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Wetlands and water storage: current and future trends and issues

Information paper prepared by the Scientific and Technical Review Panel

1. The Scientific and Technical Review Panel's work plan for 2009-2012, in Thematic Work Area 6 (Wetlands and Water Resources Management), calls for a review of the role of wetlands in water storage and preparation of a technical report on wetlands and water storage interactions (including dams and groundwater) to support the implementation of Ramsar Resolutions concerning water-related guidance. At its mid-term workshops in 2010, the STRP requested the preparation of a Briefing Note on this topic in order to provide further and updated information.

2. The attached paper was prepared by Dr Mike Acreman, STRP Thematic Work Area Lead for Water Resources 2009-2012 and Head of hydro-ecology and wetlands, Centre for Ecology and Hydrology, UK, and was published in February 2012 as no. 2 in the STRP's series of Briefing Notes.

3. The objectives of this Note are to bring relevant issues related to water storage to the attention of Contracting Parties and to help them understand the implications for wetlands; to provide additional information to supplement Ramsar's existing guidance on these issues; and to offer recommendations for responding to these issues at global, national and river basin levels.

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STRP
Scientific and Technical Review Panel

Briefing Note

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Ramsar Convention on Wetlands

Purpose of this BN

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Background

In the STRP work plan for 2009-2012, task 7.4 in Thematic Work Area 6 (Wetlands and Water Resources Management) includes a review of the role of wetlands in water storage and preparation of a technical report on wetlands and water storage interactions (including dams and groundwater) to support the implementation of Ramsar Resolutions concerning water-related guidance (see Ramsar Wise Use Handbook 8, 4th edition, 2011). At its mid-term workshops in 2010, the STRP requested the preparation of a Briefing Note on this topic in order to provide further and updated information.

Author

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Wetlands and water storage: current and future trends and issues

It is clear that in all regions of the world there will be continued growth in the demand for reliable supplies of water for climate change adaptation, food security, water security, human and economic development. In an increasingly unpredictable global environment, providing effective options for water storage will be an important aspect of meeting that demand. Both large and small dams are likely to be suggested as potential solutions for increasing surface water storage, but as Ramsar Contracting Parties have recognized in several Resolutions, dams can have both negative and positive implications for wetlands and wetland ecosystem services. In this Note, the STRP provides an overview of the implications for wetlands of current issues and trends related to potential growth in demand for surface water storage capacity.

Key messages and recommendations

- Growth in demand for water storage is expected to increase significantly in the near future, in particular as more countries begin to implement policies for climate change adaptation. After a relatively quiet period in terms of new dam construction in the years after the World Commission on Dams final report in 2000, construction of new dams and expansion and refurbishment of older dams can be expected to increase in future in order to meet at least some of the increased demand for water storage.

- Wetlands and wetland ecosystem services can be negatively impacted by dams and other water storage infrastructure, but some types of wetlands can play valuable roles as "natural infrastructure" and can provide water storage capacity under certain conditions.

- The Ramsar Convention has adopted several Resolutions which provide guidance on dealing with the impacts on wetlands of water infrastructure such as dams. That suite of guidance remains valid and useful, and Contracting Parties are urged to implement its recommendations.

- The STRP has offered the following additional recommendations for the Convention:
  - provide sound scientific justification for the water storage functions and capabilities of different wetland types;
  - define a clear Ramsar message on wetlands and water storage issues, and use the right language to ensure understanding; and
  - identify the most important target audiences for that message and develop focused strategies for communicating relevant wetland information to these audiences.

Download PDF at www.ramsar.org/bn/bn2.pdf

Why is water storage needed?

Water is essential for most aspects of our lives including drinking, washing and cooking, growing food, supporting industry, and producing energy (Gleick 1993). People also benefit further from water through its maintenance of ecosystems that provide additional goods and services (Acreman 2003) – now commonly referred to as "ecosystem services" (MA 2005).

