaced 50,000 people, but adversely affected hundreds of thousands more because of declines in crop production and fish catches. Some 40,000 people living in the Amazon basin suffered from skin rashes and other health impacts due to the release of dirty water from the Tucuruí reservoir.

ENVIRONMENTAL IMPACTS

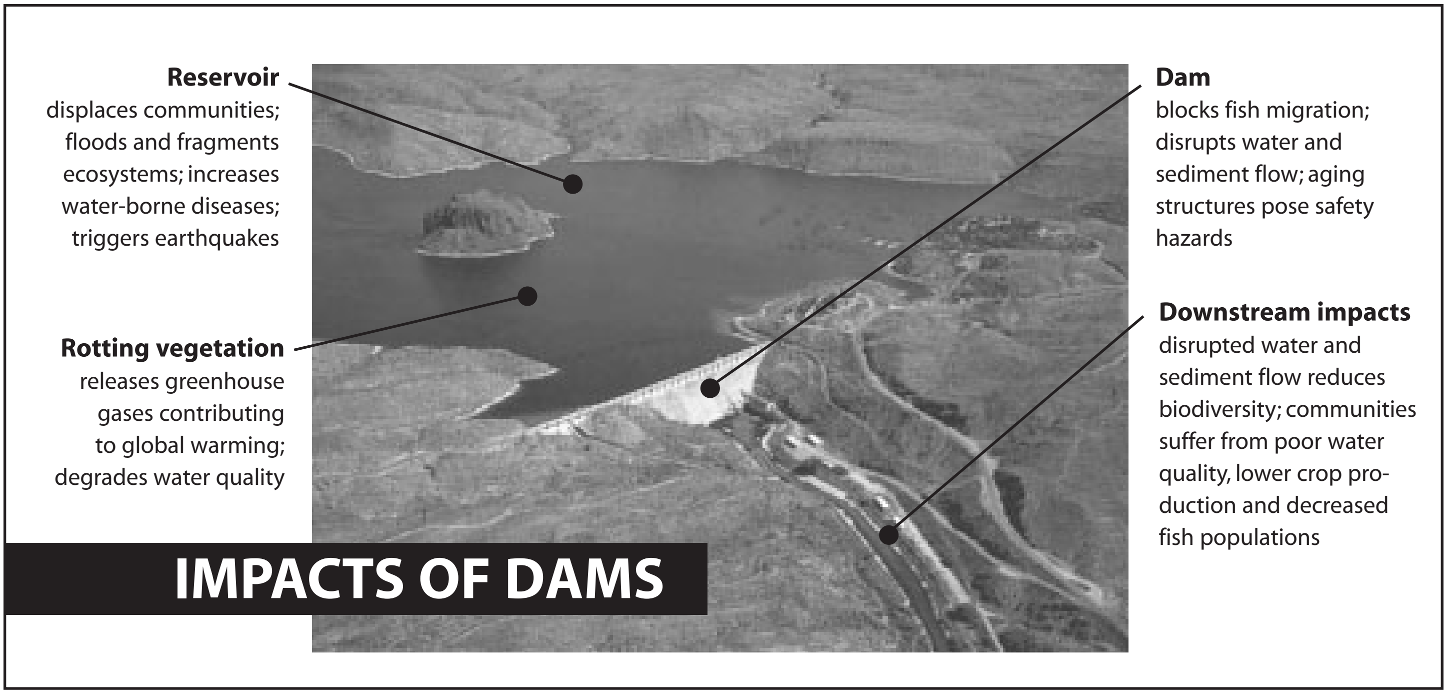
Large dams have had profound and irreversible environmental impacts. Sixty percent of the world's major rivers have been fragmented by dams and diversions. Over a million square kilometers, or just under one percent the world's land surface, have been inundated by reservoirs worldwide. This represents a much greater loss than the raw statistic implies since riverside-land supports the world's most diverse wildlife habitats and most fertile farmlands.

Floods are critical to the lifecycles of species that live in and near rivers. However, flow patterns and other important habitat conditions, such as river chemistry and temperature, have been disrupted by dams. Large dam and diversion schemes have stopped some of the world's major rivers, such as the Indus, the Nile and the Colorado from reaching the sea. In the early 1900s, the Colorado River delta supported a rich array of egrets, jaguars and other wildlife. However, the heavily plumbed river now only reaches the delta in rare flood years and wildlife populations have plummeted. The number of indigenous people who once fished and farmed the delta has also declined.

Dams have reduced biodiversity. This is due to flooding of habitat, disruption of flow patterns, isolation of animal populations and blocking of migration routes. Dams and diversions are the main reason why one-third of the world's freshwater fish species are extinct, endangered or vulnerable. The percentage rises even higher in countries which have been most heavily dammed – to nearly 40 percent in the US and 75 percent in Germany. A significant but unknown percentage of shellfish, amphibians, plant and bird species that depend on freshwater habitats are also extinct or at risk.

FAILED MITIGATION

Proponents of dams argue that the environmental impacts of dams can be mitigated. Past experience, however, shows that



mitigation efforts have largely failed. It is often too expensive, too difficult or simply impossible to recreate the characteristics of wild rivers and the web of life they support. Since 1996, the US government has spent about $430 million annually to mitigate the impacts of dams on fisheries in the Columbia River basin. Despite this enormous expense, most of the wild salmon stocks in the region are either extinct or on the brink.

A growing number of older dams are being decommissioned, mostly in Northern countries, because the social and environmental benefits of removing them outweigh the costs of maintaining them and the limited benefits they produce. In the US, nearly 200 dams were removed in the 1990s, many for environmental reasons.

ELUSIVE BENEFITS OF DAMS

More than 45,000 large dams (higher than 15 meters) have been built around the world to generate electricity, supply water, control floods and facilitate navigation. During the 20th century, an estimated $2 trillion was spent on dams.

While dams have provided considerable benefits, they have often failed to meet expectations. Hydropower dams often do not produce as much power as expected. Irrigation projects do not irrigate as much land or generate as many economic benefits as promised. Water supply dams regularly fail to supply as much water as predicted. While flood control dams have stopped smaller floods, they have also increased the vulnerability of communities to damages from larger floods. Considering the huge amounts of money spent on dams, there is clearly a need for better monitoring of their technical, financial and economic performance.

