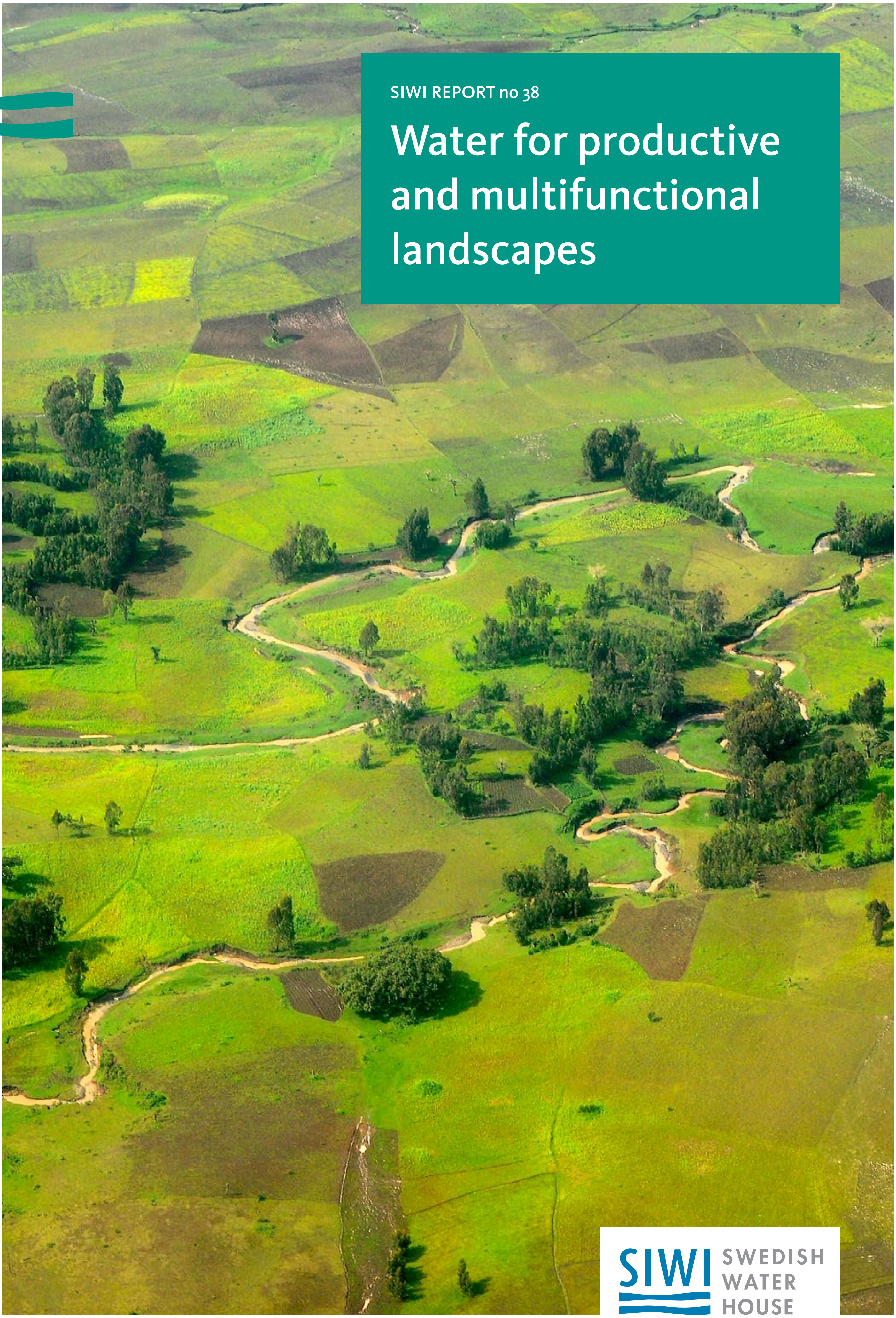
SIWI REPORT no 38

Water for productive and multifunctional landscapes



SIWI SWEDISH WATER HOUSE

ISBN: 78-91-88495-13-6

How to cite: Tengberg, A., Bargues-Tobella, A.B., Barron, J., Ilstedt, U., Jaramillo, F., Johansson, K., Lannér, J., Petzén, M., Robinson, T., Samuelson, L., Östberg, K. 2018. Water for productive and multifunctional landscapes.
Report no. 38. SIWI, Stockholm

Cover photo: iStock
Editor: Anna Tengberg
Language editing: Nick Chipperfield
Design: Johannes Ernstberger

Printing by Molind, Stockholm, Sweden. The printing process has been certified according to the Nordic Swan label for environmental quality.

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Content

Summary

The SIWI SWH Cluster Group on Water in the Landscape has examined how hydrology affects the productivity of landscapes, and what hydrological aspects need to be considered when restoring landscapes for sustainable production. Through numerous examples, the Group analysed the governance arrangements and management approaches, practices and technologies that would enable long-term sustainable management of landscapes. For the benefit of livelihoods, the environment and the climate, we recommend that sustainable management and, when necessary, restoration, of productive landscapes consider the following factors in a flexible and adaptive manner: (i) improved integration of water considerations and understanding of hydrological processes in landscapes, as addressing water management is often a key entry point to restore degraded lands and to enhance landscape resilience for the benefit of local people; (ii) continuously support the development of new integrated knowledge of evidence-based management and strengthening of capacity; (iii) strengthened multi-level governance arrangements that allow for genuine stakeholder participation in landscape management and decision making; (iv) identification and use of best management practices and innovative tools that provide practical on-the-ground solutions for sustainable management and monitoring of water in the landscape; and (v) adequate and long-term financing from both the public and private sectors to sustain ecosystem services important for the long-term productivity and sustainability of landscapes. Operationalising existing national and intergovernmental governance frameworks and policies, in Sweden and internationally, coupled with application of the latest scientific and technical knowledge and co-production of knowledge with local stakeholders would provide a good starting point for sustainable management of water in the landscape, leading to productive and multifunctional landscapes that contribute to the Sustainable Development Goals (SDGs).

Chapter 1

Water and hydrology for productive landscapes

The world's population is growing rapidly, and living standards are improving. These positive developments have a drawback: they also increase competition for water. The demand for water is growing for increased food production, manufacturing and energy production. Climate change intensifies these water challenges through changed precipitation patterns, resulting in too much or too little water, or water of poor quality. Productive, multifunctional landscapes – where a mix of trees, forests and agricultural lands support the livelihoods of people, produce raw materials, strengthen biodiversity and maintain the water cycle are a prerequisite for sustainable development. Restoring degraded landscapes is therefore becoming increasingly important. It is against this background that the Swedish Water House (SWH) has initiated a new multi-stakeholder platform – the cluster group on "Water in the Landscape".

SWH's preceding cluster group "Water and Forest" concluded that productive landscapes form the basis for meeting people's needs for water, food and raw materials, as well as conserving biodiversity and reducing negative impacts of climate change. Restoring the millions of hectares of degraded forest landscapes in the world to productive, mosaic and multifunctional landscapes would contribute to many of the Sustainable Development Goals (SDGs), not least SDG 6 on Clean Water and Sanitation, with strong links to SDG 15 on Life on Land. The cluster group "Water in the Landscape" have used these conclusions as a starting point, focusing especially on the fundamental role of water for landscape productivity. The purpose of the work has been to strengthen Swedish actors' understanding and competence in integrating hydrological aspects in landscape initiatives and approaches, so that Sweden can contribute more effectively to meeting the objectives of its Global Development Policy (PGU), Agenda 2030 and international restoration initiatives.

Swedish scientific and practical knowledge of hydrology and water-related ecosystem services, as well as restoration to productive multifunctional landscapes, could be better highlighted in Sweden's PGU and Agenda 2030 Strategy. In this way, Sweden could also contribute more to global restoration initiatives such as the Bonn Challenge, the New York Declaration of Forests and the Governors' Climate and Forests Taskforce.

Thematic workplan for the cluster group 2017/2018

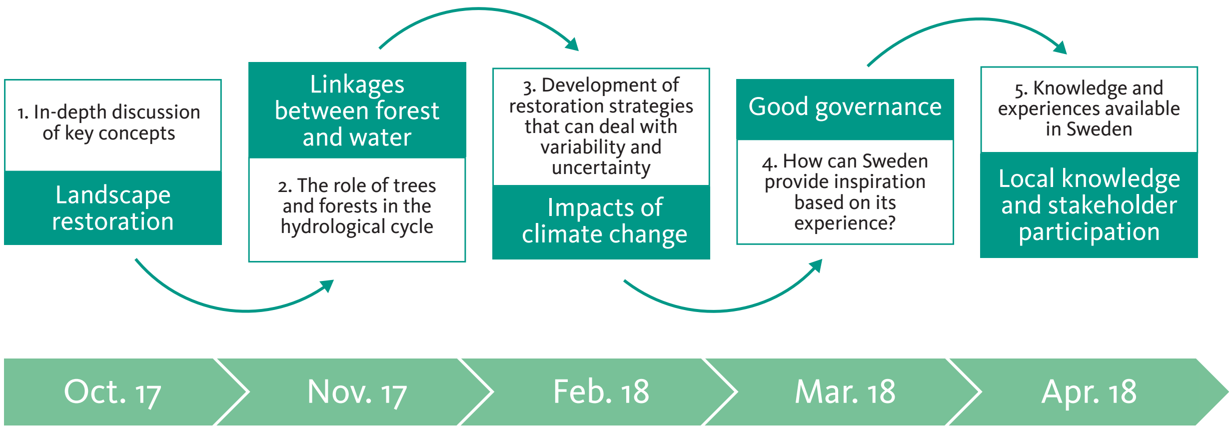

Figure 1 Thematic workplan for the cluster group 2017-2018.

