STORING WATER

The value of water to the user depends on having the right quantity, of appropriate quality, available in the desired place and time. Managing the supply of water to meet demand has everything to do with manipulating its availability in space and time through storage.

Frank Rijsberman * **International Water Management Institute**

During the twentieth century, the world's population tripled and the use of renewable water resources multiplied six-fold. This enormous increase in water use was possible due to a massive investment in water-resources development — in most cases increases in water storage and associated infrastructure. However, it had a price beyond the direct cost of investment: half the world's wetlands disappeared, groundwater levels in key aquifers are falling and many groups of people affected by water projects have raised their voice in protest.

Still, unsafe water remains the world's number-one killer. Several million children die each year of diarrhoea. Malaria, closely linked to water-resources development, remains Africa's most important cause of death. Hundreds of millions of malnourished people in the rural areas have insufficient access to water for productive purposes. To deal with these problems, and provide water security for all, Cosgrove and Rijsberman (2000) estimated that global investment in the water sector would have to double to $180bn/yr.

Dams are often regarded as a community resource.

The dam building boom

During the twentieth century the use of water for human purposes exploded. There are today over 45 thousand large dams, higher than 15m, estimated to have cost more than $2tn, providing water for 30–40 per cent of the world's irrigated agriculture and 19 per cent of world electricity.

In the dry western part of the USA and in the huge Murray-Darling basin of Australia an enormous number of small, medium and large dams were built. These were built primarily for agriculture and hydropower purposes. In the mountainous parts of Europe dams were built primarily for hydropower and later for domestic purposes. Today the total constructed storage capacity in Australia and the USA is in the order of 5000m^3 per inhabitant and the large majority of attractive sites for dam construction have been used. Dam construction in OECD countries has levelled off. The dam construction boom in Asia came later, starting in the 1960s, and has not yet levelled off.

Second thoughts

As the World Commission on Dams (WCD) writes:

> From the 1930s to the 1970s, the construction of large dams became — in the eyes of many — synonymous with development and economic progress. Viewed as symbols of modernisation and man's ability to harness nature, dam construction accelerated dramatically. This trend peaked in the 1970s, when on average two or three large dams were commissioned each day somewhere in the world' (p xxix).

The same large dams also have displaced some 40–80 million people that lived where water storage has been created. They have also affected the flow of some 60 per cent of all rivers — causing considerable social and environmental impact. As a result, there have been increasingly acrimonious debates over the desirability of new large dams. The independent World Commission on Dams, jointly sponsored by the World Bank and The World Conservation Union (IUCN), has carried out a major review of large dams and has attempted to formulate guidelines for responsible dam construction. While many people and countries accept the WCD recommendations, important groups and some key countries, particularly those favouring dam construction, have not accepted the report. The debate continues. As put by the Global Water Partnership (GWP):

> On the one hand, the fundamental fear of food shortages encourages ever-greater use of water resources for agriculture. On the other, there is a need to divert water from irrigated food production to other users and to protect the resource and the ecosystem. Many believe this conflict is one of the most critical problems to be tackled in the early twenty-first century. (GWP, p58).

While large dams feature most prominently in the debate over water storage, there are other water-storage options. The four main types of water storage are: the soil, groundwater aquifers, small reservoirs and large reservoirs.

While the storage in the soil profile is extremely important for the natural vegetation and crops, it is least amenable to manipulation. As land-use changes, however, through deforestation, desertification and urbanisation — the total usable storage capacity of the soil is altered considerably, but the nature and size of the impact is not well known.

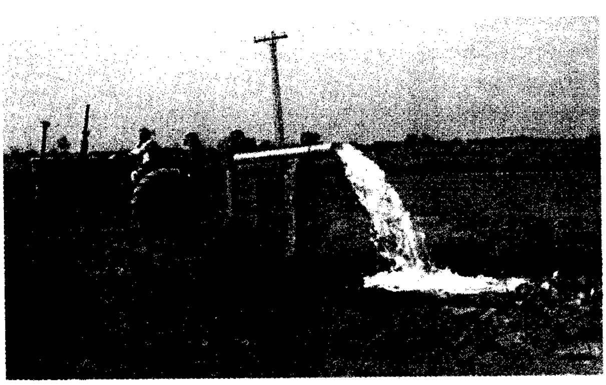
Dams — large and small

The construction of large-scale dams and reservoirs has by and large been a national government responsibility because these are very large and risky investments. The period from drawing board to commissioning is often in the order of several decades. The projects are slow, visible and draw a lot of fire from opponents. Some of the largest projects, such as the Narmada in India, the Three Gorges in China or the many planned dams on the Mekong, have gained international prominence in the debate among proponents and opponents of dam development.