ARE THERE ALTERNATIVES?

Viable alternatives to dams do exist, and are frequently more sustainable and cheaper. The most important alternative to new dams is to improve the efficiency of existing water supply and energy systems. This may involve reducing leaks in water pipes, retrofitting power plants and irrigation systems with modern equipment or reducing losses in power transmission lines. Another simple and economical option is to reduce the demand for water and energy. This can include recycling, shifting to less water-intensive crops and encouraging the use of more efficient electrical appliances. These options can diminish the need for new or existing sources of supply.

When efforts to conserve resources and improve the efficiency of existing dams are not enough to meet growing demand, renewable energy supply options should be considered. Renewable options include efficient and sustainable biomass, wind, solar, geothermal, and eventually ocean energy sources and fuel cells. Wind power is one of the fastest growing renewable energy options. The cost of wind power in good locations is now comparable to or cheaper than that of conventional sources. Some estimate that 10 percent of the world's electricity could be supplied by wind power by the year 2020. The cost of solar photovoltaics has dropped by 80 percent in the last 20 years, and although still expensive the technology has huge long-term potential.

Small-scale decentralized options have the biggest potential for supplying water and power to rural communities. Rainwater harvesting and micro-hydro dams are easier to implement, cost less and have lower environmental impacts than large-scale infrastructure. The construction of small dams to impound rainwater in India's desert state of Rajasthan has recharged groundwater supplies and increased food security and incomes for hundreds of thousands of farming families.

END OF THE BIG DAM ERA?

Over the last 20 years, a growing international movement has emerged to challenge destructive dams, promote sustainable and equitable alternatives and secure reparations for dam-affected people. This movement has forced the indefinite postponement or cancellation of numerous projects around the world.

Despite what critics say, most activists are not opposed to all big dams. What they are opposed to is current development planning processes that promote dams that benefit a few at the expense of the human rights, livelihoods and dignity of the poor. Many believe that if planners adopted the recommendations of the World Commission on Dams, destructive dams would not be built.

The WCD proposed a new framework for development based on respect for human rights. The WCD recommended that before taking a decision to build a dam, the needs for water, food and energy should be clearly assessed. All options should be considered, and first priority should go toward improving the efficiency of existing systems.

Before constructing new dams, the WCD states that outstanding claims for damages caused by past projects should be resolved. Those who would be affected should be involved in decision-making processes and should be among the first to benefit from projects. No dams should be constructed without the acceptance of affected people. Indigenous and tribal peoples should be given special consideration. For more information on the WCD and its recommendations, visit www.dams.org.

COMMON MYTHS ABOUT LARGE DAMS

"Hydropower is cheap."

Hydroelectricity can be cheap to produce – once the dams are built. But dams are hugely expensive to build and their costs are usually far higher than estimated. The WCD found that on average dams end up costing 56 percent more to build than predicted.

Dam designers typically overestimate how much power their projects will produce. Climate change is expected to increase the frequency and severity of droughts, reducing hydropower production. When these factors are considered, hydropower is frequently a very costly form of power generation.

"Hydropower is clean."

Hydropower dams cannot be considered a clean source of electricity because of their serious social and environmental impacts.

In addition, reservoirs emit greenhouse gases due to the rotting of flooded vegetation and soils, aquatic plants and organic matter flowing in from upstream. Emissions of carbon dioxide and methane are particularly high from reservoirs in the lowland tropics. In some cases, reservoirs may have a greater impact on global warming than similar-sized gas-fired power stations.

"Dams effectively control floods."

Dams can stop regular annual floods but often fail to hold back exceptionally large floods. Because dams provide a false sense of security, they can lead to increased development of floodplains. When a large flood occurs, damages are frequently far greater than they would have been without the dam. Between 1960 and 1985, the US government spent $38 billion on flood control, mostly on dams. Yet average annual flood damage continued to increase – more than doubling.

Dams can also worsen flooding by reducing the capacity of the riverbed downstream. They can also cause serious floods when reservoir operators make sudden releases during extreme storms or, in the worst cases, when dams break. Climate change is expected to increase the severity of floods, with serious implications for dam safety.

"Irrigation dams reduce hunger."

The benefits of large dam-and-canal irrigation schemes have been seriously overstated. These schemes are invariably mismanaged and waste huge amounts of water. They frequently destroy huge tracts of formerly fertile lands through salinization and waterlogging. The construction of reservoirs and canals itself consumes large amounts of fertile land.

Many large irrigation schemes have displaced small landholders and replaced traditional farming systems, increasing landlessness and rural hunger. Advocates of large dams assume that producing more crops will reduce malnutrition. However, people go hungry because they cannot afford food, not because the world does not produce enough. Malnutrition continues in countries like India, Pakistan and the US, which have produced surplus food grains for years.

IRN supports local communities working to protect their rivers and watersheds. We work to halt destructive river development projects and to encourage equitable and sustainable methods of meeting needs for water, energy and flood management. Published in 2003.

A CRISIS OF MISMANAGEMENT

REAL SOLUTIONS TO THE WORLD'S WATER PROBLEMS

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We are widely perceived to be in the midst of a "world water crisis." This crisis is commonly believed to be one of scarcity – that the world is running out of water. But in fact, the "crisis" is mainly one of mismanagement, not absolute scarcity. Freshwater ecosystems worldwide have been dammed, drained and pumped dry to supply inefficient and inequitable irrigation schemes, leaky water mains and wasteful overconsumption.

Because of mismanagement and skewed priorities, more than a billion people lack access to decent water supply, and twice as many lack access to proper sanitation. US water analyst Peter Gleick estimates that if water and sanitation services do not radically improve, as many as 135 million people will die from water-related diseases over the next 20 years.

The World Water Council, World Bank and other agencies that dominate the world water establishment promote big infrastructure projects and corporate investment in water supply as the key solutions to the "crisis." But this approach will only worsen the problems they seek to solve and hinder the adoption of real solutions that are both available and affordable.

GLOOMY ARITHMETIC OF WATER

The water establishment's usual arguments will dominate discussions at the Third World Water Forum. The arguments begin with the "gloomy arithmetic of water" as described by the World Commission on Water: demand is growing fast, rivers and wetlands are being destroyed and aquifers are being depleted. Four billion people will live under conditions of severe water stress by 2025 and nourishing the growing world population will depend on increasing water storage for irrigation.