SIWI SWH therefore took the initiative to bring together Swedish expertise and stakeholders in Swedish and global/international landscape management and restoration. The objective has been to identify key knowledge and experiences on sustainable water resources management in landscapes, which could be shared with a larger audience both nationally and internationally. The "Water in the Landscape" cluster group became active in the second half of 2017. During this period, and the first half of 2018, a number of thematic cluster group meetings (learning and discussion opportunities) were organised on various aspects of hydrology important for the productivity of the landscape and opportunities for landscape restoration. Representatives from forest, agriculture, environment, water and industry sectors have participated, as did civil society, scientific institutions and competent authorities, mainly from Sweden but also from the international organisations (Box 2). Inputs and recommendations from the seminars form the basis of this report. However, the report is the responsibility of the core group alone (see end of this chapter). This group have planned the meetings, invited speakers and hold the authorship of this report.

Box 1: Definitions of the landscape approach

Photo: Tobias Robinson

There are many different definitions of the landscape approach and integrated landscape management and over the past decade a large number of frameworks and terms have developed. Scherr et al. (2013) list 80 different terms that sometimes or always refer to integrated landscape management. In this report we are using the 10 principles for a landscape approach adopted by the Convention on Biological Diversity (CBD) to reconciling agriculture, conservation, and other competing land uses. The principles are further elaborated by Sayer et al. (2013):

1. Continual learning and adaptive management
2. Common concern entry point
3. Multiple scales
4. Multifunctionality
5. Multiple stakeholders
6. Negotiated and transparent change logic
7. Clarification of rights and responsibilities
8. Participatory and user-friendly monitoring
9. Resilience
10. Strengthened stakeholder capacity

Furthermore, the conclusions from the previous cluster group on Water and Forest (Eriksson et al., 2018) were published in a special issue of Environmental Management entitled "From Synergy to Complexity: The Trend Toward Integrated Value Chain and Landscape Governance". Relevant conclusions related to landscape governance include (Ros-Tonen et al., 2018):

- Actors can only be mobilised around a commonly felt problem and sense of urgency and landscape approaches are therefore necessarily context specific;
- dealing with multiple objectives, trade-offs as well as power imbalances and conflicting interests, implies a key role for multi-stakeholder platforms;
- it is important with locally embedded entry points for implementation of landscape approaches;
- it is necessary to accommodate multiple centres of decision making in fluid, polycentric governance arrangements;
- finally, the need to deal with diversity and dynamics suggest an element of "muddling through".

This report builds on these conclusions and further explores some of the key principles and emerging issues related to the landscape approach with a focus on integrating water management aspects.

The overall scope has been twofold:

1. How does hydrology affect the productivity of landscapes, and what hydrological aspects need to be considered when rehabilitating/restoring a landscape for sustainable production of nutritious food and other natural resources that contribute to sustainable growth locally, regionally and globally?
2. Which governance arrangements and management approaches enable and support the productivity of the landscape, minimize the risk of over-exploitation of water, and enables agreements between different stakeholders?

The more specific workplan is illustrated in Figure 1.

This report highlights the urgent need for landscape restoration from the local to global scale and the importance of careful consideration of water resources, water recharge and water management when managing natural resources available in the landscape. It draws on Swedish and international landscape management and governance experiences. Our ambition with this report is to:

1. inspire Swedish stakeholders to engage increasingly in international water and landscape dialogues and processes; and
2. initiate bilateral and multilateral activities to build resilient landscapes, with resulting benefits for water resources and productive landscapes.

Reports and presentations from seminars and workshops, as well as this synthesis report, are posted at the cluster group website:
www.swedishwaterhouse.se/water-landscape

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- Markus Petzén: DHI Group
- Tobias Robinson: Ecoloop
- Fernando Jaramillo: Department of Physical Geography and Bolin Centre for Climate Research, Stockholm University (SU) / Stockholm Resilience Centre, SU

Box 2: Participating institutions in seminars and workshops organized by the Cluster Group

- Alliance for Global Water Adaptation (AGWA)
- County Board of Västra Götaland
- DHI Group
- Ecoloop
- Federation of Swedish Farmers (LRF)
- Food and Agricultural Organization of the United Nations (FAO)
- Forest, climate and livelihood research network (Focali)
- Hermanssons & Co
- ICA
- ICRAF – World Agroforestry Centre
- Swedish Environmental Research Institute (IVL)
- Lund University Centre for Sustainability Studies (LUCSUS)
- NIRAS
- SSC Forestry
- Stockholm Resilience Centre (SRC)
- Stockholm International Water Institute (SIWI)
- Sveaskog AB
- Swedish Environment Protection Agency (SEPA)
- Swedish Forestry Agency (SFA)
- Swedish International Agricultural Network Initiative (SIANI)
- Swedish International Development Agency (Sida)
- Swedish Meteorological and Hydrological Institute (SMHI)
- Swedish University of Agricultural Sciences (SLU)
- World Wide Fund for Nature (WWF)

Chapter 2

Landscape restoration and water flows

Water flows and storage are intrinsically connected to both challenges and benefits in landscapes for people, economies and environment. By changing landscapes through development and altered land use, the water flows and its benefits are altered too. By changing water flows and storage, landscapes and the benefits we can obtain from them are affected. These interactions are particularly challenging when landscapes and their water resources are in a degraded state as people, society, landscape and water resources form a complex system. Hence, addressing water management is often a key entry point to restore degraded lands and to enhance landscape resilience for the benefit of local people.

In this chapter, we will show some global and local rapid drivers of change in water use, how it affects our landscapes, and how in turn, changes in land use affect local and global water flows. The section concentrates on the principal land use types for human use, such as forest and agricultural landscapes, under degradation.

The water flow challenges in landscapes

Global water flow impacts of land use changes | At global level, two key mega-processes are changing water use and water availability: changing diets and population growth. Both these global processes of change put landscapes and their water resources under growing pressure to retain healthy and productive capacity in terms of ecosystem services and benefits for society. Until recently, projections of future changes to the global freshwater system have mostly considered atmospheric climate variability - mostly changes in temperature (energy) and precipitation (water) - as the main driver. However, there is now more evidence suggesting that changes occurring on the surface may also transform the freshwater system, especially since human activities have now transformed the Earth's surface by using both water and land worldwide. As such, it is necessary to account for this human driving effect for realistic analysis of future changes to water resources.

Biogeophysical properties related to vegetation on land control evapotranspiration, one of the largest fluxes of water. This means that vegetation changes may alter these intensive and extensive properties. Evapotranspiration can change magnitude and direction depending on original and resulting vegetation cover after land transformation. For instance, a combination of rainfed agriculture, forest management and flow regulation in Sweden have increased evapotranspiration and consequently decreased runoff into the Baltic Sea. Even at the global scale, human activities have already left its footprint on the freshwater system. Flow regulation has decreased the intra-annual variability of runoff due to the impoundment of water for hydropower production, homogenizing runoff at the annual scale. The wide-scale effect of irrigation and flow regulation appear also to be related to the increase in relative evapotranspiration observed in the largest 100 basins during the past 100 years.

Changes in population and people's choice of food will alter water need in landscapes | Food security for all is one of the global Sustainable Development Goals (SDG 2) proposed by the UN and an important factor in landscape and water resource health. Water is fundamental to food production systems and an estimated 30 per cent of freshwater from streams, lakes, reservoirs and groundwater is often used for irrigation to produce 40 per cent of the world's food. In addition, 60 per cent of our food is derived from rainfed crop and pasture land. Population growth is estimated to increase food demand by 50 per cent by 2050, whilst it is recognized that the area used for agriculture, as well as water withdrawals, is already reaching the desired limit for sustainable use at a global level. Food availability is insecure for roughly one billion people, or nearly 1/8 of the global population. Although food availability on the global scale is a gargantuan challenge it is not the only one. Part of the challenge is also to provide better food, and more timely food to an increasingly larger share of a population changing diets. There is a growing demand for meat, dairy, and eggs, as wells as for fruit and vegetables. These foods typically require additional freshwater for their production. Consumption of more "water productive" types of calories and energy in foods such as cereals, roots and tubers, beans and peas are expected to drop. Therefore, in terms of water use for diets, there is a challenge in total demand for water due to population growth, as well as an increase in water use for more water intensive crops and livestock produce.

Climate change will alter water availability | This will affect the capacity for healthy and productive landscapes to provide food, fodder, wood and fibers. The climate is changing in several ways. For example, in most parts of the world, seasonal temperatures are increasing, with more heatwaves, affecting crop water demand. In parts of Africa, there are a growing number of examples suggesting both increasing and decreasing rainfall in many places, and also changes in seasonal length. There is a scientific consensus that expected (and confirmed) temperature increases and changes in temperature patterns may already be showing in some landscapes. At many locations, especially in the tropics and semi-arid areas, this may result in lowered yields due to heat stress and may also require more water for irrigation. The impact of climate change on hydrology at the landscape level is still uncertain and highly unpredictable. In most cases, however, this may already be the new reality; more extreme events, and greater occurrence of drier and wetter conditions. This can impact on multiple landscape features such as erosion, vegetation establishment and water availability (notably scarcity) for many people, with decreased food security as a result.

