



A state-of-the-art introduction for central governments in developed and developing countries, sub-sovereign national bodies, universities and research institutes, community organisations, banks and private investors, aid donors, multilateral financial institutions, UN agencies and other international organisations.

albaeco.



The Centre for Transdisciplinary Research, CTM
AT STOCKHOLM UNIVERSITY



RESILIENCE:

Going from Conventional to Adaptive
Freshwater Management for Human
and Ecosystem Compatibility

Note to the Reader:

Swedish Water House Policy Briefs explore key future-oriented – yet often inadequately explored or understood – water and related subjects. Each brief 1) outlines the specific issue/problem, 2) explains its relevance, 3) presents and explains new solutions and 4) offers conclusions which present policy recommendations, recommended approaches or lessons learned.

Description

This policy brief highlights the need for water management to incorporate complexity and uncertainty and introduces the concepts of “resilience” and “adaptive co-management.” It emphasises the need to go from conventional to ecosystem-oriented adaptive freshwater management.

This policy brief has been produced jointly by the Swedish Water House, The Centre for Transdisciplinary Research (CTM) at Stockholm University, Stockholm International Water Institute, IESC and Albaeco. It is based on the trans-disciplinary work of social and natural scientists in co-operation, for example: Ajaya Dixit, Malin Falkenmark, Carl Folke, Line Gordon, Marcus Moench, Per Olsson and Johan Rockström.

How to Cite: Moberg, F., Galaz, V. Resilience: Going from Conventional to Adaptive Freshwater Management for Human and Ecosystem Compatibility. Swedish Water House Policy Brief Nr. 3. SIWI, 2005.

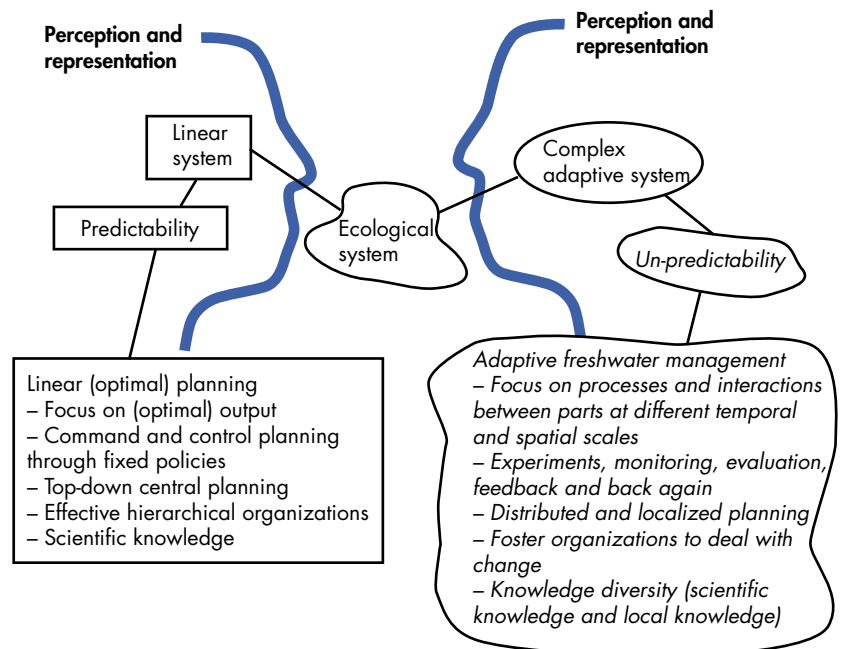
Visit www.swedishwaterhouse.se or www.siwi.org to download this or other titles



The World Changes Constantly; So Should Water and Ecosystem Management

Human well-being and development depend on ecosystem goods such as food, timber and medicines, and ecosystem services such as water and air purification, carbon storage, pollination, soil formation, and the provision of aesthetic and cultural benefits. Freshwater – the “bloodstream of the biosphere” – is crucial in this respect as it drives critical processes and functions in forests, woodlands, wetlands, grasslands, croplands and other terrestrial systems. This bloodstream of both society and nature is however becoming increasingly complex to manage. Why? Because human induced environmental changes, from the local to the global scale, have serious impacts on water flows and on ecosystems. The latter is particularly noteworthy because our earlier perceptions about the stability of ecosystems, and that change is possible to control, have proven false.