In its Water Resources Sector Strategy, the World Bank claims the "the gloomy arithmetic of water is mirrored in the gloomy arithmetic of costs. The 'easy and cheap' options for mobilizing water resources for human needs have mostly been exploited." The Bank cites the frequently used World Water Council estimate that to meet the water needs of developing countries, investments in water infrastructure would need to increase from the current level of about $75 billion to $180 billion a year.

A picture is thus created of the world facing a water-shortage crisis, which can only be solved with huge investments in expensive large-scale infrastructure. This assumption is then used to argue that governments cannot afford such high costs and that the private sector is needed to make up the difference.

CRISIS OF MISMANAGEMENT

More than a billion people lack access to decent water supplies, not because there is too little water, but because governments have failed to provide it. Just one percent of current water withdrawals would supply a basic level of 40 liters per capita per day to all those currently lacking adequate supplies – and to the two billion people projected to be added to the world's population by 2025.

So where is our water going and how can it be better used to provide water and food to the poor?

Irrigation's big thirst

Worldwide, more than two-thirds of water withdrawn from rivers, lakes and aquifers is used for irrigation, with an even higher proportion in arid areas such as Central and South Asia and the western US. Irrigation is often extremely inefficient, with more than half of the water applied to fields not reaching its intended crops. Furthermore, wrongheaded agricultural policies have encouraged farmers to grow water-intensive crops like alfalfa, sugar cane and cotton in dry areas with subsidized irrigation water rather than in locations where rainfall is plentiful. Many large-scale irrigation schemes have proven unsustainable, as huge areas of land have been abandoned due to waterlogging and salinization.

Real solutions: improving irrigation

Improving the performance of existing irrigation systems holds tremendous potential for water savings. Reducing the water consumed by irrigation by 10 percent could double the amount of water available for domestic supply worldwide. Other obvious solutions include taking the poorest lands out of production; switching to less-thirsty crops; converting to water-conserving irrigation systems; and reducing fertilizer and pesticide use. Switching to water-conserving irrigation systems has the biggest potential – installing drip irrigation systems could potentially save more than 40 percent of water now used in agriculture.

Just 1 percent of current water withdrawals would supply a basic level of 40 liters per capita per day to all those currently lacking adequate supplies plus the 2 billion people to be added to the world's population by 2025.

Urban wastefulness

Urban areas are also prodigious wasters of water, with up to 40 percent of water supplied being lost to leaks or theft in many parts of the world. In 2000, Malaysia's Selangor state lost around one billion liters of water to leakage and theft each day – enough to supply the basic needs of 25 million people.

Real solutions: conservation, decentralized supplies

Demand-side management could substantially reduce urban water use at a fraction of the cost of building new infrastructure. Demand-side management practices include encouraging households to install water-efficient fixtures and appliances, and providing incentives for industry to reduce water waste. A water conservation program in Mexico City, which involved replacing 350,000 old toilets with more efficient models, has saved enough water to supply an additional 250,000 residents. Progressive water pricing systems which charge higher rates as higher volumes of water are consumed can also reduce demand.

Upgrading and improving urban distribution systems is also critical to reduce the vast amounts of water lost through leaks and theft. Alternative supply methods such as recycling wastewater and urban rainwater harvesting (such as installing tanks to capture rain falling on roofs and parks) can add significantly to urban supplies without the need for costly new dam-and-pipeline projects.

Failure to deliver

For more than a decade, the World Bank and other international development agencies have fervently promoted private investment as the solution to the ills of urban water utilities. It is now clear that this approach has failed. Water privatization has not worked for urban consumers – and it has not worked for the small cartel of multinational water companies who are now in deep financial trouble.

In early January 2003, French water giant Suez announced it would reduce its exposure to emerging markets by more than a third by 2005 (and assumed a $500 million loss for writing off its entire investment in Argentina). Heavily indebted German utility conglomerate RWE also announced in January that it would cease making new acquisitions for at least two years. Even the World Bank's draft Water Resources Sector Strategy admits that "under current conditions the private sector will play only a marginal role" in financing water infrastructure.

Rather than continuing to push the failed strategy of water supply privatization, policy makers should support viable public utilities. Public water providers have often been poorly run, have not been held accountable and have failed to address the needs of the poor or the environment. These utilities need to be restructured and made accountable – and evidence shows this can be done. There are many well-run public providers. "Public-public partnerships" can help poorly performing utilities by providing managerial and technical assistance from well-run providers.

Water supply privatization is in any case irrelevant to the great majority of those who lack access to water. More than four-fifths of those without adequate access to safe water live in rural areas. Water multinationals have rarely shown interest in investing in rural drinking water systems. It is very difficult for companies to profit from poor, dispersed rural populations who mainly depend on local water sources such as wells, springs and streams.

Real solutions: small decentralized systems

The UN-affiliated Water Supply and Sanitation Collaborative Council estimates it would cost $9 billion a year between now and 2025 to provide all the world's people in urban and rural areas with adequate water supply and sanitation using small-scale technologies. While $9 billion is certainly a considerable sum, it is less than a third of current spending on water and sanitation infrastructure in developing countries (and is equivalent to only nine days of US government spending on "defense").

Large centralized water supply schemes are rarely relevant for rural water supply in developing countries because of the prohibitively high costs of building networks of reservoirs, pipes, aqueducts and treatment facilities. Small, decentralized and technologically appropriate solutions, in particular rainwater harvesting, are the best option for providing water to rural people (who need water for their crops and animals as well as for domestic use).

Rainwater harvesting involves building small dams and embankments and other low-cost structures to trap rainwater and recharge groundwater. Evidence from desert areas like western Rajasthan in India suggests that all but the most drought-stricken regions of the world should be able to meet basic needs for water and food with local supplies if rainwater were captured and used judiciously.

Rainwater harvesting programs can be implemented and managed by local communities with little or no outside help. This benefit is also the reason why the water establishment has not promoted it; there is little financial or political benefit for corporations and government agencies to implement rainwater harvesting projects.