Water is delivered to the Earth's surface through precipitation, which varies around the world and over different time scales. Precipitation is very seasonal in monsoon regions, the Indian sub-continent, and much of Africa. Inter-annual variability also occurs, driven by large-scale phenomena such as the El Niño-Southern Oscillation (ENSO), which can create floods and droughts on a 3 to 8 year cycle (Adhikari *et al*. 2010). Decadal persistence is also a feature of past records; in the early 1980s the Sahel experienced drought and starvation, but by August 1988 floods ravaged the same region.

Although agricultural demand for water is often seasonal, demand for household water, power generation, and industrial water use tends to be constant through the year. Storage of water in times of plenty, for use in times of scarcity, is essential because any gap between the demand and supply of water will have wide-ranging implications including crop failure, thirst, power cuts, loss of transport links, and degradation of ecosystem services.

Hydrological variability affects economic growth

Rainfall variability can significantly impact on economic growth (Brown & Lall 2006). Kenya suffered a 16% fall in its gross domestic product (GDP) as a result of the 1998-2000 drought and an 11% drop in GDP due to 1997-1998 floods, partly because the country was unable to store and distribute water efficiently for irrigation and hydropower production (Economic Commission for Africa 2008). The Comprehensive Assessment of Water Management in Agriculture (Molden 2007) concluded that 20% of the world's population lives in areas of physical water scarcity.

Water is stored in many components of the hydrological cycle: in the atmosphere, such as in cloud forests, in soils, in underground aquifers, rivers, lakes and other wetlands. Groundwater is the largest store of unfrozen fresh water and it currently provides the majority of water used in the world. For example, in Africa, 60% of the population live in rural areas and depend on small-scale groundwater supplies (Calow *et al*. 2009). In many areas of the world groundwater is replenished by rainfall soaking slowly into the ground, which can take many months. So groundwater has the potential to provide water over a number of years and hence to buffer availability of water resources through both seasonal and multi-year variations in rainfall and major droughts.

The potential for groundwater to meet water demands

Groundwater is often preferred by farmers for crop irrigation as they have direct control over the resource. Yet over-exploitation (where withdrawal exceeds long term recharge), often for short-term gain, has led to lowering of the water table and significant problems in China, Mediterranean Europe, and India. In northern China, for example, there were 2.6 million wells at the end of 1997, resulting in the water table falling 42 meters in 30 years (Brown 2000). Over much of sub-Saharan Africa, hard crystalline rocks bear only limited groundwater potential.

Where water entered an aquifer in the distant past and is not currently being recharged, it is often described as 'fossil water' (Abd El Samie & Sadek 2001), and its exploitation is termed 'groundwater mining.' As with mineral resources such as oil, fossil water is an exploitable resource with a finite life. For example, the groundwater in the Kufra and Sirte basins in Libya was last replenished during a wetter period several millennia ago, but the resource is vast, has been exploited to irrigate crops for the last 30 years, and will continue to provide water for several decades to come (Wright *et al*. 1982).

How and why is demand for water and water storage changing?

The debate over water storage has intensified in recent years due to global and regional economic, demographic and climate changes, which in turn affect the timing, location and extent of water demands and hence the need for increased or new water storage options.

Demographic and social changes affecting water demand

The world's population is expected to rise from the current 7 billion to 9 billion by the year 2042 (DESAPD 2006), generating greater demands for food from irrigated agriculture and for clean safe drinking water. Irrigation already accounts for more than 70% of all water abstracted, yet water for food security is an increasingly critical issue (Hanjra & Qureshi 2010).

Despite progress towards the Millennium Development Goals (MDGs), almost 900 million people still lack access to safe drinking water. Efforts by governments and agencies to expand access to water for basic human needs will undoubtedly require reliable sources of water (Sullivan *et al.* 2003).

Regional policies for achieving food security will increasingly become issues of global significance. Some countries such as Kuwait and Saudi Arabia are buying land for food production in other countries (e.g., Sudan, Pakistan), which creates new demands on water resources and new political issues.

Will social changes lead to water conflicts?