Today we know that freshwater systems are complex, adaptive but vulnerable systems. Aquatic ecosystems and their terrestrial siblings often do not respond to gradual change in a smooth way, rather a stressed ecosystem can suddenly shift from a seemingly steady state to an undesired state that is difficult to reverse. Until management



It's all in the mind: the standard perception of freshwater management leads to inflexible, and often ineffective, command-and-control approaches (left); accounting for ecological complexity opens avenues to adaptability which builds better resilience to, for example, flooding. Illustration by Henrik Ernstson.



institutions are capable and willing to embrace this uncertainty, and to systematically learn from their actions, integrated water resource management is likely to fail to deal with complexity and uncertainty in freshwater management. The challenge is to live with change without losing important structures and functions in life-supporting ecosystems and in societies. Both change and persistence is required.

Water: A Key Resource for Human Development

There is a growing need for a wiser, more adaptive approach to management of ecosystems and water flows. Water powers our industries, grows our crops, facilitates sanitation and drives our life-supporting ecosystems.

Despite immense technological progress and urbanisation, human society still depends on the capacity of ecosystems to

produce goods (like timber, crops and medicines) and services (like flood control, shoreline protection, pollination and water purification) which support and sustain social and economic development. Unfortunately, human influences on freshwater flows all over the planet are straining the support capacity of ecosystems and making them more vulnerable. The days of living with resilient (see Box 1), predictable and self-repairing ecosystems that “bounce back” from stresses and disturbances (such as storms, fires and pollution) are over. What’s more, population growth, increased food production, climate change, urbanisation and industrialisation have made water and ecosystem management even more complex.

The crucial challenge now is to improve our ability to actively co-manage water and water-dependent ecosystems so that both social and ecological resilience, and thus sustainable

Box 1:

What is Resilience?

Ecosystem resilience is the capacity of an ecosystem to cope with change and perturbation, such as storms, fire and pollution. Loss of resilience leads to more vulnerable systems, and possible ecosystem shifts to undesired states that provide fewer ecosystem goods (like fish and crops) and services (like flood control and water purification). Such loss of resilience can be caused by, for example, pollution, climate change, loss of biodiversity or altered freshwater flows. With decreased resilience, clear lakes can suddenly turn into murky, oxygen-depleted pools, grasslands into shrub-deserts, and coral reefs into algae-covered rubble. Resilience is the capacity of a system both to withstand pressures and to rebuild and renew itself if degraded.

Resilience as the “Immune System” of Ecosystems

Stressed, sleep-deprived and/or poorly nourished people are more susceptible to illness and recover more slowly afterwards. Likewise, studies of rangeland, forest and ocean ecosystems show that human-induced stress and overexploitation of species

reduce their resilience to storms, fires or other events which they coped with before. Just as a person might seem unaffected by his or her destructive lifestyle, an ecosystem with low resilience often seems unaffected until a disturbance causes it to exceed a critical threshold. When resilience is lowered, even minor disturbances can cause a shift to a state that is difficult, expensive or even impossible to reverse.

Social Resilience

Social resilience is a measure of a community’s ability to cope with change (for example in its environment) without losing its core functions as a community, including its economic and management possibilities. Human societies depend on ecosystems for survival but also continuously impact them from local to global scales. For such intertwined social-ecological systems (SES), resilience is the capacity to absorb, or even benefit from, perturbations and changes that affect them, and so to persist without a qualitative change in the system’s structure and function. Notably, social resilience differs fundamentally from ecosystem resilience by having the added capacity of humans to anticipate and plan for the future.

development, is achieved; for this, an adaptive approach to ecosystem and water flow (Box 3) management is needed. These issues should be a top priority for the international community if it wants to meet the UN's Millennium Development Goals to improve health, halve hunger and reduce poverty.