Decentralized groundwater recharge is also vital to reduce the vulnerability of rural areas to increasingly severe droughts caused by climate change (and another benefit of rainwater harvesting and forest regeneration is that they reduce the destructiveness of floods, which are also increasing due to global warming). Climate change is expected to cause major disruptions to the hydrological cycle, meaning that drastic cuts in greenhouse gas emissions are a key component in water security.

Supplying food to the hungry

The world water establishment argues that we need more water for irrigation to feed the hungry. However, hunger happens not because the world is short of food – actually we produce much more than enough – but because hundreds of millions of people are too poor to buy it. India now boasts a huge surplus in food grains, its storehouses now holding a quarter of world food stocks – yet more than half of India's children are classified as underweight.

Past experience has shown that dam and canal irrigation schemes will not solve the world's hunger problem. These cap-

LOW COST, HIGH REWARD SOLUTIONS

A stark example of the huge cost differences between the top-down establishment approaches to water management and community-led approaches comes from Alwar district in the Indian state of Rajasthan. Since 1986, an NGO known as Tarun Bharat Sangh (TBS) has helped villagers build or restore nearly 10,000 water harvesting structures – mainly earthen embankments or small concrete dams across seasonally flooded gullies. The structures impound water, which soaks into the ground and recharges groundwater. This water is then drawn from wells. TBS calculates that around 700,000 people benefit from improved access to water for household use, farm animals and crops.

TBS has contributed around 70 million rupees ($1.4m) to the cost of the water harvesting structures. This works out to a cost of 500 rupees per hectare irrigated and 100 rupees (two US dollars!) per person supplied with drinking water. By comparison, supplying one person with water from the notorious Sardar Sarovar Dam project on India's Narmada River will cost 10,000 rupees, and supplying one hectare with irrigation water from the megaproject will cost 170,000 rupees – 340 times more than in Alwar.

ital-intensive technologies can raise yields (at least over the short-term) for larger farmers who can afford them or who happen to own land in the limited areas to receive irrigation water. But poor farmers, and the majority living outside the irrigated lands, end up being starved of investment and become poorer and less food-secure.

To reduce hunger, policies must focus on land reform, improvements in traditional, ecologically sustainable agricultural technologies, and the production of food for local consumption rather than for export. More equitable food distribution may also be necessary to satisfy the global population's nutritional needs. For the past 30 years, around 40 percent of the world's grain supply has gone to feed livestock. This grain, and the water used to grow it, could be used more productively to grow food for people instead.

The cheery arithmetic of water

Analyze carefully the water establishment's "gloomy arithmetic of water" and one sees that it does not add up. But doing the math, dissecting the problems and assessing solutions can be a heartening exercise: the solutions to world water problems are affordable and can be implemented. The main problem is institutional; solving it will require citizens to persuade their governments to stop listening to, and stop funding, the self-interested construction and privatization lobbies of the global water establishment.

WATER MANAGEMENT SOLUTIONS

The World Commission on Dams found major problems with water supply and irrigation dams. Seventy percent of water-supply dams did not meet their targets, and half of large-scale irrigation projects underperformed.

The WCD report included numerous suggestions for alternatives to dams for water supply, including the following:

IRRIGATION AND AGRICULTURE SECTOR

- improve performance and productivity of existing systems; and
- use alternative supply-side measures that incorporate rain fed, local, small-scale, and traditional water management and harvesting systems, including groundwater recharge methods.

WATER SUPPLY SECTOR

- revitalize existing sources;
- introduce appropriate pricing strategies;
- encourage fair and sustainable water marketing and transfers, recycling and reuse; and
- local strategies such as rainwater harvesting.

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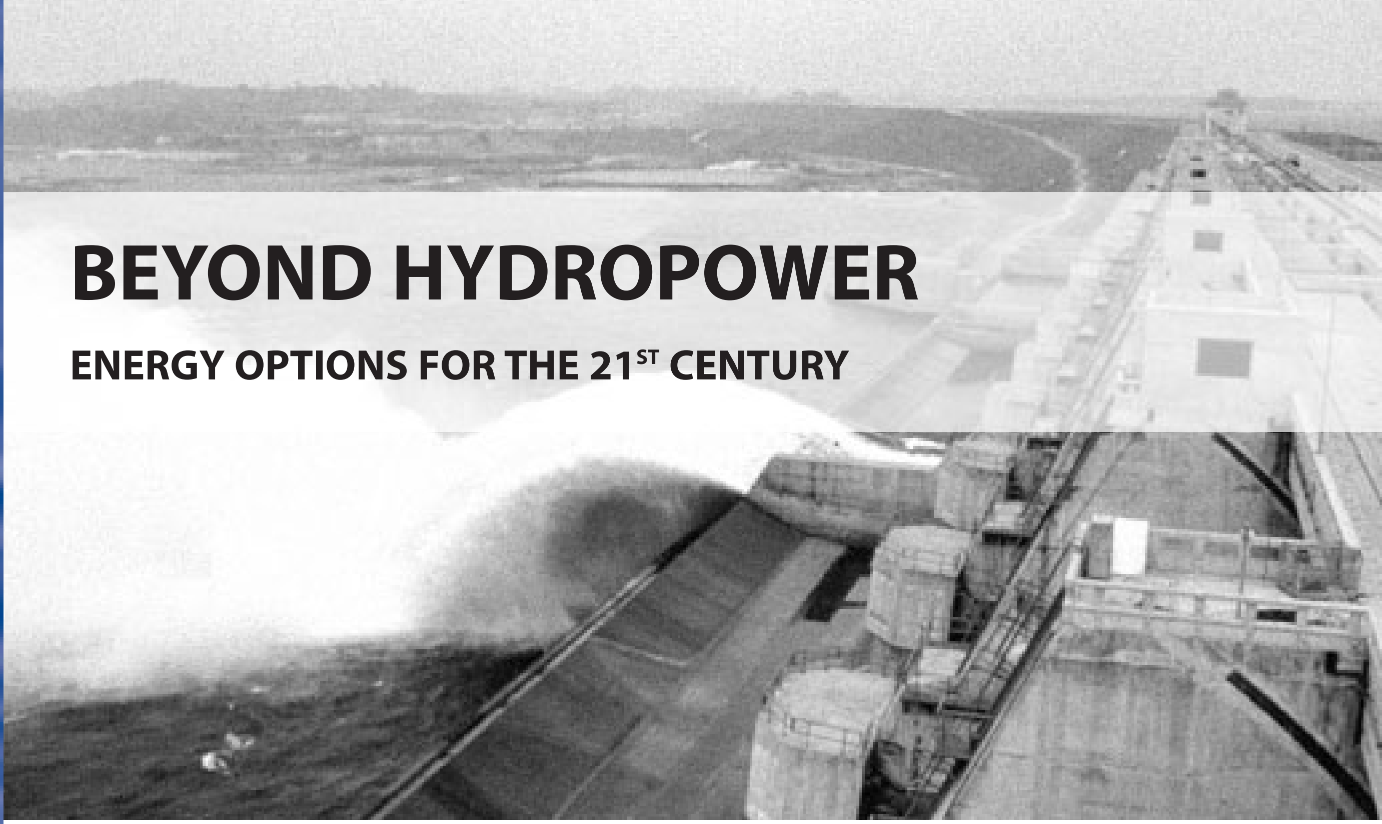