Multiple factors combined can cause big shifts in landscape production capacity | Water management is critical to avoid unwanted tipping points and to avoid threats to people's wellbeing in several places. There are geographies in the world were land use, climate and population demands are developing in ways that make landscapes particularly vulnerable and/or to retract into a more degraded state. Figure 2 illustrates an analysis of various degrees of land use challenges combined with known water resources challenges and climatic trends. When combining these factors, it is clear that several very important food-producing landscapes of the world are under threat of degradation, water insecurity and climatic change that may reduce productivity significantly. Examples include the Midwest United States and Southeast Australia, which export food, feed and other biomass globally. The challenges facing parts of East Asia and the South Asia regions are severe as these are regions with very high population dependencies, with in some cases exponential demand for more water appropriating diets as middle classes grow. In parts of West, North and East Africa, regions and countries with very high population growth coincide with regions of already scarce water and food supply, presenting great challenges for the near future.

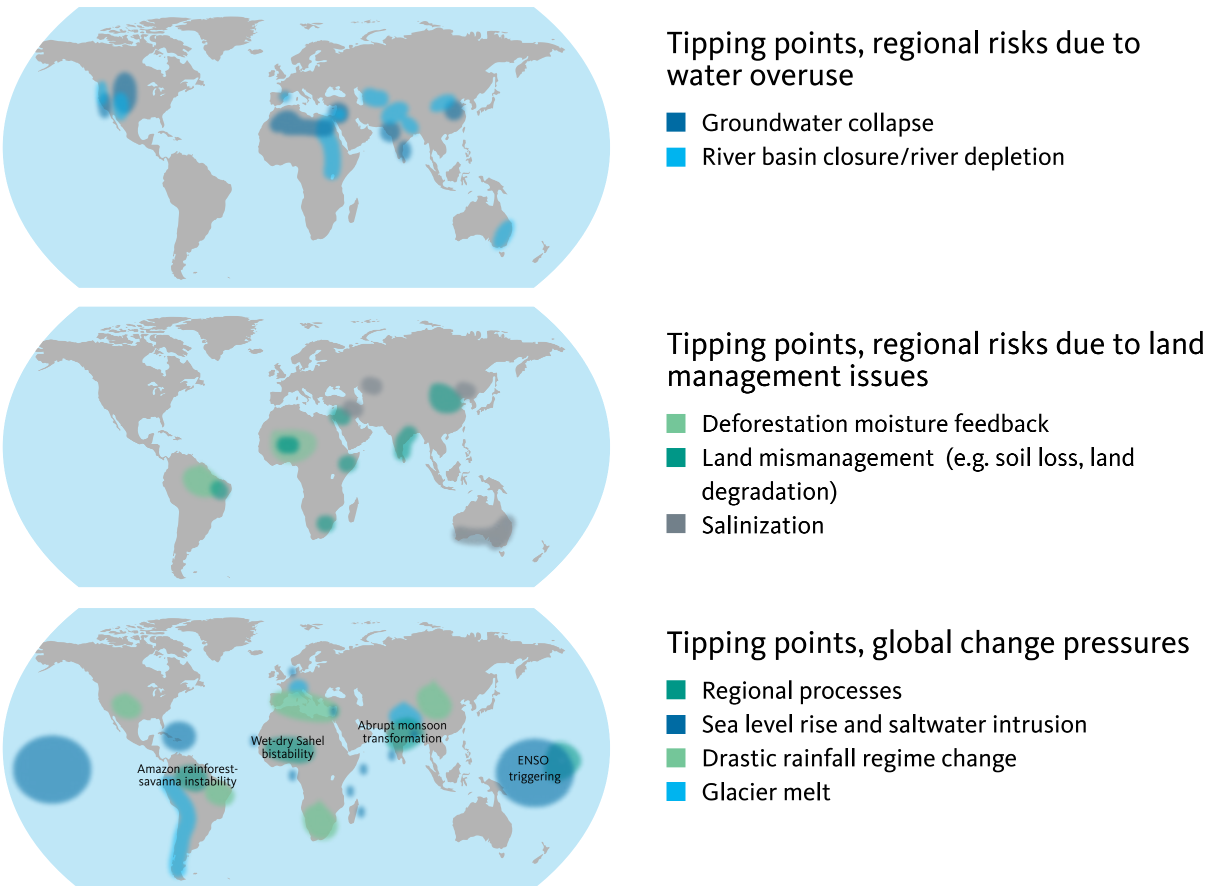


Figure 2. Water, land and climate change creates critical pressures on important production systems (Rockström et al., 2014).

Landscape restoration

Agricultural landscapes | As future climate variability increases there is a growing need to regulate and manage our use of water much more than we are doing today, especially when it comes to agricultural landscapes, to meet both more demand for water, for both agriculture and other purposes, whilst ensuring environmental health and habitats. Water management is critical for addressing tipping points, such as increased degradation, threatening people's wellbeing in several places.

Box 3: The Machobane intercropping system of Lesotho

The soils of the mountainous southern African country Lesotho are very prone to erosion, particularly rill and gully erosion. A local mixed intercropping initiative, developed by farmer J.J. Machobane since the 1940s, has successfully retained more reliable plant cover than that of conventional monocropping of maize, improved food security, and provided valuable cash crops. Better plant cover throughout the year also prevents erosion.

The system is based on rows of potatoes intercropped with rows of pumpkin or water melon. In the same rows as the pumpkins and watermelons it is possible to grow grain crops such as maize, peas, sorghum or wheat, amounting to at least seven crops being cultivated simultaneously. Potatoes are gradually covered with soil, forming ridges which, as well as increasing the potato yield, serve as windbreaks and small water retaining "terraces".

The system has proved more successful during droughts than monocropping, and less erosion is recorded even if potato ridges occasionally burst. A focus on cash crops also brings economic benefits. One drawback to the system is that it is labour intensive. It has been concluded that the Machobane system provides an answer to sustainable agriculture in Lesotho, but also that it requires certain behavioural changes among farmers. The Machobane system is also more adaptive and resilient to climate change and improved soil fertility compared to conventional farming. Since its reintroduction in the 1990s the system has attracted more than 5,000 farmers, half of whom are women.

There are many ways to regenerate agricultural landscapes, often combining soil and water management across rainfed crops and pastures as well as irrigation development needs. The purpose is to make the most of available soil moisture and irrigation water on existing crop and pasture, to avoid crop area expansion.

There is a need for supplementary irrigation or dry-season irrigation in agriculture, but also for ways how to handle too much water and flooding (especially in urban areas). We will need more water for food production. Areas that are already cultivated will be cultivated more intensively and provide higher yields per hectare (as in South Asia). We need to intensify efforts to meet agricultural water demand, especially in Africa, with better accessibility and use of withdrawn water, i.e. improve productivity per drop used. For example, small-scale dams that provide decentralized infrastructure, provide better opportunities for irrigation and have little impact on downstream flows. Improved use of groundwater, in particular shallow groundwater, can present cost efficient and healthy supply for agricultural water use to ensure improved production and productivity alongside restoration of degraded lands.

However, to improve water management in degraded and productive landscapes, there is an urgent need for capacity development and knowledge, including data. Currently, critical landscape water data on availability and use is often lacking in public data sources. There is a lack of data on water flows, storage and quality at landscape scale affecting the efficient use of water. Data on existing irrigation, both area and quantities used form different sources, such as surface and groundwater, are also very poor and need to be improved. We need to make data/information available and undertake analysis of needs. The lack of data and capacity to analyse and support improved landscape water management, especially in degraded landscapes, is a serious barrier for sustainable and productive use of land and water.

Reducing soil erosion caused by water is also an urgent priority in many landscapes. Two contrasting examples below – one from Lesotho and one from Sweden – illustrate different approaches with the common purpose of maintaining a good ground cover throughout the year to prevent the development of gullies.

Forest landscapes | Ambitious targets have been set internationally for forest landscape restoration, such as the Bonn Challenge, which is a global effort to restore 150 million hectares of the world's deforested and degraded land by 2020, and 350 million hectares by 2030. It was launched in 2011 by the German government and IUCN, and later endorsed and extended by the New York Declaration on Forests at the 2014 UN Climate Summit with the 2030 goal. These are voluntary commitments, and by 2017, there were 156 million hectares committed to restoration (i.e. statements of political intent), mostly by countries from the South that are so far leading the process. More countries from the North need to commit to these goals as well. However, the question is how to move from commitment to action and to find context-specific solutions.

Most restoration work (74 per cent) follows the "mosaic method" that integrates increased tree and/or permanent vegetation cover with existing land use, such as cropping

Box 4: 'Greppa Näringen' – a Swedish success story of farm management in the landscape

Greppa Näringen (Swedish "seize the nutrients") started in 2001 with the adoption of Swedish national environmental quality goals. The primary goal was to reduce eutrophication. The core of Greppa Näringen is personal advice, where extension services support farmers individually through personal meetings - advice that is tailored to context of specific farms. Farms must be at least 50 hectares and/or have at least 25 livestock units to be eligible for individual advice. Greppa Näringen has completed 53,000 farm visits to date. County boards are also included.

Figure 3. Farmers' assessment of erosion rills and gullies, surface runoff and flooding in the landscape (provided by Faruk Djodjic, SLU).

Soil erosion can be traced in the Land Surveying Agency's high-resolution database and appears as "wounds" on fields. This provides information to develop tailored protection zones that act as sticking plasters or "grass patches". To date, some 80,000 grass patches have been established to control gully erosion. Preventive work also includes avoiding soil compaction. Another initiative includes the establishment of Watercourse Groups and new extensive support to "catchment officers" to better utilize local knowledge with support from the Swedish Agency for Marine and Water Management (Havs- och Vattenmyndigheten).