This policy brief shows that management of water and ecosystems is changing. It is becoming more integrated (cross-sectoral), flexible and expanding in its focus from human uses of freshwater as a technical issue to the role of freshwater for human development.

In particular, this policy brief illustrates how the concept of resilience can help this shift in perspective in water management. From management being focused on the aspiration to control change there is now a move towards a perspective that strives for sustaining and enhancing the capacity of both human and natural systems to cope with, adapt to, and shape change. This latter perspective is seen in this policy brief's featured case studies from both developed and developing countries.

“The traditional form of analysis with its linear and mechanistic thinking is becoming increasingly ineffective to address modern problems.”

Peter Senge, systems thinker and senior lecturer at the Massachusetts Institute of Technology

Key Recommendations

- Policy and decision makers should promote cross sectoral water management that shifts their focus only from human uses of freshwater as a technical issue to the role of freshwater in catchments for the generation of ecosystem and societal services.
- Policy and management should be based on a recognition that freshwater systems are complex and adaptive and hence seldom change in a smooth way, rather they might suddenly shift to both irreversible and less productive states.
- Freshwater management should allow for adaptation to environmental change and crises.
- Policies should provide incentives for stakeholder participation and incorporate their ecological knowledge into institutional structures in a multi-level governance system.
- Social networks with a wide scope of actors should be developed aiming to connect institutions and organisations across scales in order to build trust, facilitate information flows, identify knowledge gaps and create nodes of expertise for adaptive freshwater management.



Shifting from Conventional Management in a World

Humans and Ecosystems Share the Same Water

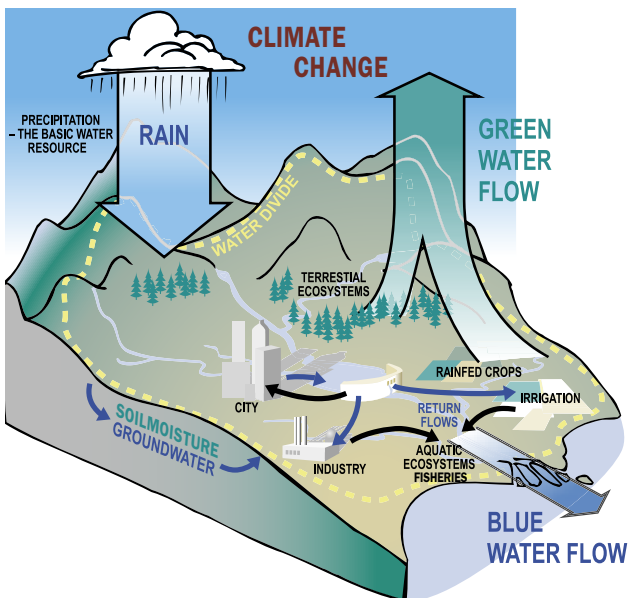
Water is a key resource for social, economic and cultural development. This is illustrated by the fact that most of the world's poorest countries are those where coping with water scarcity will be a key component in agricultural development. This situation is expected to sharpen in the near future, so that two out of three people will live under water-stressed conditions by the year 2025. When discussing this looming water crisis, people often focus on the amount of liquid water drawn from lakes, rivers or groundwater aquifers. However, the water cycle is not only affected by this increased demand for water. Changes in land-cover and climate also affect the amount of water available for drinking, irrigation and industrial uses, as well as recreation, waste disposal and maintenance of healthy ecosystems.

To better understand these changes, hydrologists introduced the concept of “green water,” the water flow that supports plant production in forests, grasslands, rain-fed croplands and wetlands and is responsible for much of the production of wealth in the world. An estimated 60% of the world's staple food production relies on this green water (“rain-fed irrigation”). In Sub-Saharan Africa, almost all food production depends on green water.

Remarkably, past international freshwater assessments of the global water crisis have largely neglected the “green” water flows supporting the generation of ecosystem services. There is indeed reason to be concerned over future “blue” liquid water use, but the largest proportion of production of food, biomass and ecosystem services originates from rain-fed land use.