BEYOND HYDROPOWER

ENERGY OPTIONS FOR THE 21ST CENTURY

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Electricity brings many benefits. But generating electricity has also caused massive environmental and social problems. We must revolutionize the way we produce and use energy to reduce these impacts while providing energy services to the billions of people who have inadequate or no access to electricity. Population growth makes the challenge even harder.

The energy revolution will require moving from 20th century electricity systems based on large-scale fossil fuels, large hydro and nuclear fission plants to a 21st century energy system based on new renewables and massive improvements in the efficiency with which we produce, transport, store and use energy.

In 2000, the World Commission on Dams (WCD) issued a report criticizing the performance of dams and laid out a set of recommendations which could revolutionize how energy-related decisions are taken. If implemented, these recommendations would open up energy planning to public participation, limit the distorting influence of vested interests, and expose the true economic, social and environmental costs of different energy choices.

DIRTY HYDROPOWER

The WCD, which was set up by the World Bank and the World Conservation Union (IUCN), found that the costs of dams have been "unacceptable," particularly in terms of impacts to people displaced, downstream communities and the environment.

According to the WCD, 40-80 million people have been forcibly evicted from their homes to make way for dams. Millions more have lost their land, livelihoods and access to natural resources and have endured irreparable harm to their cultures and communities.

Dams have taken a huge toll on the environment. They have flooded diverse wildlife habitat and fertile farmlands, blocked fish migration and disrupted river flow patterns. Dams are a leading reason why one-third of the world's freshwater fish species are extinct, endangered or vulnerable. Efforts to mitigate these impacts have met with little success.

Further, growing evidence suggests that reservoirs emit significant quantities of greenhouse gases. Emissions are particularly high from hydropower in the lowland tropics – in some cases greater than those from similarly sized gas-fired plants.

While only a minority of the world's 45,000 large dams generate electricity, the largest dams which have displaced the most people and had the greatest environmental impact almost always have a hydropower function.

UNRELIABLE AND EXPENSIVE POWER

Hydropower is often falsely promoted as cheap and reliable. While the operating costs of hydropower dams are low compared to fossil fuel plants, their construction costs are extremely high, running into the billions of dollars for major projects. They are also prone to cost overruns. The WCD found that on average dams cost 56 percent more than projected.

Hydropower dams often do not produce as much power as predicted. Fifty-five percent of the hydropower projects studied by the WCD generated less power than planners promised.

Because it depends on the vagaries of the hydrological cycle, hydropower is not a reliable source of energy. Many hydropower-dependent countries, including Brazil, Norway, Ghana, Sri Lanka, Ecuador and Vietnam, have suffered serious power shortages due to droughts.

Global climate change will increase rainfall variability and unpredictability, making hydropower production more undependable. Increased flooding due to global warming also poses a major hazard to the safety of dams. Countries that are heavily dependent on hydropower must diversify their energy sources if they are to reduce their vulnerability to climate change.

In addition, all reservoirs lose storage capacity to sedimentation. While the rate varies widely, in many cases sedimentation seriously diminishes the capacity of dams to generate power. Up to one percent of world reservoir volume is lost to sedimentation annually.

BUILDING BLOCKS OF THE ENERGY REVOLUTION

The lowest impact, quickest and most cost-effective alternatives to building new generation projects are to reduce waste and improve the efficiency of electricity use. Another important option is to upgrade existing generating plants and distribution networks. In some countries, transmission losses are as high as 40 percent.

Most of the two billion people who do not have electricity live in remote villages in developing countries. Expanding electrical grids to these people is expensive and slow. Decentralized, small-scale projects provide the greatest opportunity for providing power to unserved rural areas. Options for off-grid rural electrification include biomass and biogas-powered generators, micro-hydro units, windmills and solar photovoltaics. More than 1.3 million small solar systems have been installed in homes in the developing world since 1980.

Wind power

Wind power is one of the world's fastest growing energy sources. In many areas wind power is already economically attractive compared to fossil fuels and hydropower. In 2002, total installed wind power capacity grew by a third in the European Union to reach 23,000 megawatts (MW). Wind power is also growing rapidly in developing countries: India's installed capacity, for example, exceeded 1,700 MW last year.

The European Wind Energy Association projects that by the year 2020 the installed capacity of wind turbines could reach 1.2 million MW (nearly twice current global hydropower capacity).

Solar photovoltaics

While sales of solar photovoltaic (PVs) cells are growing fast they still account for only 0.04 percent of the world's electricity generation. PVs are expensive for grid-connected generation although their prices are coming down fast as production volumes increase and research intensifies. The European Photovoltaic Industry Association predicts that solar energy could provide a quarter of global electricity demand by 2040.

The main constraint to both solar and wind power is that they only generate when the sun is shining or wind is blowing. The rapid progress in fuel cell technology should help overcome this problem. Excess power from solar panels or wind turbines during sunny days or windy periods could be used to produce hydrogen by passing a current through water. Hydrogen-powered fuel cells could then cleanly generate electricity as needed.

Other options

Other clean generating options include geothermal power (an established technology with about 8,000 MW installed worldwide), new efficient biomass-powered turbines, and ocean energy systems such as wave and tidal power.