More than half of all people now live in urban areas and most future population growth is expected to take place in cities (UNFPA 2007). Over the next 30 years, the populations of African and Asian cities are expected to double, posing particular problems for water supply. Changes in diets, for example from vegetables to meat in China, may also have an impact, though recent increases in meat demand have been met by national production (Ray 2008).

Some commentators have expressed concerns that during the next 25 years competition for water will be a catalyst for conflicts in many regions as countries fight for access to increasingly scarce resources (Mason *et al*. 2007). However, to date, the numbers of direct conflicts over shared waters remain low, and other commentators see water resources issues as a catalyst for cooperation (e.g., Grey & Sadoff 2007).

Climate changes affecting water demand

Intensification of the hydrological cycle will increase rainfall variability and more extreme floods and droughts (Meehl et al. 2007, Burke *et al* 2006). Highly populated regions adjacent to the Himalayan and Andean mountain ranges are considered particularly vulnerable to the impacts of glacier retreat (Barnett *et al.* 2005). In marginal recharge areas, groundwater storage may become non-renewable. Major land use change can also affect large scale atmospheric cycles, for example Amazonian deforestation is likely to change rainfall patterns in Mediterranean Europe (Gedney *et al.* 2006). This growing unpredictability of water availability is increasing the need for additional water storage.

Economic changes affecting water demand

Over the summer of 2008 oil prices rose from $30 to $140 per barrel, giving further impetus for development of renewable energy sources, such as hydropower, biofuels and wind energy, that do not use fossil fuels (although the financial and economic crisis led to a 2% fall in global energy demand in 2009 (IEA 2010)). Some countries, such as those in Latin America, are already heavily reliant upon hydropower (Millan 1999). Hydropower can be generated by run-of-river schemes that have limited impact on river flows. However, the most productive hydropower stations are associated with large dams, which alter river flows significantly. A detailed discussion of the possible implications for wetlands of energy policies, plans and activities can be found in a new Ramsar Technical Report (Anderson & MacKay in prep.), which has been prepared in support of the Draft Resolution for COP11 (DR10) on “Wetlands and energy issues” (Ramsar Convention 2012).

The complex links between water infrastructure, water security and economic development

In general, access to water infrastructure tends to be lowest in those parts of the world where water insecurity risks are highest (UNDP 2006). Why this should be so is not always clear. Grey & Sadoff (2007) claimed that many of the world’s wealthiest nations also have achieved the highest water security through investment in water storage schemes. However, direct cause-effect relationships are not clear: national wealth may enable extensive water storage, or alternatively water storage may be the source of such national wealth.

Economic prosperity does not necessarily depend on investment in water infrastructure, if natural storage, such as groundwater, is available and a country’s economy is not reliant on water demanding sectors. Many Middle Eastern states, such as Saudi Arabia and United Arab Emirates, have had sufficient groundwater for domestic use and have relied on income from oil sales to obtain food produced in other countries; but they are also now leasing land in Africa to grow their food, e.g., in Ethiopia (Economist 2009). However, as fossil groundwater and oil reserves become depleted, these economics may change. Furthermore, water security in many rural areas will continue to be limited by access rather than physical availability for the foreseeable future (Sullivan *et al*. 2003).

Less obvious costs and benefits of infrastructure development may not be revealed in national economic statistics such as GDP or the UN gini coefficient (Gini 1912). For example, hydropower generation at the Manantali dam in Mali has led to better electricity supplies to ur-

Water infrastructure and wealth

The USA invested heavily in multi-purpose dams starting in the 1930s with the Tennessee Valley Authority. The Hoover and Glen Canyon dams on the Colorado River supported economic development of southwest USA. Many European states have invested available wealth in dam construction; for example, for hydropower in Norway and Switzerland and for irrigated agriculture in Spain. In Australia, water infrastructure, particularly in the Murray-Darling basin, has been instrumental in industrial growth and development of agriculture and livestock production.