Lessons learned: One-to-one advice is effective, but it must be based on recurring visits. Farmers want to do the right thing. We have a rapid structural transformation of agriculture with larger and fewer farms. Long-term and systematic support is crucial to success. Advisors have also become better environmentally educated as a result of Greppa. Read more at www.greppa.nu

and grazing, resulting in a multifunctional patchwork or mix of forests, trees, and other uses, including agroforestry, agriculture, and settlements. Areas most suitable for mosaic restoration are those with higher population densities and multiple demands for goods from the landscape, such as food and forest products. Land that only supports open and savanna-like forest also falls into this category. Often, what can bring incentives to local land use improvement is economic benefits and income generation. Such income gain may or may not be associated with the management of water in the landscape. For example, a recent trend of tree planting on smallholder crop land and field boundaries in north western Ethiopia, is essentially driven by market demand for construction poles in Ethiopia and Sudan. Compensation mechanisms such as Payment for Ecosystem Services (PES) schemes for reducing sediment to downstream reservoirs (such as River Tana, Kenya) has incentivised upstream farmers to improve degraded land and reduce sediment flows from fields. Even though neither of these examples directly address water management, the improved practises result in healthier landscapes and healthier water sources. The landscape should thus be the system boundary. However, it is also important to recognize that activities upstream affect water flows/access downstream. A successful restoration process generally exhibits three common themes, which is also in line with the landscape management principles discussed in Chapter 1:

1. A clear motivation - decision makers, landowners, and/or citizens are inspired or motivated to catalyse processes that lead to forest landscape restoration.
2. Enabling conditions in place - a number of ecological, market, policy, social, and institutional conditions are in place that create a favourable context for forest landscape restoration.
3. Capacity and resources for sustained implementation - capacity and resources are mobilized to implement forest landscape restoration on a sustained basis on the ground.

Figure 4a. Southern Sweden 120 years ago - characterized by land degradation e.g. overgrazing. Photo courtesy: Skogsstyrelsen.

Figure 4b. Southern Sweden today. Photo courtesy: Skogsstyrelsen.

Restoration has also been conducted in Sweden, involving agroforestry where the trees keep nitrogen in the soil, decreasing the use of fertilizers, which in turn changes agricultural management. 150-100 years ago, northern Sweden was characterised by forest degradation and southern Sweden by overgrazing and land degradation, but as can be seen in Figure 5 below, the forest stock and harvest has grown steadily since restoration took place and land degradation has been halted.

Conclusions

- Degraded landscapes result in costs, and negative impacts for people, (societies), economies and for ecosystem services. There are both global and local challenges, including current state of environment/ use of water and land resources, population increase and changes in diet, as well as climate that puts specific landscapes at risk for becoming more degraded, or remain in degrade states, unless proactive management is done.
- Water-related considerations should be better integrated into landscape management and vice versa. There is a need to regulate and manage our use of water much more than we are doing today, especially when it comes to degraded landscape.
- Management strategies are knowledge and capacity intensive, and context specific, but good experiences from Sweden and elsewhere exist and can be shared. In situations with rapid structural transformation of production landscapes with larger and fewer farms, long-term and systematic support to farmers is crucial to success.
- There are many opportunities for forest landscape restoration linked to international commitments, such as the Bonn Challenge, etc. A successful restoration process generally includes a clear motivation, a conducive enabling environment, and capacity and resources for sustained implementation.

Sweden since 1926: Growing stock and harvest

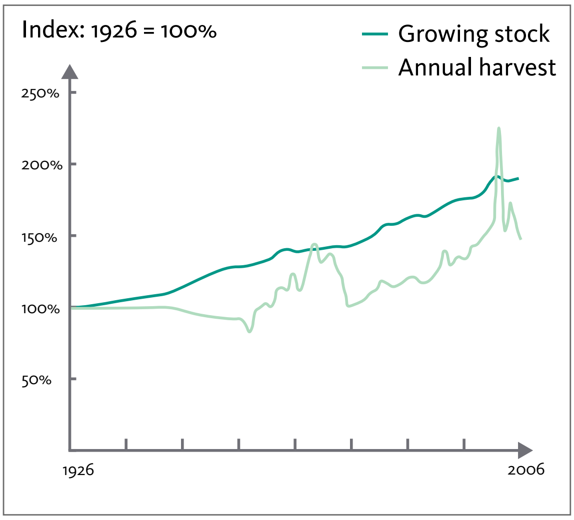


Figure 5. Forest and landscape restoration in Sweden. Skogsstyrelsen.

Forests, agriculture and water

Trees and forests regulate water flows, clean water, store carbon, enhance biodiversity and reduce erosion and runoff from landscapes. Yet, their impacts on the hydrological cycle at different scales is still poorly understood. Below we take stock of recent research findings from international and Sweden-based institutions before highlighting some management challenges and opportunities.

Forest, water, moisture recycling and hydrologic space

Recent research shows that it is necessary to think beyond the watershed to understand where water comes from. Through evapotranspiration (ET) trees recharge atmospheric moisture, contributing to rainfall locally and in distant locations, and it is therefore important to consider the hydrological space and identify what share of rainfall comes from ET. ET feeds an important share of terrestrial precipitation, and, on average, forests provide more atmospheric moisture through ET than other land cover surfaces.

Figure 6. Drip irrigation in a Sahelian agroforestry parkland, Niger. Photo: Anna Tengberg.

The Blue Nile Basin provides a good example of a hydrological space. An important proportion of atmospheric moisture in Ethiopia comes from the Central African rainforest, mostly the Congo Basin, where increased deforestation leads to reduction in rainfall in Ethiopia, some predict as much as a 25 per cent reduction. However, the question is whether more forest equals more or less water. Forests consume water and reduce water flows downstream – this is the demand-side view of forest-water relationships that only considers the catchment, and not the space outside it. The supply-side view has less support, i.e. that forests produce water, and a larger framework and improved awareness of this view is needed to understand the origin of precipitation. To that end, a model has been developed to predict how forests change precipitation in the catchment. It shows that understanding the spatial organisation influences the perception of whether trees and forests produce or consume water, and that it matters where you plant forest. In conclusion, forests can potentially contribute to increased precipitation in the following locations:

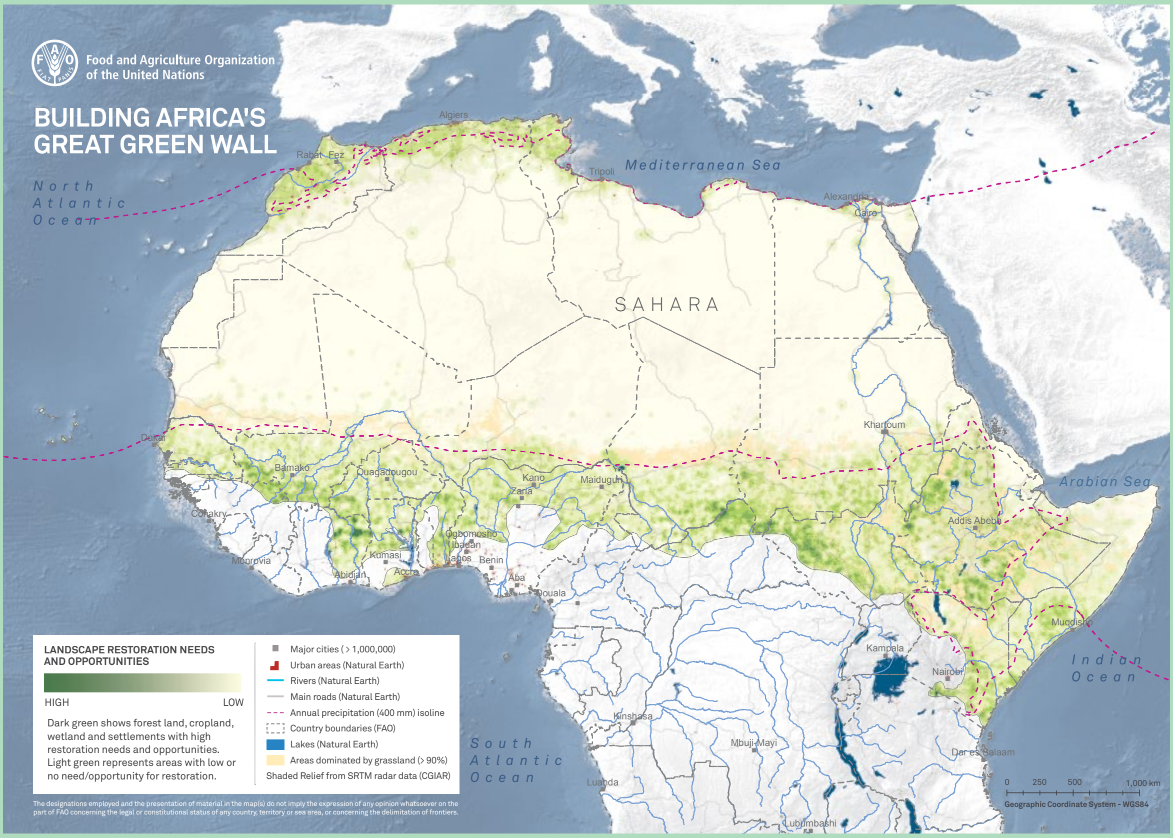
- Upwind coast
- Locations that are not water-stressed
- High altitude and cloud forest regions

The consequences of removing forests could lead to more water to downstream users, but this may have the consequence of reducing ET output from the basin, which in turn will reduce precipitation in downwind locations. Some downwind communities could suffer significantly by losing an important portion of their precipitation.