By contrast, farmers, groups of farmers and municipalities, have constructed the majority of small dams. In Africa and Asia, small dams and rainwater harvesting structures are often constructed through efforts of non-governmental organisations, villages or even individuals. The smaller size is more manageable. The small dams are perceived to have a more 'human', or community, scale and their public reputation is often quite good. Scientists and engineers, however, tend to question the true value of small dams, as they may well evaporate more than they produce in areas where evaporation is high and reservoirs are very shallow. In river basins where a large share of the water is already used, in closed basins to be precise, new small dams upstream simply re-allocate the water from the downstream to the upstream user. Large numbers of small reservoirs also have a major impact on natural streamflows and, therefore, environmental impact and possibly negative health impact through water-related diseases such as malaria. Even less is known about the total costs and benefits of large numbers of small dams than is known about the impacts of large dams.

Storing water in aquifers

Since the development of small and affordable diesel and electrical pumps, these have rapidly become extremely popular to pump water for agriculture from the groundwater. In India, Pakistan and China alone there are approximately 20 million energised tubewells



Underground aquifers are crucial for farming in water-scarce areas.

Groundwater is often accessed through shared irrigation wells.

(deep-bored wells equipped with electric or diesel-powered pumps). The size of the groundwater economy in India, China and Pakistan is conservatively estimated to be $10bn.

The large majority of the tubewells are the result of private investment by farmers or groups of farmers. Almost wherever they have access to good-quality groundwater and the resources to invest in a (shared) tubewell, farmers prefer this direct access to stored water because of the greater control it provides to them. It provides water-on-demand, as opposed to water in surface water (canal) irrigation that is more or less successfully managed by irrigation managers. There is no question that tubewells, combined with the storage function of the aquifer, have produced large private benefits for their users and created enormous wealth in the rural areas.

It is proving to be extremely difficult, however, to avoid overuse of the groundwater storage function, once the tubewells are installed. In key aquifers in India, Mexico, the USA and China — the countries where the majority of groundwater use is located — groundwater levels are falling by as much as 2–3m per year. Farmers in North-Gujarat, India, started using groundwater for agriculture some 30–35 years ago with bullock-driven pumps from depths of up to 10m. They have seen the groundwater fall to depths of 150m during their lifetime. With 50hp diesel pumps installed in 200m deep tubewells, they know that the end is in sight. Already there are areas in India where over 60 per cent of the wells have been de-commissioned. The wells have fallen dry.

Complicating the issue is that the groundwater boom has been driven in part by the provision of subsidised electricity and diesel fuel. As the energy sector is battling its own collapse under mountains of debt, prices go up and some rural areas now experience de-electrification. The linkages between the water and energy sectors are known but far from understood.

Ecological alternatives

There are ecological alternatives to building dams. Along the banks of rivers that flood seasonally, such as the Senegal, people have practiced small-scale agriculture based on the natural flooding cycle for many centuries. During most of the boom period for large-scale dams in the last century, the benefits of this type of agriculture, or the services yielded by the wetlands or the fisheries in the rivers, were not well recognised. Recognition of the value of these pre-dam benefits may well render some storage construction projects

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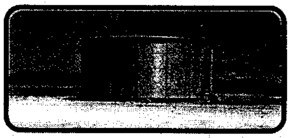

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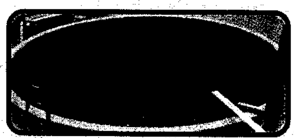

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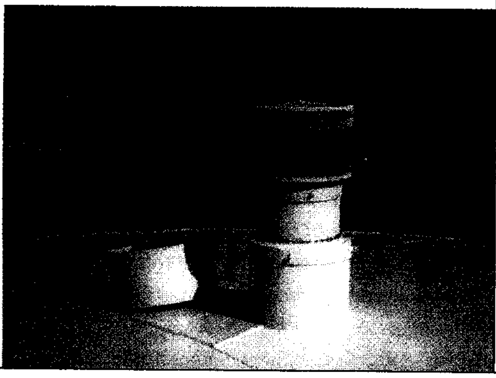