The best of the fossil fuel options is natural gas-fired cogeneration which achieves a high efficiency by using heat from the combustion process for heating water or buildings. Biomass and fuel cells can also power cogeneration systems.

In Europe and North America where rivers have already been extensively dammed, environmentalists are often opposed to new hydropower plants of any size. In many developing countries, however, sustainable power advocates favor small hydro (plants with a generating capacity of under 10 MW) because it can be built with local expertise, capital and materials, and has few social and environmental impacts.

NO MORE HYDROPOWER AS USUAL

Hydropower plants come in so many shapes and sizes and are built in so many different social and environmental contexts that it is difficult to make categorical statements against the entire technology. International Rivers Network strongly believes, however, that too many destructive hydropower dams have been built and too many are being planned, and that better alternatives are being ignored.

Following the recommendations of the World Commission on Dams would ensure that new hydropower plants are built only when they are democratically agreed to be the best option for meeting people's genuine needs. By following the WCD's recommendations, we can advance toward a more just and sustainable energy future.

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WARMING THE EARTH

HYDROPOWER THREATENS EFFORTS TO CURB CLIMATE CHANGE

The Petit Saut reservoir floods a French Guyana forest, emitting greenhouse gases. Caption: Jacky Brunetaud

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The hydropower industry is eager to promote dams as "climate-friendly" alternatives to fossil fuel plants, hoping to benefit from subsidies intended to curb global warming. But, growing evidence suggests that dams and reservoirs are globally significant sources of the greenhouse gases carbon dioxide and, in particular, methane.

Scientists have studied more than 30 reservoirs, and found emissions at all of them. In tropical countries, several of the hydropower plants studied appear to have a much greater impact on global warming than natural gas plants generating equivalent amounts of electricity. While the global warming impact of hydropower outside the tropics does appear to be significantly lower than that of fossil fuel-generated electricity, it is not negligible as has commonly been assumed.

HOW EMISSIONS ARE PRODUCED

Reservoirs emit greenhouse gases because of the rotting of organic matter – the vegetation and soils flooded when the reservoir is created, the plants that grow in the reservoir, and the detritus that flows into the reservoir from upstream. The gases are emitted continuously from the surface of the reservoir, in sudden pulses when gases bubble up from the reservoir bottom and when water is discharged through turbines and spillways.

Canadian scientists have made a preliminary estimate that reservoirs worldwide release up to 70 million tons of methane and around a billion tons of CO_2 each year. This is equivalent to four percent of CO_2 emissions from other sources linked to human activities and about one-fifth of total human-related methane emissions.

The science of quantifying reservoir emissions is still young, however, and filled with uncertainties which are the subject of a heated scientific – and political – debate. The controversies include determining the best methods for measuring emissions from reservoir surfaces, how to account for sources and sinks of gases in the watershed before a dam was built, the magnitude of emissions generated when water is discharged from the dam, and how to compare hydropower emissions with those from fossil fuels.

Gross reservoir emissions are those measured directly at the reservoir surface and dam. But the actual impact of a dam on the global climate depends on *net* emissions. These are calculated by factoring in pre-existing sources and sinks of greenhouse gases in the watershed and how the dam has altered these.

At the Petit Saut Dam in French Guyana, researchers were surprised to find massive methane emissions from water released from the dam – much as a can of fizzy drink suddenly froths up when it is opened and depressurized. These turbine and spillway emissions were much greater than the total volume of methane released from the surface of the Petit Saut reservoir. Few other attempts have been made to measure turbine and spillway emissions. If the Petit Saut data is representative of other dams, researchers may have substantially underestimated actual emissions.

GLOBAL WARMING IMPACT OF VARIOUS ELECTRICITY OPTIONS

Power plant type	Emissions ($g\ CO_2$-eq/kWh)
Hydro (tropical)	200-3,000*
Hydro (temperate/boreal)	10-200*
Coal (modern plant)	790-1,200
Heavy oil	690-730
Diesel	555-880
Combined cycle natural gas	460-760
Natural gas cogeneration	300

**Represents gross emissions and does not include emissions produced when water is released from the reservoir.*

Canadian researchers have estimated average figures for the *gross* emissions from hydropower, without considering turbine and spillway releases. They calculate that average hydro emissions in Canada are 10-200 grams of CO_2-equivalent per kilowatt-hour generated; in the tropics, reservoir emissions are between 200 and 3,000 g CO_2-eq/kWh. By comparison a modern coal plant releases around 1,000 g CO_2-eq/kWh (see table). CO_2-equivalent combines the warming impact of both CO_2 and methane.

BANKING ON CARBON CREDITS

The dam industry has been working hard to ensure that large hydro projects gain from the emergent trade in "carbon credits" being established under the United Nations' Kyoto Protocol. The Protocol's Clean Development Mechanism (CDM) is a carbon-trading scheme that allows developed countries to purchase "carbon credits" that subsidize "climate friendly" projects in developing countries. This is supposed to create a win-win situation by helping developed countries meet their emissions quotas under the Protocol and by helping developing countries finance projects that have low greenhouse gas emissions.

Research by IRN and the Indonesia-based NGO CDM Watch reveals that the large-hydro industry could be one of the biggest winners from the CDM. Efforts to reduce climate pollution will suffer as a result. Big hydro threatens to undermine the Kyoto Protocol by taking carbon credits for projects that do not actually reduce emissions, both because of dam and reservoir emissions and because many of the dams proposed for credits would be built even without the credits. Approving carbon credits for big hydro will also divert credits that might otherwise have gone to promoting new renewables like solar or wind power.

Of the 30 projects proposed for credits as of November 2002, seven are large hydropower schemes. These large hydropower projects make up 38 percent of the potential emission reduction credits. New renewable projects, by comparison, make up only 27 percent of the claimed credits.

The main result of Northern countries buying these carbon credits would not be to support climate-friendly projects. It would instead be to subsidize hydropower developers – which for these projects are mainly subsidiaries of large US energy corporations.

Based on growing evidence that reservoirs are globally significant sources of greenhouse gases, policymakers are urged to adopt the following recommendations.

- Dams and reservoirs (including non-hydropower dams) should be incorporated into global and national inventories of sources of greenhouse gases.
- Regulatory agencies and funders should require an estimate of the global warming impact of any proposed dam project as part of the project approval process, as recommended by the World Commission on Dams.
- The only hydropower projects eligible for Clean Development Mechanism credits should be small projects (10 MW) which comply with the recommendations of the World Commission on Dams.