In conclusion, forests consume and produce water. The large-scale spatial organisation and connectivity of land use practices and forest cover must be carefully considered when addressing issues of forest cover, water availability and the hydrological cycle. Although trees and forests could be used to improve sustainability, adaptation and mitigation efforts, forest-driven water and energy cycles are poorly integrated into regional, national, continental and global decision-making.

A regional initiative in Africa to reduce desertification and land degradation is a good example of landscape restoration (Box 5) that may also have positive effects on ET and rainfall in some locations.

Box 5: Great Green Wall Initiative in Africa



Globally, drylands cover 41.5 per cent of the land surface, and are home to two billion people. With climate change, drylands are expected to expand by 11-23 per cent. FAO is involved in the Great Green Wall (GGW) initiative that is an African response to climate change and zero hunger (SDG2). It is not a wall of trees, but a mosaic of sustainable land management practices. The objective is to restore 10 million hectares of land per year. Communities and their preferences are at the heart of forest and landscape restoration activities, and the focus is not only on trees, but also feed, medicines, food, fuel, etc. Moreover, water is at the centre of restoration in drylands. Restoration success requires the following conditions: supportive policies; good governance; sufficient technical, operational and financial capacities; incentives for communities to sustain their actions; and continuous monitoring and learning. Actions required include:

- Promoting natural regeneration, in which farmers protect and manage the natural regeneration of native species in forests, croplands and grasslands.
- Investing in large-scale land preparation and enrichment planting where degradation is so severe that natural vegetation will not regenerate on its own; communities select the native woody and grass species to be used.
- Fighting sand encroachment by establishing and protecting native woody and grassy vegetation adapted to sandy and arid environments.
- Mobilizing high-quality seeds and planting materials of well-adapted native species to build ecological and social resilience.
- Developing comprehensive value chains that benefit local communities and countries and enable the flourishing of green economies and enterprises.
- Building inexpensive, participatory information systems to support baseline assessments, identify interventions, track progress, inform stakeholders and investors, and aid learning and adaptive management.

The GGW receives support from a number of multilateral and bilateral organisations, including the Global Environment Facility (GEF), which is the financial mechanism of the Multilateral Environmental Agreements (MEAs), discussed in Chapter 5. It thus links global environmental governance instruments with national policies, institutions and local actions to restore degraded landscapes. Read more at: www.fao.org/in-action/action-against-desertification.

Optimum tree cover

There is a long history of debate over the role of tree cover in the hydrological cycle and its effect on groundwater and stream flow yields. Governments, tree planting organisations, and local stakeholders have often argued that forests are like sponges, capturing water during the wet season and slowly releasing it during the dry season. Many catchment studies looking at the impacts of tree cover on water yields show that forestation leads to reductions in streamflow due to higher ET from trees, while the opposite happens with deforestation. Such studies give support to a simplified version of the water balance in which the effect of trees on streamflow is only the result of increased evapotranspiration losses. However, this understanding ignores any positive effects of trees on soil hydraulic properties that are closely related to groundwater recharge and thereby to dry season flows. In the seasonally-dry tropics, this is problematic as when trees are not present, soils are often degraded due to prevalent high rainfall intensities coupled to soils prone to degradation. Since catchment studies looking at the net impact of (de)forestation are biased towards humid temperate regions, and are mostly on non-degraded soils, the positive impact of trees on groundwater recharge and dry season flows has not been possible to detect.

Theoretically, improvements in infiltration capacity associated with increasing tree cover may outweigh extra ET from trees. A review on the impacts of afforestation and agroforestry on infiltration capacity in the tropics showed an increase of two to five times with trees. Other studies have shown that in landscapes with scattered trees, soil infiltration capacity increases in the vicinity of trees as far as 20 metres away from the closest tree stem. Therefore, in the tropics we need to look at the whole landscape to understand the net impact of changes in tree cover on water yields. For instance, in systems with open tree cover, such as agroforestry parklands or open woodlands, it is important to consider the water balance both in areas under trees, and in small and large gaps among trees.

In agroforestry parkland in Burkina Faso, a study showed that groundwater recharge was maximized with intermediate tree cover (Figure 7). Under trees, high ET resulted in low groundwater recharge despite improved infiltration capacity. In the small gaps between trees, infiltration capacity was still high, but since ET was lower, this lead to higher groundwater recharge. The positive effect of trees on soil infiltration capacity disappeared in the larger gaps far away from trees, causing surface runoff and low infiltration. In addition, the water infiltrated into these areas moved slowly through the soil profile and was thus more exposed to soil evaporation. Altogether, this resulted in low groundwater recharge in the large gaps.

So how do trees improve soil infiltration capacity and water drainage in soils? Under trees, litter inputs from leaves, branches and roots lead to increased soil organic matter. This organic matter promotes soil aggregation and attracts microorganisms and soil fauna, which together with root activity enhances soil macroporosity under trees. Better soil structure under trees also improves infiltration capacity and reduces surface runoff. That

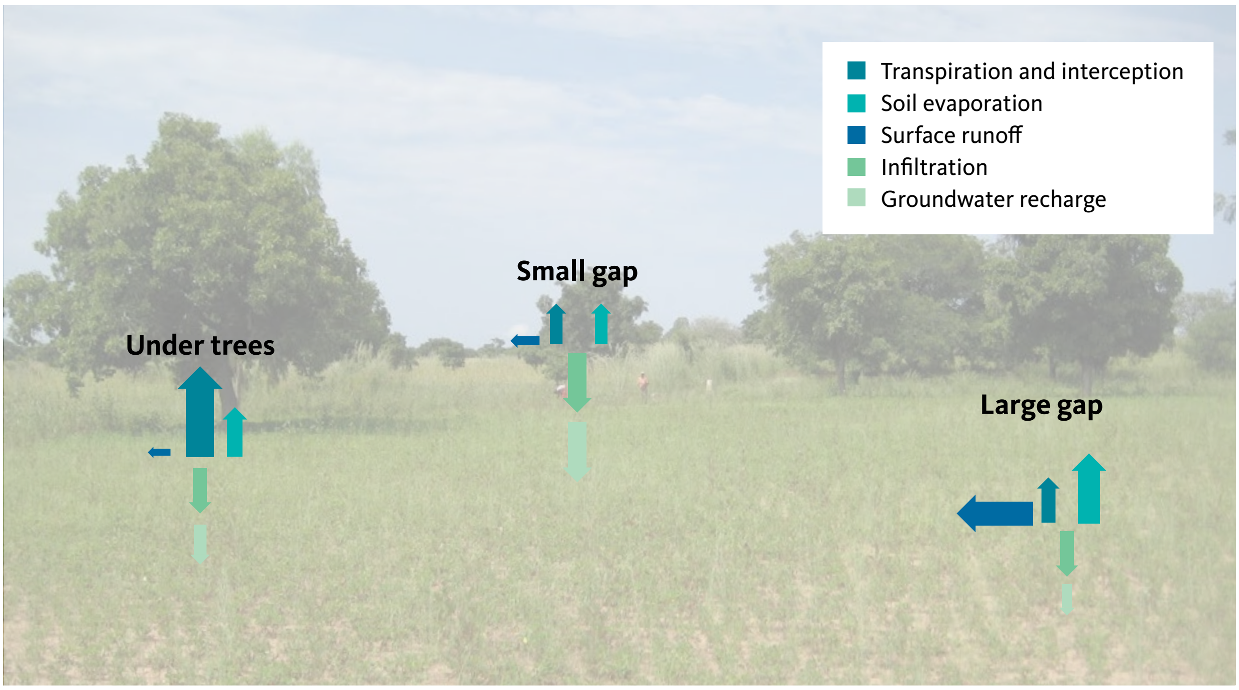


Figure 7. Groundwater recharge was maximized in small gaps among trees in an agroforestry parkland in Burkina Faso. Under trees and in large gaps, groundwater recharge was lower due to high transpiration and interception losses from trees, and low capacity for soil infiltration in large gaps between trees. Figure courtesy: Aida Bargues-Tobella and Ulrik Ilstedt.

is, a higher percentage of water on the soil surface will go into the soil and thus be available for groundwater recharge. If macropores are present, infiltrating water can flow through these macropores, moving quickly down the soil profile and bypassing most of the soil matrix. Macropore flow not only increases the flow of water in soils, but it actually also reduces soil surface evaporation as water is escaping the topsoil layers that are exposed to evaporation.

The specific tree density that maximizes groundwater recharge will depend on several factors including climate, soil characteristics, tree species, tree age and size, tree spatial distribution, land use and management (e.g. tree pruning and grazing). Although more research is needed on the impact of these factors, it is now clear that increasing tree cover does not always lead to reduced groundwater recharge.

Local-level management challenges – Example from Helge Å Model Forest, Sweden

The Model Forest (MF) concept originates from Canada where it was developed to handle conflicts between logging companies, indigenous people, environmentalists, governments, communities, etc. It was launched at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. Today, about 60 Model Forests are distributed over four continents, of which three are in Sweden. The development of Helge å MF (Helge river MF) is a result of a shift in Swedish policy and practises regarding sustainable development towards more inclusive approaches and tools when it comes to planning and managing natural resources. Helge å MF also works according to the European Landscape Convention's principles of promoting public participation in landscape protection, management and planning.