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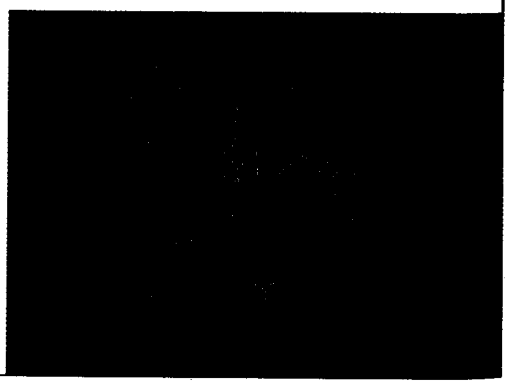

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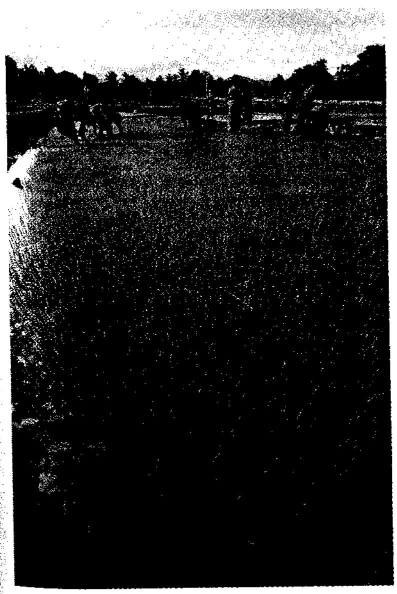
infeasible. At the same time, increased understanding of how environmental flows can be maintained after dam construction, such as those methods pioneered in the Lesotho Highlands project to transfer water resources to South Africa, can reduce the impact of storage projects on these other values.

In some cases even restoration may be possible. In Cameroon, a floodplain has been brought back to life through the Waza Logone Rehabilitation Scheme. A dam constructed in 1978 for rice irrigation greatly restricted the downstream flooding of the downstream floodplain along the Logone River. In 1988, the IUCN initiated a project to rehabilitate the floodplain, including the 171,000ha Waza Park. Pilot water releases through newly constructed openings in the main river levee have enabled restoration of approximately 60 per cent of the affected floodplain. The renewed flooding dramatically improved the living conditions for the people and their environment, without affecting the rice scheme.

Finding solutions

Managing water implies making it available when it is needed. But how much water should be stored and what type of storage provides maximum benefits for least cost, is a question that can only be answered by the stakeholders in each basin. However, there are some typical situations. First, in river basins where only a small proportion of the renewable resources are currently used for human purposes, such as in areas of Africa and Latin America, increasing storage through infrastructure development remains attractive. Second, in areas where infrastructure has been developed for much but not all of the resources, such as in Sri Lanka, improved management of the existing infrastructure may well yield 'water savings' to cover growing demands. Third, in closed basins, where all available resources are already used such as in north-west India and the China Plains, 'saving' water through infrastructure or improved management only increases the water use of the upstream user at the expense of the downstream user. In the last case only re-allocation of water to higher value uses, increasing the productivity of water, can create added value.


Recharging groundwater can improve agricultural productivity.

In all cases, as water becomes more scarce, the key to increasing its value to society lies in increasing the productivity of the water used, rather than in increasing the efficiency of its use. At the field scale, increased water productivity translates into 'more crop per drop'. At larger scale levels, the definition of water productivity also needs to include other values. For example, for the Kirindi Oya basin in Sri Lanka, the fisheries in the irrigation reservoir upstream of the rice paddy generated an additional value equal to some 20 per cent of the rice production. The trees and home gardens downstream of the rice fields in the same Kirindi Oya basin evapotranspirated more water than the rice, largely through recycling of the water coming off the paddy fields.


Rainwater can be collected from mountain catchments to irrigate the water-scarce slopes

The increased focus on, and understanding of, all values produced by water resources should lead to better decisions on whether and how water should be stored. There will still be a need for dams — but we will want to build 'good dams', not 'bad dams'. Good dams will be those where their impact has been recognised and properly accounted for and where all stakeholders have been heard and benefits are properly divided among all affected. At the same time, we need increased recognition of the role played by other forms of storage, notably groundwater stored in aquifers. Designing institutions that sustain the groundwater boom may well be more difficult than designing good dams. ✱

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