RESOURCES

"Damming the CDM: How Big Hydro is Ruining the Clean Development Mechanism," by International Rivers Network and CDM Watch.

"Flooding the Land, Warming the Earth," published by International Rivers Network.

Both reports can be downloaded at www.irn.org/programs/greenhouse/.

CDM Watch
www.cdmwatch.org

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THE COMING STORM

PREPARING FOR A WARMING WATER WORLD

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Even under the most optimistic scenario for cutting greenhouse gas pollution, the world will likely warm substantially in coming decades. This will cause major disruptions to the patterns of rain and snow that societies and ecosystems have evolved under. We are already experiencing worsening droughts and floods and fast-receding glaciers, and there can be little doubt that much worse is on the way.

The water systems we are planning and building now need to be safe and effective under the unpredictable hydrological conditions we will be experiencing several decades into the future. Existing systems also need to be reevaluated in the light of climate change to ensure that they can cope with new extremes of rain and drought.

Adaptation strategies should be based on three key principles: increasing the climate resilience of the poor; prioritizing flexible, cost-effective approaches; and mitigating environmental harm.

According to the World Health Organization, floods and droughts accounted for 90 percent of the natural disasters that occurred in the 1990s. These disasters affected almost two billion people. The great majority of these people lived in developing countries. Most vulnerable are people who directly depend on ecosystems for their survival, as well as those forced by poverty to live in landslide- and flood-prone areas. The best strategies for adapting to climate change will be strategies which also reduce poverty.

No one is certain how quickly our planet will warm or how global warming will alter local and regional climates. Measures to increase resilience to climate change should therefore be flexible, cost-effective and provide benefits under a wide-range of different climates. Adaptation should be done on a no-regrets principle: strategies should improve water management and the livelihoods of the poor even under current climate conditions.

Lastly, adaptation measures should seek to mitigate the damage to ecosystems from current and future human activities as well as from climate change. Freshwater ecosystems are under severe stress from water-management infrastructure and other human activities. Climate change will exacerbate the pressure on these ecosystems.

ENSURING ADEQUATE WATER SUPPLY

Reducing demand

The best flexible, cost-effective, no-regrets adaptation measure is to lower demand for water by reducing waste and improving the efficiency of its use. If we need less water for our farms, factories and homes, it will matter less when droughts cut into available supplies. Reducing demand can make more water available to ecosystems, thus increasing their resilience to climate change. It is almost always cheaper to bring down demand than to increase supplies.

Underground storage

Rain rarely falls exactly when needed for human use. Some method of storing water is therefore essential, especially in areas with infrequent and unreliable rainfall or river flow. By far the best place to store water is underground. Unlike water in surface reservoirs, water stored underground does not consume land or displace people, does not evaporate and does not depend on expensive and destructive dams.

Adaptation to climate change will require a drastic improvement in the management of underground water sources, which are the main supply for billions of people but are being rapidly depleted. Major regulatory and management changes (such as shifting to less water intensive crops, installing more efficient irrigation technologies and taking land out of irrigated production) are urgently needed to control groundwater mining.

Measures to reduce groundwater use must be accompanied by a major increase in efforts to recharge aquifers. Harvesting rainwater behind small dams and embankments is one proven method of doing this.

Rainwater harvesting is much cheaper than large storage projects and can be implemented with local labor, materials and expertise. Mobilizing rural communities around rainwater harvesting has catalyzed the establishment and empowerment of local political structures, which help poor people gain control over and improve many aspects of their lives. Rainwater harvesting alleviates poverty by enabling farmers to increase yields. It lightens the workload of women who have the responsibility for gathering water. Rainwater harvesting can also provide more geographically widespread benefits than big reservoirs, which help only the limited areas that can be reached with canals and pipelines.

Rainwater harvesting can also help drought-proof urban areas. Cities in Japan, Germany and India have passed ordinances requiring new buildings to include rainwater tanks. Urban areas can also make themselves more climate-resilient by reusing wastewater, and in some cases building desalination plants as a back-up source.

Problems with surface storage

The World Bank, World Water Council and other pro-dam lobbies argue that adapting to climate change will require increasing surface water storage and supply by building more dams and long-distance water transfer schemes. Focusing adaptation on building new megaprojects would be expensive and inflexible, would worsen poverty and environmental damage, and simply would not work.

The drawbacks of large surface reservoirs will be magnified by climate change. Reservoirs lose water to evaporation, which will increase as temperatures rise (evaporation from large reservoirs is already equal to about five percent of global water withdrawals). Sedimentation reduces the amount of water that reservoirs can store. The rate of sedimentation will increase as worsening storms, droughts and wildfires increase soil erosion.

A warming climate also threatens dam safety. Engineers build dams to cope with extreme floods that are predicted based on hydrological records. But as the climate changes, it gets harder to guarantee that the spillways of existing or planned dams will be able to cope with future floods. When a spillway is overwhelmed there is a high risk of a dam break, with potentially catastrophic consequences for people downstream.

FLOOD CONTROL VS FLOOD MANAGEMENT

Around the world, flood damage is steadily increasing due to complex factors such as land degradation, poor urban planning and the construction of counterproductive dams and embankments for flood control. Without a doubt, however, increasingly intense rainstorms are also a major cause.

Flood damages have increased rapidly worldwide, in spite of expenditures of tens of billions of dollars on conventional flood control measures. It is increasingly apparent that non-structural solutions are essential to effective flood management. These include implementing flood warning systems, preparing evacuation plans, discouraging floodplain development, improving drainage and giving rivers room to flood by restoring wetlands and demolishing or moving back embankments. Embankments should have a limited role in flood management, such as protecting vulnerable urban areas.

REDUCING ENERGY VULNERABILITY

Dependence on hydropower multiplies countries' vulnerability to global warming. When a serious drought strikes, a hydro-dependent country has to cope with not just water shortages and reduced agricultural production, but also cutbacks in industrial output due to energy shortages.