There are clear examples of countries which experience high hydrological variability but have limited water storage and less successful economies, such as Ethiopia and Yemen. Ethiopia has only 165 million m^3 of water storage per capita (including the new Tekeze dam on the Atbara River) compared to 4,500 million m^3 in Australia, a country with a very similarly variable climate. Less than 6% of Ethiopia's irrigable land is under irrigation, whilst in neighbouring Sudan 14% of the land is under irrigation (FAO 1987).

ban areas in Senegal, Mali and Mauritania, but there has been little electrification in rural areas and rural people have suffered loss of other important ecosystem services such as fisheries due to alterations to the river flow regime downstream of the dam (Acreman 1996).

Some argue that major water resources projects stimulate broad regional economic growth which has significant direct and indirect benefits to poor people, through generating employment and improving services such as roads and healthcare, whilst some organisations focus on appropriate local technologies (e.g., treadle pumps) that do less for GDP, but more for direct local community poverty alleviation amongst the very poorest people. The World Bank is supporting a focus on national economic growth as a top-down mechanism to pull people out of poverty rather than a bottom-up local livelihoods approach.

Potential for growth in surface water storage capacity

Whilst China and India, in particular, have major ongoing programmes of dam development, most developing countries have exploited little of the potential for infrastructure-based surface water storage; Asia, Africa and Latin America have only developed 22%, 7% and 33% of their potential hydropower, respectively (IHA 2008). In Africa, 94% of agriculture is rain-fed. The Commission for Africa (2005) highlighted the severe poverty and lack of economic growth in many parts of Africa and recommended investment in infrastructure (including water storage) to double the area of irrigated land.

Are dams the solution to the storage challenge?

Many large dams have brought significant social and economic benefits. The broad links between infrastructure development (including dams), increased agricultural productivity and economic growth have been documented (Hussain & Hanjra 2004, Hanjra *et al*. 2009). However, largely because of the adverse environmental and social impacts that they can bring about, large dams are controversial.

During the past few decades, there has been an increasing awareness that large-scale "hard" engineering, such as dams, can be an inflexible approach to water management with costs, both direct and indirect, in some cases outweighing benefits. The World Commission on Dams (WCD 2000a) concluded that dams have made an important and significant contribution to human development, but the social and environmental costs have, in too many cases, been unacceptable and often unnecessary. This has led directly to a period of reduced activity in dam building as the implications of the Commission's report were debated.

Additional concerns regarding the impacts of dams have been raised in recent years. For example, high emissions of methane (CH_4) have been recorded at shallow, plateau-type tropical reservoirs where the natural carbon cycle is most productive (Delmas 2005), although deep water reservoirs at similar low latitudes tend to exhibit lower emissions. A desk-study of greenhouse gas (GHG) emissions from creation of hydropower reservoirs in India (World Bank 2007) concluded that emissions would be low, because India's reservoirs are to a large extent located in regions where natural conditions restrict processes that give rise to methane emissions.

More water evaporates from reservoirs than is consumed by humans (UNEP 2008) and hydropower generation in the USA consumes more water per KWatt than fossil fuel generation does (Torcellini *et al.* 2003).

Because dams provide significant water storage capability, they can be multi-functional, for example, by playing a significant role in reducing floods downstream. The Three Gorges dam on the Yangtze generates hydro-

Dams: good and bad

During the Dams and Development Project (the UNEP follow-up to the WCD), the International Rivers Network (IRN) followed the progress of several dams to see if WCD processes were implemented. They concluded that major projects, such as dams at Bui (Ghana), Lom Pangar (Cameroon), Epupa (Namibia), Bakun (Malaysia) and Mphanda Nkuwa (Mozambique) have not followed WCD guidelines. However, there is no complementary global information collection from governments or dam associations with which to compare the IRN findings.