Box 6: Forests and Water Monitoring Framework and Online Tool

Figure 8. Collection of firewood in the Mount Kenya forest, which provides essential water ecosystem services downstream. Photo: Anna Tengberg.

FAO is developing a Forest and Water Monitoring Framework and online tool to enable practitioners to consider water in their forest/tree-related projects. The tool will provide guidance to the necessary standardized indicators, variables and methods to measure the effects of forest and land management decisions on water. In addition, users will be able to customize how they monitor forest-water interactions by selecting the most appropriate recommended methods. The online tool will eventually provide aggregated and/or synthesized data that can provide local, national, regional and global information, which will be used to inform integrated forest, water and landscape management practices and policies.

The tool has been developed using a participatory process, engaging forest and water researchers, practitioners and other experts that were invited to contribute to the development of standardized indicators and to recommend appropriate methods to monitor these indicators. Through surveys, workshops and peer reviews these indicators and methods were refined into a framework with six high level indicators measuring the direct bio-physical relationships between forests and water, the enabling environments that support integrated approaches and potential socio-economic benefits.

The monitoring framework and tool will ultimately support the justification of integrated forest-water practices and policies, as well as improve our understanding of forest-water interactions. Thus, facilitating evidence-based natural resources planning, practices and policies to achieve better management of forest ecosystems, soil health and water resources, including water quality, groundwater recharge, and water availability and access. Read more at: http://www.fao.org/in-action/forest-and-water-programme/news/news-detail/en/c/1070350/.

Along with the monitoring framework, a training programme has also been established that involves multiple modules to meet the needs of countries and stakeholders wishing to implement the framework at a national or project-based level.

Figure 9. Field visit with local stakeholders in Älmult county to a nature path along Helge å, part of the Model Forest and Local Nature Preservation Effort (LONA). The project is also financed by IKEA and by the local municipality. In-kind contributions are provided by NGOs and the Swedish Forest Agency. Photo: Jan Lannér.

There are three central aspects of the MF concept: a large landscape, broad partnerships; and commitment to sustainability. Each MF provides examples, solutions, good practices and disseminate knowledge on how to manage ecosystems and landscapes combining social, environmental and economic needs.

The starting point of the Helge å MF was increasing problems with brownification and flooding and their connection to land use along the river. Problems that originated in the upper parts of the basin had negative effects in the lower parts of the river basin. Three organisations came together to find a way to address the problems: the economic forest owner's association Södra; the Biosphere Reserve Vattenriket; and the Swedish Forest Agency. The Helge å Model Forest is organised as a non-profit organisation and represents stakeholders such as land owners, local authorities, Non-Governmental Organizations (NGOs), municipalities and government authorities.

The Helge å MF uses a multi-level governance model to address several of the Sustainable Development Goals (SDGs). The MF six principles include: (1) partnerships; (2) landscape approach; (3) commitment to sustainability; (4) transparent, consensus-based and inclusive governance; (5) programme activities reflective of stakeholder needs; and (6) knowledge sharing, capacity building and networking. Challenges include financial sustainability and to build a resilient social network to ensure the future of the MF approach. Another challenge related to building a resilient social network, is the gender aspect. There is a lack of women active in the engaged NGOs which makes it difficult to get female candidates to influential bodies such as the board and other committees. There is a better gender balance in the external cooperation with the County Administrative Boards and universities.

Challenges in Helge å MF represent different scales and cover a range of issues, including:

- Rural and local development based on nature and cultural values
- Participatory processes for peri-urban nature and planning
- Green infrastructure for natural forest values
- Capacity building and mediation
- Restoration of stream habitats
- The future biodiversity and species in the forest landscape
- Brownification and reducing its impact on a variety of ecosystem services

The above mix of problems and issues ranging from governance issues at national level to technical issues and problems at local level is common in many sustainable and participatory approaches to landscape management. In planning processes, it could thus be wise to categorise different problems into e.g. "governance" and "technical" in order to achieve a clearer overview of what needs to be done, by whom, when and with what resources resulting in a more efficient resource allocation.

Box 7: Blue targeting – planning best management practices in forestry along small streams

Blue Targeting is a tool for best management practice (BMP) in forestry along small streams. The tool was originally developed by WWF Sweden in corporation with the forestry sector in 2007-2011. It was designed for small streams (width approx. <10m) in boreal and Scandinavian conditions and is now being developed and scaled up to be used in the whole Baltic Sea region, and also in tropical forest areas. The main objective of the tool is to implement the right measure, at the right place, to the right extent.

The tool uses a stepwise approach to assess the appropriate management levels in the forested riparian zone, to protect and sustain biodiversity and water quality and flow. The first step is to check for available data on present biodiversity and chemical status of the water. The next step is an inventory of stream sections using a simple check list. Data are collected for present conservation values, sensitivity for impacts on physical, chemical and biological status from present human activities, and if there are any and added values present in the riparian zone selected such as cultural values/heritage. These data are collectively used to assess what management strategies are needed for the area. The result can be used in forest management plans at different geographical scales.

The Blue Targeting tool (BT) is scientifically based but simplified for use by non-professionals in practice. Since 2017 the BT is in operational and used by the Swedish Forest Owners Association in connection with forest management planning. Moreover, Swedish companies with large forest properties have implemented the BT at a landscape level in pilot studies.

Conclusions

- There is a need to widen the geographical perspective from watersheds to whole continents and cross-regional perspectives to understand where precipitation originates from to better integrate forest-driven water and energy cycles into regional, national, continental and global decision-making, as trees and forests could be used to improve sustainability, adaptation and mitigation efforts.
- For water flows, it is sometimes better to focus on density and types of trees than forests as such, taking into consideration different species, age of trees, spacing/density, etc. The specific tree density that maximizes groundwater recharge will depend on several factors, but it is now clear that increasing tree cover does not always lead to reduced groundwater recharge.
- Local-level forest management initiatives often face a mix of problems and issues ranging from governance challenges at national level to technical issues and problems at local level. A key- success factor is to work with participatory processes and partnerships. A forum which offers neutral arenas for dialogue between different interests seems to be an important tool to be able to move forward and see results. Challenges include financial sustainability and to build a resilient social network, which includes the gender aspect.

Chapter 4

Management of impacts of climate change on landscapes

One of the major challenges to sustaining multifunctional and productive landscapes is rapid climate change and the pressures it exerts on ecosystems and water resources. This calls for measures to adapt to climate change that are easy to implement and cost effective. To adapt to climate change, it is also necessary to monitor, report and model changes to water resources availability in the landscape. In many countries, there is limited availability of hydrological data and information about how water flows in the landscape, and how land uses and/or climate change affect it, as we saw in chapter 2. However, new and innovative technologies and approaches for monitoring, reporting and modelling are emerging that could provide a strengthened evidence base for design of nature-based solutions and other measures that would safeguard the hydrological functioning of landscapes and their resilience to climate change.

Nature-based solutions

Nature-based solutions (NBS) for water was the theme of the 2018 United Nations World Water Development Report. NBS have an intrinsic linkage to landscape management, as they are inspired and supported by nature. They use or mimic natural processes to contribute to the improved management of water. Moreover, NBS, such as landscape restoration, can in some situations offer the only viable solution to urgent water management challenges.

Example of NBS for climate adaptation from Västra Götaland, Sweden | NBS is increasingly being mainstreamed into policies and action plans, including in Sweden, evidenced by the fact that the County Administration of Västra Götaland, one of Sweden's most important agricultural regions, has developed an NBS tool on how to manage flood risk in its agricultural and forest landscapes. Although Sweden's climate is cooler and wetter than most parts of the world, some conclusions of a more general nature related to the usefulness and applicability of NBS can be drawn.

The NBS tool is targeted at communities to help adapt to climate change and increased flood risk in the landscape.

Figure 10. Traditional pastures in Kyrgyzstan where climate change has impacted water flows and communities need to adapt. Photo: Anna Tengberg.

Communities need to think about how they should tackle climate change using natural measures, such as natural water retention measures to prevent flooding. The cost is lower than for hard engineering measures and they give multiple positive outcomes for biodiversity, etc.

To design an NBS intervention, many questions need to be asked, for example: How much water can be managed in urban areas? How often will this amount be exceeded? Which volumes are too high? Where can water be stored? Where does the water come from? What does the landscape look like? Where do you find information about the landscape? Which partners do you need to involve? In short, we need to think in new and innovative ways to adapt to a changing climate and new circumstances, to embrace and implement new knowledge, additional and

Table 1. Nature based solutions to water management in the landscape in Sweden (adapted from Bergstedt, 2018).