As human activities and ecosystems depend on the same water, trade-offs are inevitable. For example, upstream consumption patterns and pollution loads affect aquatic ecosystems and people downstream. Balancing is also needed between different sectors, such as city supply and irrigation.

to Adaptive Ecosystem-oriented Freshwater Where Trade-offs Are Necessary



Water resources have to be used to increase social and economic welfare but without compromising the resilience of vital ecosystems. The reality of the big picture is that in a drainage basin perspective, the rainfall over an area is the water resource. Part of the water is consumed in terrestrial ecosystems by vegetation and evaporation from moist surfaces (green water flow), while the surplus recharges aquifers and rivers (blue water) becoming available for societal use and aquatic ecosystems. Naturally, the green-blue balance is determined by the local hydroclimate, but also by soil, land cover and land use. The challenge is to co-manage freshwater and the terrestrial and aquatic ecosystems with which it interacts in order to balance humans and nature.

Box 2:

The Danger of Conventional “Command-and-Control” Management

In *The Odyssey*, the old and wise Greek god of the sea Proteus can change his shape at will and so resist being caught. He combines a capacity to change with inner wisdom and persistence. Psychologists have often used the character of Proteus to illustrate how modern humans can adapt to a constantly changing world.

Similarly, sustainable development – i.e. not undermining the resource base – requires both change and persistence. It is about maintaining important structures in life-supporting ecosystems and societies while responding to and shaping change. Unfortunately, there is a tendency to do the opposite. Western resource management has tended to seek to control nature and subdue changes or uncertainties in order to create “efficient” systems in fisheries, forestry and agriculture. However, there are risks with such “command-and-control” management. When small disturbances such as floods, pests and diseases are prevented by human interventions like dams, pesticides and antibiotics, the risk of average size disturbances diminishes, but the vulnerability to more severe disturbances increases. Eventually, this can cause much larger impacts on water resources and biological diversity over broader scales, with severe consequences to human welfare.



Adaptive Freshwater Management: A Continuous Learning-by-Doing Process

Movement of freshwater in the landscape, water availability in soils, moisture recycling from forests and recharging of groundwater are fundamental for both terrestrial and aquatic ecosystems resilience. Most ecosystems develop around freshwater flows in a process that generates natural resources and ecosystem services in a complex, ever-changing and unpredictable manner. The realisation that this inherent change and uncertainty in nature exists calls for more flexible governance with the ability to respond to environmental feedbacks. That is, we must learn to live with change through an active, adaptive management approach that is diversified and open for renewal (see Box 3).

“Conventional resource management has tended to want too much control over nature.”

Adaptive Co-management: Learning-by-Doing to Meet Environmental Uncertainty

Seeing the natural world as a moving target implies that it is critical that institutional and organisational structures allow for experimentation with different strategies for water and ecosystem

Box 3:

Adaptive Co-management

Adaptive co-management is an approach based on collaboration among agencies, researchers and local stewards. Management of ecosystems and water is regarded as controlled experiments, with the consequent need for monitoring, evaluation and constant improvement. It requires horizontal (local) as well as vertical (regional to global) collaboration. Hence adaptive management allows managers to take action in the face of global change, to enhance and complement scientific knowledge in order to reduce uncertainties, and to craft policies that respond to, and even take advantage of unanticipated events.

management. Along this line many scientists have started to emphasise so-called adaptive co-management. This is a system of flexible management whereby researchers, managers and local resource users collaborate at the local, regional, national and international levels. Too often we assign authority according to political borders that rivers and forests do not follow.

Moreover, conventional resource management has tended to want too much control over nature (see Box 2). For example, we fertilise, irrigate and spray pesticides to suppress natural disturbances and ensure consistent harvests, even though this entails negative side effects like polluted rivers and nutrient pollution in the coastal zone. Advocates of adaptive co-management, on the other hand, stress that human organisations must mirror the scale and variability of the ecosystems or natural resources in question.

Adaptive co-management sees resource management as a continuous learning-by-doing process that recognises public participation and collaborative learning. Ecosystem resilience is important in this context as it provides ecosystems with a buffer against failed management actions. It allows managers to learn and to actively adapt their policies and so avert from unsustainable and undesirable development paths. Hence, adaptive co-management can provide social structures that better monitor, detect and respond to signals of environmental change.