In contrast, there are many examples of dam developments demonstrating good practice against sustainability criteria. For example, the 50 MW Bumbuna project in Sierra Leone is seen as a good model of local community benefit sharing, where a Trust has been set up, supported by the World Bank and with a multi-stakeholder board, which has empowered local communities in deciding on how the funds are used. Issues and experience with dams since 2000 have recently been reviewed by Moore *et al.* 2010.

power, but it is also designed to reduce the frequency of major downstream flooding from once every 10 years to once every 100 years, and it saved many hundreds of lives in 2010. Whilst the USA has over 1000 dams purely for flood management and a further 1000 multipurpose dams that include flood management, none of the Indian dams registered in the ICOLD World Register of Dams (http://www.icold-cigb.net/GB/World_register/world_register.asp) has a flood control function, as India has not particularly favoured flood control by regulation, preferring to use levees instead.

There are numerous examples of positive benefits of dams. In Cameroon, the Waza dam is operated to inundate the Logone floodplain, with releases made to optimise ecosystem services such as fisheries, flood recession agriculture, and post-flood livestock grazing (Loth 2004). It could be argued that storage of water in the dam offers security against droughts and large floods, which would be less optimal for the floodplain. Dams create a water body which can have many characteristics of natural lakes, including valuable fish and bird species. Indeed, quite a few reservoirs have been designated as Ramsar Sites, such as Rutland Water in UK, often for their waterbird populations, although these are generally less diverse and more dominated by common species than are equivalent natural lakes (Davidson & Delany 1999).

The positive and negative socio-economic and environmental impacts of dams are well-known and can be mitigated, whilst the impacts of alternative water storage options are relatively unknown (Alhassan 2009). Pressures on water resources, including climate change as well as increasing demands for flood protection, food and energy, will inevitably lead to more dams being built.

Reducing the impacts of dams on wetland ecosystems

The International Hydropower Association continues to be an influential organisation. IHA has, for example, worked with WWF to produce sustainability guidelines (IHA 2004) and an assessment protocol for hydro dams (IHA, 2006). The World Bank has produced criteria for assessing likely adverse environmental impacts of dams (Ledec & Quintero 2003) and has also adopted the concept of environmental flows as part of its safeguards policy for water infrastructure (Brown & King 2003, Acreman 2003) that must be followed to secure Bank loans.

In fact, recent water laws in several countries include environmental flow requirements to maintain the ecosystem services of rivers and associated wetlands downstream, for example, in Costa Rica (Jiménez *et al.* 2005, Le Quesne *et al.* 2010), South Africa (Rowlston & Palmer 2002), and Tanzania (Acreman *et al.* 2006). There have been many regional initiatives, such as in the Mekong, and studies of individual dams. Yet implementation of environmental flows remains elusive due to limited information on trade-offs (Acreman & McCartney 2000) and lack of political will to change historical water rights, to take back water currently used for public supply, agriculture and industry, and in some cases to pay compensation. Designing in or retro fitting large gates and spillways to allow managed flood releases can be very expensive.

Achieving appropriate water quality is also a key challenge of environmental flows. The temperature of re-

Ramsar's existing guidance addresses ways to plan for and manage the impacts of dams on wetland ecosystems:

- Resolution VIII.1 (*World Commission on Dams*);
- Handbook 9, 4th edition (*River basin management*);
- Handbook 10, 4th edition (*Allocation and management of water for maintaining the ecological functions of wetlands*);
- Handbook 11, 4th edition (*Managing groundwater*);
- Handbook 16, 4th edition (*Impact assessment*).

leased water may be different from natural water, especially if the reservoir is deep. The water may also contain noxious substances, such as hydrogen sulphide (Petts 1984). In addition, extra storage may be required to retain sufficient water for the releases in addition to other requirements of the dam, particularly if the system is to be future climate-proofed. Convincing justifications will be needed to attract additional investment funds for these adaptations even though they can help to reduce the impacts of dams on wetland ecosystems.

Can wetlands provide realistic water storage alternatives?

There have been many scientific studies that demonstrate the key role of wetlands in the hydrological cycle and the resultant high economic values of wetlands as water infrastructure (Emerton & Bos 2004). However, the manner in which this role has been described has led to generalisations that suggest that all wetlands perform all functions and deliver the same services and values to the same degree.