NBS Category	Examples of NBS measures	Benefits
Soil management	• No-till agriculture • Spring tillage • Controlled traffic farming • Green cover • Soil structure liming	• Increase soil infiltration • Less surface runoff • Ground water build-up • Less sediment and nutrients in streams and rivers
River bank buffer strips	• Size and vegetation dependent on agro-climatic zone	• Slow high flows • Increase soil infiltration • Enhanced biodiversity • Less sediment and nutrients in streams and rivers
Trees for infiltration and slowing of water flows	• Hedgerows • Targeted tree planting • More trees in the catchment • Forestry without clear cuts	• Increase soil infiltration • Evapotranspiration • Slow water flows • Interrupt surface flows • Greater biodiversity
Measures in ditches	• Open up underground drainage • Careful maintenance of ditches • Two-step ditches • Re-meander ditches • Block forest ditches	• Increase soil infiltration • Slow water flows • Water storage • Greater biodiversity • Less sediment and nutrients in the rivers
Dams	• Create wetlands • Dams for capturing phosphorus • Dams in previous waterways • Capture surface runoff • Barriers hold high flows back in ditches	• Increase soil infiltration • Evaporation • Slow water flows • Water storage • Interrupt surface flows • Greater biodiversity • Less erosion, sediments and nutrients in streams and rivers
Controlled flooding (e.g. directing high flows out of streams)	• Woody debris in streams • Open up the outside of a meander	• Increase soil infiltration • Slow water flows • Water storage • Less erosion, sediments and nutrients in streams and rivers • Greater biodiversity
Major projects	• Restoring lakes • Restoring floodplains	• Increase soil infiltration • Evaporation • Slow water flows • Water storage • Greater biodiversity • Less sediments and nutrients in waterways

complementary to traditional knowledge and measures. Examples of natural flood management measures include: enhanced soil infiltration, river bank buffer strips, trees for infiltration and slowing of water flows, measures in ditches, and dams. These measures can usually be implemented easily and cost effectively. However, there are also bigger projects that need more effort, such as restoring lakes and flood plains, which can be very efficient in reducing floods, but are also more expensive.

The development of the tool also benefitted from international co-operation. The European Commission has described 53 Natural Water Retention Measures, Västra Götaland County Board selected a few of them for further analysis. The County Board intends to share their experiences with community leaders in other parts of Sweden, to enable/facilitate alternatives to traditional engineering and "grey" solutions. However, further considerations are needed regarding responsibilities for granting land for NBS measures and clarification of the responsibility of private individuals and local stakeholders. There is also a need to consider possible conflicts of interests between implementing NBS measures and need for farmland.

Data and modelling considerations

Climate change makes it increasingly important to predict extreme weather events and effects on agricultural production and food security. This also requires reliable data on rainfall. Some examples of innovative new measurement techniques and models developed with support from Swedish institutions and companies are described below.

Precipitation measurements using mobile technology | The Ericsson Weather Data (EWD) tool is based on telephone masts sending microwave links, which are weakened by rain. Microwave links are the backbone of mobile phone networks. There are about four million such links globally. Many low-income countries do not have any other infrastructure to measure weather-related data, which is a good reason to make use of the growing market for mobile phones. Measuring weather has no negative impact on networks, and there are large numbers of microwave links in cities. The technology has been developed in the past 10 years, and has been trialled in the Netherlands and Israel. SMHI has conducted a Swedish pilot in Gothenburg since 2015. Improved rainfall monitoring with real time mapping enables monitoring of rain intensity, not only the amount. Improved observation data lead to improved forecasts and warnings.

An algorithm has been developed to derive precipitation from the microwave links. Rainfall disrupts links, from which data is calculated. Data need some degree of correction, otherwise rainfall is overestimated. During peak rainfall intensity, the mobile network is more effective at capturing peak intensities compared to radar, as the data has a better temporal and spatial resolution.

Potential users are meteorological agencies, municipalities, insurance companies, energy providers, media, and especially developing countries for which microwave links provide an affordable leap-frog technology for weather measurement. However, mobile networks are not evenly distributed, such as in mountain areas, which are also areas where it is very important to collect data on weather as it affects water flows downstream. In rich countries where there is already infrastructure for measuring weather data, this is more of a complement to existing technology, but in developing countries it could be the only data available.

Water balance modelling | The water balance in a catchment is an important measure of a catchment's potential to produce a multifunctional landscape (e.g. biodiversity, producing hydropower, supply food and drinking water). A computer model is a powerful tool to study the impact on a catchment's water balance in a changing climate and under changing land use conditions. A model that correctly replicates the natural and anthropogenic processes in a catchment can evaluate the effect of landscape restoration on the water balance.

A method has been developed by DHI and used in Sweden and in Kenya, among other countries. The aim was to use the method to build adaptive capacity for climate change by looking at the possibility of, for example, increased water storage and reintroducing wetlands.

Figure 11. The High Pamirs between Kyrgyzstan and Tajikistan where Citizen Science can help map fragile and poorly known mountain ecosystems services. Photo: Anna Tengberg.

In short, the work process encompasses the following steps:

- Rural and local development based on nature and cultural values
- Participatory processes for peri-urban nature and planning
- Green infrastructure for natural forest values
- Capacity building and mediation
- Restoration of stream habitats
- The future biodiversity and species in the forest landscape
- Brownification and reducing its impact on a variety of ecosystem services

The collection of catchment data such as topographical information, land use and soil maps, as well as hydrographic data, can be carried out using field data and/or remote sensing data if field data is unavailable. The latter involves the collection and evaluation of precipitation, evapotranspiration and temperature data. These data will form the boundary conditions for the hydrological model, which drive the model. In addition, discharge data is utilised to calibrate the model. Calibration of the model is the process where the model is set up to replicate the natural processes of the catchment.

It is also important to consider water rights and to collect and map all water users in the catchment, as many water users in a catchment operate without a consent. It is thus important to try and identify all users, even the ones without a consent, and both public and industrial water users in the catchment need to be identified and mapped. Water treatment plants withdraws water from the river or aquifer and wastewater treatment plants reintroduce the water to the system. In some instances, water might be withdrawn from one catchment and released into another, i.e. diversion of water.

Irrigation data in the catchment should also be collected and mapped, as well as all dams/regulated lakes, followed by and evaluation of which ones have a significant impact on the water balance, base flow and peak flow. Many small hydropower schemes do not have any significant effect on base flow and peak flow. The next step is to develop a water balance model that represents the hydrology, hydraulic routing, structures and demands in a geographically correct manner. MIKE HYDRO Basin is a multipurpose, map-based decision support tool for integrated water resources analysis, planning and management of river basins. Figure 11 shows an example of such a model that was developed for the County Board of Blekinge, Sweden. The developed and calibrated model is used to analyse the water balance and water scarcity in the catchment. The analysis is based on an extended hydrographic data record of, for example, more than 30 years. Future conditions are analysed based on a number of climate projections and greenhouse gas concentration trajectories.

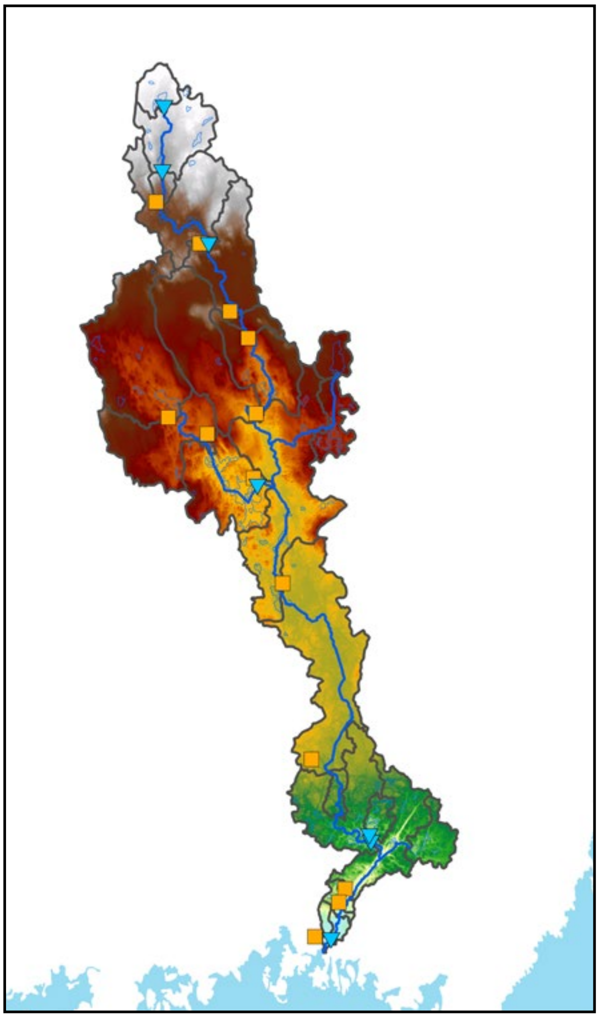


Figure 11. MIKE HYDRO Basin model for Lyckebyån river in Blekinge County, Southeast Sweden. Regulated lakes and dams are illustrated with blue triangles, demands such as water supply and irrigation are illustrated with orange squares, the sub-catchments as grey polygons, and the river as a thick blue line.

The results in this example showed that water scarcity in the Lyckebyån catchment will increase in the future, but that one of the regulated lakes have capacity to withstand the drier climate. In a similar study of another river in Sweden, landscape restoration (reintroduction of wetlands) was modelled with good results. That study showed that base flow would increase, and peak flows would decrease. The method has also been used in Kenya where large parts of the country are facing serious water scarcity. Climate change may further aggravate this situation.

In summary, water balance modelling can be a very powerful tool to provide decision support in a planning stage, in real-time or as forecast for future water shortages. Modelling can provide integrated analysis of the efficiency of measures on a catchment scale. Similar analysis would be almost impossible with other tools. Providing forecasts can improve the preparedness of water users in a catchment.

Bottom-up approaches to climate adaptation

Many current climate models attempt to predict the future for water management decisions. However, these models contain a high degree of uncertainty, and their usefulness for decision-making that typically requires a high degree of confidence, and/or long-lived assets like infrastructure or ecosystems, is therefore limited. Understanding the degree, form, and severity of climate risks facing water management and landscape productivity is necessary to achieve sustainable resource management and development goals for energy, food production, sanitation and supply, and ecosystems. That is where the paradigm of "bottom-up" approaches come in.