Hydropower provides more than 50 percent of the total electricity supply in 63 countries. Hydro-dependent countries that have suffered drought-induced blackouts and energy rationing in recent years include Albania, Brazil, Chile, Colombia, Ecuador, Ghana, Guatemala, Kenya, Peru, Sri Lanka, Tajikistan, Thailand, Vietnam, Zambia and Zimbabwe.

Key no-regrets adaptation policies for hydro-dependent countries include improving the efficiency of energy use and diversification of supply, especially by developing new renewable sources such as wind, efficient biomass and solar.

Lessening the damage caused by a continuously warming atmosphere will require societies to make extraordinary efforts to adapt to new climate patterns. Effective adaptation to the hydrological impacts of global warming fortunately provides an opportunity to take measures that provide many benefits even in the absence of climate change.

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NO MORE DAM ILLUSIONS

THE GROWING SUCCESS OF DAM OPPONENTS IN JAPAN

Citizens march against the Tokuyama, Tomada and the Kawabegawa dams. Credit: Struggle Committee Against Tokuyama Dam

Japan is one of the most heavily dammed countries in the world. Over 3000 dams have been built across the country, and there are virtually no rivers which have not been dammed. Another 350 dams are planned or under construction. However, growing recognition of the problems with dams, declines in water and energy demands, and increasing opposition to dams have made it difficult to build new projects. The cancellation of 80 proposed dams in the past few years gives reason to believe that the era of dam building in Japan is passing.

IMPACTS OF DAMS

Japanese dams have experienced huge cost overruns. The Miyagase Dam, completed in 2000, cost 400 billion yen ($3.3 billion), roughly four times the original estimate. Such enormously expensive public works projects have helped fuel colossal budget deficits for the national and prefectural governments, estimated at approximately 800 trillion yen ($6.6 trillion).

When a plan for a dam is proposed, residents may spend as long as 40 years living with uncertainty about their futures before actually being relocated. Dam proponents have used methods such as pay-offs to break down opposition movements and sow rifts within affected communities, thus destroying the cohesion of local societies.

Dams have caused considerable damage to the environment in Japan. They have obstructed water and sediment flow and impeded animal movement. They have also degraded water quality and fragmented riverine habitats. By trapping sediments that would previously have been washed out to sea, they have increased shoreline erosion.

Until recently, dam promoters rarely made project data public. Even after the passage of a freedom of information law in 1999, inadequate access to information has hindered debate about the merits of projects. No systematic means have been provided for affected residents to participate in the decision-making processes regarding dam construction.

With the recent revision of the Rivers Law, watershed committees have been established with public participation, and some debates have occurred over the construction of dams. These committees, however, cover only a very small fraction of all affected areas. The public must be able to analyze and discuss dam plans and alternatives before decisions are taken.

NO NEED FOR MORE DAMS

Many of the plans to build dams in Japan have been based on meeting the rising demand for water that accompanied Japan's rapid postwar industrial growth. Since the energy crises of the 1970s, the rate of growth of industrial and municipal water demand has dropped. Over the last decade, there has been almost no growth in industrial and municipal water use.

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Industrial and municipal demand is now projected to remain constant or decline. This is partly because Japan's industrial structure is shifting away from heavy industries that use large amounts of water to less water-intensive service industries. Increasing water-use efficiency in homes, offices and factories has also helped reduce demand. Japan's population is expected to decline starting in 2006 which should cause demand to drop further.

Demand for water from agriculture is also declining. The area of rice paddies, which require lots of water, has fallen substantially due to urbanization and subsidies to remove land from production.

Most of the sites suitable for production of hydroelectric power have already been utilized. In addition, demand for electric power has leveled off.

Dam proponents have argued that dams are necessary to prevent major losses of life and property damage from floods. These claims are based on unrealistically high flood estimates. More accurate predictions of extreme flood levels estimate flow rates that could be accommodated by existing river channels.

Because a large proportion of river management expenses have been poured into new dam construction, maintenance of levees and other flood management measures has been neglected. Most proposed dam sites are located in upper watersheds, far removed from the areas downstream that need flood protection. In many cases, new dams would not contribute to mitigating flood peak levels downstream.

RESISTANCE TO DAM BUILDING

The status of dam building in Japan has changed dramatically in recent years. Eighty projects have been cancelled since 1997 because of the growth of anti-dam movements and an increasing recognition that dams are unnecessary.

Opposition to the Nagara River Estuary Dam in the 1980s was a pivotal campaign. It sparked citizens' concerns about the treatment of the nation's rivers and raised awareness about the environmental destruction of dams. As a result, dam opposition movements spread like wildfire throughout Japan.

Opposition to the Yoshino River Estuary Dam led to the first ever people's referendum concerning dams in January 2000. The referendum led to a *de facto* suspension of the project. After his election, Yasuo Tanaka, governor of Nagano Prefecture, issued a declaration opposing new dam plans in the prefecture. As a result, plans were scrapped to build the Ohbotoke, Asakawa and Shimosuwa dams.

MORE DAMS, BUT MORE HOPE

Despite the success of the dam opposition movement, 350 dams are still planned nationwide. Still, there are many reasons for hope. As outlined above, declines in water demand have reduced the justification for building water supply dams. There is also growing recognition that effective flood control depends on maintaining existing flood channels and levees, not on building more dams.

The relationship between national and local governments in Japan has changed in a way that was unthinkable just a decade ago. Local authorities are now openly stating their needs and influencing national decision-making. The governor of Kumamoto Prefecture, Shiotani Yoshiko, initiated a series of public debates regarding the merits of the Kawabe River Dam, promoted by the national government, prior to the start of construction. The declaration against dams by the governor of Nagano Prefecture is another example, and there are continuing examples of localities giving up water-use rights that they no longer need and expressing opposition to costly and unnecessary dams.

Dams are no longer seen as unstoppable. The Asakawa Dam was stopped by the governor of Nagano Prefecture even though construction was underway and half the total budget of 400 million yen ($3.3 million) had already been spent. Plans for dams on the Yodogawa River system were cancelled by a committee set up to advise on river management plans even though construction was already underway. For the first time an operating dam in Japan is slated for removal. The Arase Dam on the Kumagawa River is to be dismantled in seven years. If the dam opposition movement continues to strengthen there is a strong possibility of stopping further dams.

Edited by IRN with the cooperation of Suigenren, Heather Souter and Richard Forrest.

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