Not all wetlands store water

In part, misunderstandings arise because the term "wetlands" (according to the Ramsar Convention) covers a wide range of habitat types from coral reefs to underground lakes and it has been mistakenly assumed that functions and services that exist in one wetland type occur equally in all types (see Bullock & Acreman 2003).

For example, it is widely quoted that "wetlands act like a sponge", soaking up water during rainfall (thus reducing flood risk) and releasing it slowly during dry periods (thus augmenting low flows). In some wetlands the soil water table level rises and falls seasonally; this is called the hydro-period (Mitsch & Gosselink 2007). Rises in water table signify uptake of water into storage; falls in the water table denote evacuation of water from storage.

It is true that wetlands can reduce floods if storage is available, for example when heavy rainfall coincides with a low water table level and water can be taken rapidly into storage. But in many headwater wetlands, soils are saturated for most of the time, which means that they have little available storage; indeed headwater wetlands are often termed 'contributing areas' by hydrologists because they tend to generate flood runoff, rapidly shedding water. But much also depends on the management of such wetlands, and actions such as reversing drainage and re-vegetating denuded areas can significantly reduce flood runoff.

Floodplains on the other hand often have large above-ground storage capacity, and there are many examples of floodplains significantly reducing flood risk downstream (Acreman *et al*. 2003). Wetlands with a large hydroperiod thus are able to store considerable water. Storage capacity also depends on soil type because saturated soils can contain anything from between 20% and 80% water.

It has long been recognised that vegetated wetlands, such as the Sudd (Hurst 1933), evaporate large volumes of water that can exceed evaporation rates from open water bodies such as reservoirs, because of the larger leaf area of wetland plants (Blaney & Muckel 1955). However, in some cases evaporated water is recycled locally through local weather systems. Evaporation from wetlands in the inner Niger delta is responsible for generating local rainfall that sustains grazing land in surrounding drylands (Taylor 2009). Similar analysis of the Sudd suggests that rainfall induced from evaporation is small in relation to the scale of the entire Nile catchment area (Mohamed *et al*. 2005), but it may be quite significant locally.

Yet for a storage option to be viable, storing a sufficient quantity of water is not enough: the water stored must also be of adequate quality. Some wetlands also perform important water quality functions. For example, the Nakivubo papyrus swamp in Uganda receives semi-treated sewage effluent and highly polluted storm water from Kampala (Kansiime & Nalubega 1999). During the passage of the effluent through the wetland, sewage is absorbed and the concentrations of pollutants are considerably reduced, such that water can be abstracted nearby for the public water supply. Ecosystem services vary significantly between wetlands: wetland ecosystems can be easily overloaded by pollutants, and their tolerance is often not known.

An alternative option for utilizing the storage capability of wetlands is to enhance natural storage by creating artificial wetlands to perform hydrological functions. For example, managed aquifer recharge is practised widely in India (CGWB 2005) where millions of small structures capture monsoonal rainfall on the surface and allow it to infiltrate into the often low storage capacity basement aquifers. In the Shiquma scheme, north of the Gaza Strip, a small dam has been constructed to create a reservoir which holds flood water. The water is then pumped to large depressions (infiltration basins) in the sand dunes near the coast where it percolates into the ground to recharge the dune aquifer. Tanks have been the main source of irrigation in many parts of India for

Water storage issues cross political and ecological boundaries

Economic development is increasingly seen as a river basin scale issue. For example, if Ethiopia develops consumptive uses, such as irrigation, it may have hydrological implications for Sudan and Egypt. Although hydropower is a non-consumptive use of water and may only change the timing of flows, this can have positive or negative effects: reducing wet season flows and increasing dry season flows as a result of hydropower operations may benefit irrigation in Sudan. Furthermore, storing water upstream where evaporation losses are lower makes more sense than storing it downstream. But whatever the infrastructural developments, the real issue is building trust between the riparian states in shared river basins. The Nile Basin Initiative supported by the World Bank is promoting sharing of benefits from water rather than sharing the water itself (Sadoff & Grey 2002).