“The challenge is to live with change without losing important structures and functions in life-supporting ecosystems and societies.”

Similar approaches have been proposed in order to provide social resilience through so-called “polycentric governance.” This is a system of flexible decision-making shared by many different democratic sub-units, from national governments to local villages, seeking a balance between local and central governance. Sub-units are allowed to experiment with different kinds of rules and can learn from the experiences of parallel units. This makes governance less rigid and less vulnerable, since the failure of one or more units can be compensated by the success of other units in an area.

Box 4:

An Adaptive Approach is Nothing New

One well analysed example is Lake Mendota in Wisconsin, USA. This was originally a pristine, clear water lake which has undergone a long, slow slide that reduced the lake’s resilience and made it undesirably turbid. Management efforts to regain the more clear water state have involved a long journey of five sequential steps, each one responding to unexpected changes occurring in the lake:

1. Settlement in the lake catchment from the 1840s onward altered the nutrient inflow to the lake through sewage and plowing of the rich prairie soils. As agriculture and urbanisation intensified the nutrient stress increased and the lake water quality collapsed after World War 2.
2. A public debate led to a diversion of sewage effluents from the lake beginning in 1971. Minor water quality improvements from the reduced input of phosphorus were noted. Increased use of fertilisers and a sprawling urbanisation, however, led to invasion of an exotic aquatic plant – a highly visible nuisance to the people living near the lake. An explosion of a plankton-eating fish in 1978 altered the entire lake food web, reduced water quality even more and led to an institutional response.
3. The authorities tried to tackle the diffuse pollution coming from agricultural fertilisers by working with the farmers. Farmers were, however, never motivated enough to participate on a broad enough scale. Therefore only small reductions of the diffuse nutrient input were achieved, and there was an institutional recognition that a different approach was needed.
4. In the 1980s, so-called biomanipulation was tested. A large number of predator fishes were introduced in order to reduce the numbers of smaller plankton-eating fish, allowing potent grazing plankton to flourish and thus reduce the concentrations of algae in the water. This was initially successful, but an unexpected intensification of fishing pressure severely reduced the number of introduced fishes. Finally, heavy summer rains in 1993 brought the largest phosphorus inputs ever to the lake, once again calling for an institutional response.
5. An aggressive plan was initiated in 1998 aiming at halving the diffuse pollution problem. A number of measures were introduced: cost-sharing incentives for farmer participation, erosion control of construction sites, and purchasing of wetlands for restoration. An unexplained decline of phosphorus in the soils surrounding the lake turned out to be helpful by contributing to an increase in the resilience of the clear state. Even so, the aim has not yet been achieved as the lake has yet to return to a clear water state.



Development of Adaptive Co-management

Catchment-based freshwater management has gained momentum in recent years. A catchment is an area of land from which water eventually flows into one common river or major body of water. This change in management is reflected in, for example, the decision to divide the landscape into catchments within the European Union's Water Framework Directive, and there have been several similar developments around the world. It is also reflected in the Global Environment Facility's effort to move towards "land/water integration in a catchment-based ecosystem approach."

There is also growing realisation that such catchment management cannot only be based on natural scientists' knowledge and understanding. Also the social dimensions have to be taken into consideration to understand which features contribute to the resilience of social-ecological systems. In this context, flexible social networks and organisations that proceed through learning-by-doing seem better adapted for long-term survival than rigid social systems with fixed prescriptions for resource use.

“Flexible social networks and organisations that proceed through learning-by-doing seem better adapted for long-term survival than rigid social systems.”

Social Networks and Collaborative Learning

One such social-ecological management system is the wetland landscape in Kristianstad, Sweden (See Box 5). These unique wetlands and their surrounding agricultural landscape generate a variety of essential ecosystem services for the region, including flood control and maintenance of species diversity, as well as cultural, recreational and educational services.

Here, adaptive resource management emerged through local initiatives as a response to ecosystem changes and uncoordinated management efforts that threatened the cultural and natural values of the lower parts of a river catchment. Today, management is based on collaborative processes including in-

ternational organisations, national, regional and local authorities, non-profit associations and farmers as well as other land-owners. Remarkably, a single key leader, or "steward," played a crucial role in this process by developing a social network built on trust and dialogue. The term "Kristianstads Vattenrike" (the rich wetlands of Kristianstad) was also coined, and an "Ecomuseum Kristianstads Vattenrike" (EKV) was developed to serve as a bridge between local actors and governmental bodies. EKV functions as an umbrella association, and has demonstrated a remarkable ability to respond to environmental feedback and to develop new knowledge and understanding necessary for adaptive co-management. Examples include: managing floods, dealing with the crop damage problem caused by increasing numbers of cranes and geese, protecting and restoring tributaries of the major river in the area, and the creation of social structures and processes to secure the continued cultivation of the flooded meadows.

Box 5:

How Adaptive Co-management Developed in Kristianstad

1. Scope of management widened from a particular issue (floods) to a broad set of issues related to freshwater flows and ecological processes across scales
2. Management expanded from individual actors to groups of actors
3. Organisational and institutional structures evolved as a response to deal with the broader set of water and ecosystem issues
4. Knowledge of ecosystem dynamics developed as a collaborative effort and became part of the organisational and institutional structures
5. Social networks developed to connect institutions and organisations and facilitate information flows, identify knowledge gaps, and create nodes of expertise of significance for adaptive co-management within the catchment
6. The social network mobilised knowledge for management, which complemented and refined local practice and improved the capacity to deal with future uncertainties and surprises

Adapting to Floods, Droughts and Climate Change in South Asia

Floods and droughts are the most common natural disturbances affecting human development in South Asia. In recent years their effect has been greatly exacerbated by human-induced changes of water flows and ecosystems as well as migration to vulnerable areas. In 2002, flooding cost the world economy an estimated USD 27.3 billion. Moreover, the UN climate advisory body (IPCC) has warned that global environmental change will entail increasing climate variability and increased occurrence of extreme weather events. Wet areas are likely to become wetter, with more frequent flooding, whilst dry areas may become drier, with longer periods of drought. This, in combination with the resulting uncertainty in fisheries, forestry and agriculture, means that rigid governance systems with prescriptions for resource use will most likely become outdated. Instead, new development strategies are needed that minimise the undesirable effects of climate change and enhance the resilience of vulnerable social and ecological systems.

Understanding Adaptive Strategies of Households

There is a growing interest in understanding the factors that enable communities to adapt to floods, droughts and climatic variability. In particular, the adaptive strategies that households use during floods and droughts have attracted increasing interest. Studies conducted in drought- and flood-affected regions of India and Nepal have identified at least eight factors that influence vulnerability and adaptive capacity to flood and drought events (see Box 6).

What is noteworthy is that the poor and landless are not automatically the most vulnerable, contrary to what most disaster relief efforts have assumed. Rather, the ability to adapt to floods and droughts often depends on specific livelihood characteristics and whether the local systems can connect to regional and global levels. It does not seem to matter whether the extreme event is a sudden onset of conflict or economic collapse or a more gradual process of environmental degradation or economic change – livelihood systems must respond at multiple levels from the individual household to the international level in order to remain viable.

The flexible approaches of rural households in South Asia (described in Box 6) hold lessons for resource managers everywhere who are working in an increasingly unpredictable environment due to global environmental change. Rather than attempting to fundamentally reduce or eliminate inherent change and variability, their approach is to work with them in order to maintain resilience of societies and their life-supporting ecosystems.





“The ability to diversify is critical to minimise the vulnerability of rural agricultural livelihood systems.”