Even if the water courses are not transboundary, the benefits may be – e.g., hydropower energy may be exported across national boundaries. Nepal has hydropower potential that exceeds internal demand, but large-scale hydropower projects, such as the 70 MW Middle Marsyangdi Hydro Project, are feasible in Nepal only when India is prepared to buy power at commercial rates and to share the benefits accrued (WECS 2002). In the Democratic Republic of Congo, two hydropower dams (Inga I and II) exist on the Congo River with a combined capacity of 1775 MW (IWPDC 2008). There now plans for new dams Inga III (4320 MW) and Grand Inga (40 GW), which will be the world's largest hydropower scheme, with transmission lines proposed to Egypt, Nigeria and Southern Africa. Energy security will depend on regional political stability.

centuries. These are low, earthen bunds constructed across a shallow valley, creating storage to hold the monsoon rainwater.

Wetlands can be managed in order to maximise water storage but this could compromise other ecosystem services, such agricultural production (Acreman *et al*. 2001) – presenting a trade-off in services. So incentive mechanisms such as payments from those who benefit need to be found (Smith *et al*. 2006).

Integrated planning with combined surface and groundwater management and use is likely to be the best strategy for coping with future rainfall variability (McCartney & Smakhtin 2010). For example, combinations of small and large reservoirs were particularly effective for providing water for irrigation in southern Sri Lanka (Keller *et al*. 2000).

The science underpinning the storage ability of wetlands needs to be reviewed and clear supportable conclusions defined that are honest about what each type of wetland can and cannot do in terms of providing viable water storage options. Convincing water managers, who often have an engineering background, is part of the challenge, so terminology is particularly important. Use of a term such as 'natural infrastructure' is likely to be more effective in achieving understanding than employing ecological language such as 'biodiversity', 'ecosystems', or 'ecosystem services'.

Who influences decisions on water storage?

River basin authorities are being created in many regions, either within national boundaries, such as the seven authorities established in Tanzania, or transboundary authorities, such as the Mekong River Commission. The concept of Integrated Water Resources Management and the development of river basin plans are being emphasized as key to achieving water-related Millennium Development Goals, an approach that is supported by the Global Water Partnership. River basin authorities are increasingly becoming focal points for decisions concerning water allocation and infrastructure development and management. In some parts of the world, economic integration or coordination bodies are playing significant roles in water management and water infrastructure, and are being reinforced by the donor community. The Common Market for Eastern and Southern Africa (COMESA), the Southern African Development Community (SADC), the United Nations Economic Commission for Africa (ECA), and the Economic Community of West African States (ECOWAS) are examples of bodies which function in this way, to varying degrees.

Funders of large infrastructure can also strongly influence decisions on water and water storage. In recent years there has been significant diversification of the institutional framework for funding large infrastructure.

- Multilateral banks have come back into development of dams after a 10-15 year lull following the World Commission on Dams report; however, although these banks often lead the study phase, they do not necessarily fund the actual investment. The World Bank is now only involved in 5% of dams in developing countries, and, though the Bank applies environmental safeguards policies, these can only be effective for dams which it supports.

- Bilateral funding agencies tend to avoid supporting dam development with the exception of Agence Francaise de Développement, which has expressed interest in funding dam development in central and west Africa.
- Export credit agencies can provide support if the World Bank safeguards are met.
- The role of the multilateral banks has increasingly been taken over by private or sovereign investment organizations, some of which have few, if any, conditionalities. Governments wanting to build dams are increasingly able to "shop around" among groups of potential funders/donors, or to put together their own internal financing packages without reference to others.

Who is funding dam development?