Box 6:

Factors that Influence Vulnerability and Adaptive Capacity to Flood and Drought Events in South Asia

1. The extent to which people diversify their income strategies and incorporate non-farm components, which tend to be less vulnerable to floods and drought.
2. The ability of people to migrate or commute in order to obtain sources of income outside drought- and flood-affected areas (this is not to say that all migration is good or desirable as displacement due to disaster often leads to impoverishment).
3. The ability of information, goods and services to flow into and out of affected areas.
4. The social capital that households have access to, including education, self-help groups, government departments and banks, NGOs, the media and social networks.
5. The existing patterns of vulnerability created by gender, income and social position.
6. The degree to which infrastructure (roads, houses, water supply systems) is vulnerable to floods and droughts, as well as the extent to which infrastructure promotes the maintenance of livelihoods during extreme events (e.g. by serving as a point of refuge or facilitating the movement of goods, services and people).
7. The ability of affected households to obtain secure sources of water, from local or trans-boundary sources, water markets or rural supply schemes.
8. Environmental conditions such as loss of natural wetlands, degradation of vegetation along riverbanks and increased presence of roads or flood control embankments, often interfere with natural drainage and pave the way for flooding.

Strengthened Resilience to Cope with the Challenge to Balance Water for Humans and Water for Nature

This policy brief has highlighted the need for water management to take complexity and uncertainty seriously and has introduced the concepts of “resilience” and “adaptive co-management.” It has also emphasised the ongoing shift from conventional to adaptive freshwater management that enhances the resilience of both social and ecological systems.

In the coming two to three decades the world will have to feed another 2–3 billion people. This requires enormous amounts of water as more than 3,200 litres per capita and day are needed to produce food for an acceptable nutrition level. This is 70 times more than the 50 litres per day needed by the average household in a developing country for its domestic needs. Clearly, the challenge is to balance water for food and water for nature.

“Ecosystems must be included in water rhetoric and practice to reach sustainable development and poverty alleviation goals.”

Hence, ecosystems must be included in water rhetoric and practice – and water included in ecosystem rhetoric and practice – to reach the sustainable development and poverty alle-

viation goals that the international community is heavily investing in.

The overall challenge is to actively strengthen the resilience of ecosystems and local communities – i.e. their capacity to cope with disturbances and global environmental change – and explicitly recognise the role of freshwater in this context. The key recommendations from this brief are thus:

- Policy and decision makers should promote cross sectoral water management that shifts their focus from human uses of freshwater as a technical issue to the role of freshwater in catchments for the generation of ecosystem and societal services.
- Policy and management should be based on a recognition that freshwater systems are complex and adaptive and hence seldom change in a smooth way, rather they might suddenly shift to both irreversible and less productive states.
- Freshwater management should allow for adaptation to environmental change and crises.
- Policies should provide incentives for stakeholder participation and incorporate their ecological knowledge into institutional structures in a multi-level governance system.
- Social networks with a wide scope of actors should be developed aiming to connect institutions and organisations across scales in order to build trust, facilitate information flows, identify knowledge gaps and create nodes of expertise for adaptive freshwater management.

References

- Berkes, F., J. Colding, and C. Folke. 2003. *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.
- Carpenter, C., B. Walker, J.M. Anderies, and N. Abel. 2001. “From Metaphor to Measurement: Resilience of What to What?” *Ecosystems*. Pages 765–781, Springer Verlag.
- Folke, C. 2003. “Freshwater for Resilience: A Shift in Thinking.” *Phil. Trans. R. Soc. Lond. B* (2003) 358, 2027–2036.
- Falkenmark, M. 2003. *Water Management and Ecosystems: Living with Change*. TEC Background Paper No. 9, Global Water Partnership.
- Falkenmark, M. and J. Rockström. 2004. *Balancing Water for Humans and Nature: The New Approach in Ecohydrology*. Earthscan, UK.
- Folke, C., J. Colding and F. Berkes. 2003. “Synthesis: Building Resilience and Adaptive Capacity in Social-ecological Systems.” Pages 352–387 in F. Berkes, J. Colding and C. Folke editors. *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.
- Moench, M. and A. Dixit. 2004. “Adaptive Capacity and Livelihood Resilience – Adaptive Strategies for Responding to Floods and Droughts in South Asia”. Institute for Social and Environmental Transition. Pages 11–19.
- Olsson, P., C. Folke, and T. Hahn. 2004. “Social-ecological Transformation for Ecosystem management: The Development of Adaptive Co-management of a Wetland Landscape in Southern Sweden.” *Ecology and Society* 9(4): 2. [online]
URL: <http://www.ecologyandsociety.org/vol9/iss4/art2>
- Forthcoming**
- Galaz, V. 2005. Does the EU Water Framework Directive Build Resilience? Harnessing Complexity and Uncertainty in European Freshwater Management. Policy Paper I, The Resilience and Freshwater Initiative, Swedish Water House.
- Moench, M. 2005. *Water, Climatic Variability and Livelihood Resilience: Concepts, Field Insights and Policy Implications*. Policy Paper II, The Resilience and Freshwater Initiative, Swedish Water House.