After the World Bank turned down a request for funding the Tucuruí Dam in Brazil, which plans to generate 8370 MW and provide navigation, funding was instead procured by Eletronorte and Brazilian institutions such as Eletrobrás, BNH, Banco do Brasil, Caixa Econômica Federal and FINAME (WCD 2000b). Of the 19 dams planned for the main stem of Mekong in Cambodia, Laos, Thailand and China, most are funded by provincial power companies and Chinese banks. Chinese financing is involved in 59 dams in Burma (though some are on hold or shelved) including the Tasang Dam (7100 MW) on the Salween River, costing $9 billion and funded by the China Power Investment Co (Burma Rivers Network 2008). The Gulf Funds and Islamic Development Bank have also emerged as key financiers of dams.

Responding to changing water storage issues: recommendations for the Ramsar Convention

Provide sound scientific justification for the water storage functions and capabilities of different wetland types

There is a need to:

- review the scientific basis for quantifying storage functions of different types of wetlands, and
- ensure there is a clear audit trail from policy-relevant statements back to scientific papers and reports.

This will enable Ramsar to build a strong case for the extent to which wetlands can provide water storage, regulate water flows, and provide existing water resources through their natural infrastructure, and for how this capability varies between wetland types and geographical locations. This needs to be taken into consideration in any future development of linked guidance on evaluating ecosystem services.

Define a clear Ramsar message on wetlands and water storage issues, and use the right language to ensure understanding

Ramsar should define a clear message on water storage issues and future trends as these affect wetlands, using language appropriate to the target audience. All sectors have their own language. The ecological community has developed a number of concepts, such as the ecosystem approach and ecosystem services, which are still being debated even within that community. If water engineers are the target audience for advocacy, it is better to use concepts such as "natural infrastructure" which they will understand better than "ecosystem services".

Likewise, although 'environmental flows' is becoming everyday language in the conservation community, it is a new and baffling concept to many outside that community. After many years (decades) of development and awareness building, environmental impact assessment, for all its faults, has become widely understood and accepted (however well or badly EIAs may eventually be done). River basin authorities operate through approaches such as IWRM or IRBM, and thus Ramsar guidance needs to be translated into the language used in these approaches.

Identify the most important target audiences for this message and develop focused strategies for communicating relevant wetlands information to these audiences

Priority target groups:

- Those involved, directly or indirectly, with global water policy processes, including the Global Water Partnership, World Water Council, FAO, UNEP, UNDP and WMO. Engaging with this group provides the opportunity to promote the role of wetlands in water issues at a high strategic level, particularly when addressing major issues of climate change adaptation and mitigation, food security, and responses to major events such as floods and droughts. Wetlands need to be incorporated into international policy statements, decisions, and action programmes on water and infrastructure, including briefings for government delegations to relevant international meetings. This is particularly important in implementing the *Changwon Declaration on wetlands and human well-being* (Ramsar Resolution X.3, 2008) which indicates action steps for how to deliver some of the world's most critical environmental sustainability goals.

- National government environmental departments and agencies, which are often politically weak and do not lead the key processes of planning and decision-making in relation to water storage, though they are often statutory consultees. The Ramsar Convention already provides guidance to support focal ministries in becoming involved in the water management and planning process.
- Subnational and international river basin authorities. Increasingly water and infrastructure planning, which is likely often to be transboundary, will be part of the activities of river basin authorities.
- Strategic planning institutions. In particular the wetland community needs to participate in planning for water storage in processes where storage options are being considered for strategic energy planning (hydropower and others), water supply planning (especially urban and agricultural), transport, and flood control. Additional guidance may be needed, such as on co-management.
- Energy sector institutions. Interaction should also be increased with organisations associated with the energy industry, such as the International Hydropower Association (IHA). The IHA is currently working with WWF to produce sustainability guidelines (IHA 2004) and an assessment protocol for hydropower dams (IHA 2006).
- Private sector institutions. The private sector, particularly banks and power companies, is becoming more influential and offers sources of funding for dams throughout the world. Private sector entities that are significant water users will generally have an interest in protecting their water supplies, for example in the beverage industry, and can influence both wetlands and water resources management.

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