10 Key Points

- Humans shape freshwater flows and ecosystem dynamics all over the planet. The challenge in this new situation is to actively enhance and strengthen the resilience (the capacity to cope with change and perturbations) of both ecosystems and human societies, and to explicitly incorporate the role of freshwater in this process.
- Recognising the importance of resilient ecosystems for secure water supplies, and the importance of secure water supplies for resilient ecosystems must be included in water rhetoric and practice in order to reach the international community's sustainable development and poverty alleviation goals.
- Global environmental change will entail increasing environmental variability and increased occurrence of extreme weather events leading to droughts and floods. This poses a fundamental challenge to present freshwater management and institutions.
- The days of living with resilient, predictable and self-repairing ecosystems that "bounce back" from stresses and disturbances are over.
- An ecosystem with low resilience often seems unaffected by human-induced stress and environmental change until a disturbance causes it to exceed a critical threshold. Such a shift to a less productive state tend to be difficult, expensive or even impossible to reverse.
- The resilience concept shifts our perspective from an aspiration to control change to one that sustains and enhances the capacity to cope with, adapt to, and shape change. Our ability to actively manage freshwater for ecosystem services (the benefits humans derive from ecosystems) and social and ecological resilience is crucial for sustainable development.
- Until freshwater management institutions are willing to embrace uncertainty, and to systematically learn from their actions, integrated water resource management is likely to fail to deal with complexity and uncertainty.
- Adaptive management is an approach that allows managers to take action in the face of global change, to enhance and complement scientific knowledge and thereby reduce uncertainties, and to craft policies that respond to, and even take advantage of unanticipated events.
- Flexible social networks and organisations that proceed through learning-by-doing seem better adapted for long-term survival than rigid social systems with set prescriptions for resource use.
- Water management cannot be based on natural scientists' knowledge and understanding alone. The social, economic and managerial dimensions have to be understood and accounted for in order to strengthen the resilience of intertwined human and ecological systems.



The Swedish Water House

The Swedish Water House is an initiative that stimulates co-operation and networking among Swedish-based, internationally oriented academic

institutions, consultants, government agencies, NGOs, research institutes and other stakeholders. SVWH is funded by the Ministry for Foreign Affairs and the Ministry of Sustainable Development and administered by the Stockholm International Water Institute (SIWI). www.swedishwaterhouse.se



The Stockholm International Water Institute

The Stockholm International Water Institute (SIWI) is a policy institute that contributes to international efforts to

find solutions to the world's escalating water crisis. SIWI advocates future-oriented, knowledge-integrated water views in decision making, nationally and internationally, that lead to sustainable use of the world's water resources and sustainable development of societies. www.siw.org



Albaeco

Albaeco is an independent non-profit making organisation founded by researchers in Natural Resource Management at Stockholm University together with representatives

from advertising, media and business economics. Albaeco works in collaboration with the Centre for Transdisciplinary Environmental Research (CTM), based at Stockholm University and have thereby access to an extensive network of international researchers from both the natural and social sciences. www.albaeco.com

The Swedish Water House is administered by SIWI.



STOCKHOLM INTERNATIONAL WATER INSTITUTE, SIWI

HANTVERKARGATAN 5, SE-112 21 STOCKHOLM, SWEDEN • PHONE +46 8 522 139 60
FAX +46 8 522 139 61 • siwi@siwi.org • www.siw.org