Most approaches considering future climate conditions focus on optimizing a single future scenario. Decisions are taken from a top-down perspective, starting with decision makers defining a problem statement, a technical analysis to develop a single solution, and finally reaching out to different stakeholders. In contrast, bottom-up approaches start with users and stakeholders to create a shared vision and statement of a given problem, moving on to stress tests, and before presenting a solution to decision makers. When multiple stakeholders are involved at an early stage of the process, more perspectives and scenarios will be included, which leads to better-informed and more comprehensive solutions. Linking water and climate in integrated policies is important and bottom up approaches and methods in this area are quite new. There is an online platform available for these methodologies called "Knowledge platform for Bottom-up Approaches to Resilient Water management" that is managed by the Alliance for Global Water Adaptation (www.agwaguide.org). Citizen science is another emerging approach that has proved useful to engage local stakeholders. It is further explained below.

Citizen science | Citizen Science (CS) is an approach where non-scientists are actively involved in generating new scientific knowledge. CS is about co-generation of knowledge and interactive learning exchange. It brings citizens into the democratic dialogue to answer questions such as: How to better capture and understand local experience about water? How to better achieve specific targets and local implementation? and link these actions to governance structures and adaptive governance. CS methods are not the standard way data is collected in the field of water. Frequently, expensive instruments are used to collect data, with no accessibility for local citizens. Different variables are included in collecting data: for example, precipitation, streamflow, water quality, and water use. All variables offer both opportunities and challenges as to where CS can contribute with certain tools/methods to develop new ways of collecting data. CS does not yet include management variables and some of the methods fit better at the local level.

A study carried out in Nepal, Ethiopia, Peru and Kyrgyzstan used CS to map fragile and poorly known mountain ecosystems services. This was linked with interactive models of information exchange, knowledge generation and learning. A case study from the Mustang area in Nepal illustrated water management at the village level. People were concerned about lower levels of water, which was also affecting the crops farmer chose to grow and their scope for diversification. Different ties need to be forged with local governments and science institutions to carry out CS methods. CS experiments in Mustang showed that these approaches can complement other development interventions, but that there is a need to be careful not to replace existing responsibilities of local state/government, but to combine more traditional methods with CS. Sweden has also established mechanisms for CS.
For example, on the "Artportalen" portal, citizens report different animal species and contribute to the collection of data on biodiversity. There is also a new portal for Sweden's new national platform for citizens: arenas for co-operation through citizen science (ARCS) to create a dialogue between universities and the public.
In conclusion, CS allows more actors to engage in the monitoring of water and other natural resources through decentralized and diverse methods and participatory processes. However, there is a need to be careful about power relationships between research and stakeholders.

Conclusions

- NBS for managing climate risks are promising and cost effective, but there is also a need to consider the feasibility of implementing NBS when there is also a pressing need for farmland and potential conflicts of interests.
- Rainfall monitoring can be improved using microwaves from telephone masts and can help inform management of landscapes in a changing climate.
- Geographical water balance models can be used to assist in the planning of water adaptation measures.
- Bottom-up and participatory approaches to monitoring and modelling, such as CS lead to inclusion of more perspectives and scenarios and more informed and comprehensive solutions.

Chapter 5

Good water governance in landscapes

Good governance is characterised as participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive, and rule of law following. The principles for the landscape approach discussed in chapter 1 are well aligned with these characteristics with its focus on adaptive management, participation, and rights and responsibilities of different stakeholders. This chapter highlights linkages between global governance and national policy frameworks and issues that need to be considered at the local level to ensure sustainable management of water in the landscape. Examples are given from Sweden and the global South on how to combine different governance approaches, and public as well as private sector instruments.

Figure 12. Discussions with stakeholders in the lower Senegal river basin, Mauritania, about restoration of landscapes suffering from desertification. Photo: Anna Tengberg.

Global, regional and national policy frameworks

The opportunities and relevance of public/stakeholder participation to solve environmental challenges was first brought up on the international agenda at the UN conference on the Human Environment in Stockholm 1972. Public participation became a vital part in governance policies and politics with the report "Our Common Future" (the Brundtland report on sustainable development) in 1987. Five years later, the Rio Declaration on Environment and Development stated in its 10th principle that: "Environmental issues are best handled with participation of all concerned citizens, at the relevant level … and the opportunity to participate in decision-making processes".
Swedish policies on natural and cultural heritage have transformed in recent decades, from expert-oriented to a more inclusive, participatory approach. For example, in the 1990s, the Swedish National Heritage Board (NHB) started a process to widen the definition of cultural heritage. The Water Framework Directive (WFD) was adopted by the EU in 2000. It states that citizens have a key role to play to achieve its objectives of reaching good ecological status in European freshwater systems. Article 14 of the directive requires member states "to encourage the active involvement of interested parties" in the implementation of the directive. Its implementation has been a strong driver of bottom-up private and public partnerships to secure water quality and water flows in Sweden.

In the international arena, several initiatives have been established to promote the implementation of the Brundtland and Rio declaration insights and visions, such as Biosphere Reserves (BR), Model Forests (MF), and the European Landscape Convention (ELC). Multilateral Environmental Agreements (MEAs) adopted in Rio included the UN Framework Convention on Climate Change (UNFCCC) and the Convention on Biodiversity (CBD), followed some years later by the UN Convention to Combat Desertification (UNCCD), all with implications for integrated landscape management. In terms of policy frameworks for forest landscape restoration, the REDD (Reducing Emissions from Deforestation and forest Degradation) policy, first negotiated

Box 8: Social factors of soil and water conservation – the Lesotho example

The landscape of the small southern African kingdom of Lesotho sports a striking but destructive feature: deep, long gullies that intersect fields, make farming difficult and decrease yields. Gully and soil reclamation schemes since the 1930s have returned very poor results. Ever since the first attempts at curbing gully formation, many soil reclamation experts have commented on an apparent paradox: farmers receiving help from such reclamation schemes, aimed at restoring their own soil, really do not seem to bother, at times they are even hostile to them. The people of Lesotho had the best part of their land taken from them by Afrikaner settlers in the late nineteenth century. In the small area they could keep, they were forced to use inferior soils, previously used for extensive grazing, for subsistence crops (maize, sorghum, wheat) and vegetables.

The intensive use of the sensitive Lesotho duplex soils made them prone to soil erosion. Inspired by American erosion science, the British government started the first erosion prevention programmes in the 1930s, mainly by different kinds of constructions that diverted or concentrated surface runoff. But though these techniques had proved successful in America and in South Africa, they were devastating on the Lesotho duplex soils where high water pressure caused sub-surface pipes to develop that later would develop into gullies. Local farmers resented the schemes, which also rested on very little scientific studies of local conditions, be it soil, climate, cropping traditions or social structure. Instead, American techniques were hailed as symbols of modernity without being questioned or evaluated. Attempts to involve – and more importantly listen to – local knowledge only started in the 1970s. A review of different soil conservation projects concluded that projects were more likely to succeed if local farmers were consulted and their needs addressed. Lack of dialogue between conservation officers and farmers, techniques that reduced productive field area or plants introduced to stabilize the soil without offering value for fodder or food were factors that devalued the projects in the eyes of the farmers.

The conclusion is that soil and water conservation practices must adapt to local conditions in terms of soil, crops, climate, land tenure and social structure. Science has an important part to play in finding the causes of land degradation and suggest scientifically based solutions, but local knowledge and acceptance are crucial to success.

under the UNFCCC, is an important instrument. By increasing the extent of forests in some areas, the decrease of forests in other areas can be balanced (as for example logging in Brazil). There are thus opportunities to create political coalitions and alliances of states in green zones. The Ramsar Convention on Wetlands from 1971, is an important instrument for managing water in the landscape. More recent approaches to governance of natural resources in landscapes also consider the role of the private sector and economic instruments and mechanisms, such as Payments for Ecosystem Services (PES), Public-Private Partnerships (PPPs), value-chains and certification, as will be discussed below.

Gender considerations and social factors

The importance of involving all stakeholders in the management of water was recognised at the United Nations Water Conference in 1977, and reinforced at the International Conference on Water and Environment in Dublin in 1992. The third Dublin principle states that women are central to the collection and safeguarding of water, as they are responsible for more than 70 per cent of water responsibilities and management globally, and also make up the majority of agricultural workers in many countries. Studies of women in agriculture often focus on workload, tasks, allocation of time, access to land or credit, and rarely on women as owners, users of technology, and legal aspects. A case study from Zimbabwe illustrates how gender affects everyday farming in many ways, for example rights to land: women's land is called a garden, while men's land is the agriculture/productive land. Frequently, the right to land for women is a negotiation and they may not have official rights, only unofficial.

Thus, the issue of rights to resources is crucial and complex and needs the gender perspective. There are many different rights that control access to water. Legal rights on paper do not always ensure practical implications. Other kinds of rights such as customary law can overrule legal rights in terms of access to, and use and control of resources. With respect to water, it is often considered female when collecting for household needs, while male in water infrastructure and technical development. Methods for gender analysis range from counting women and men (at its simplest level), to analysing gender as social relationships, explaining identity and diversity beyond gender, and into intersectionality and reflexive questioning of knowledge production.

The example below from Lesotho illustrates the importance of also considering broader social factors that determine adoption of sustainable management of water in the landscape, and that it should be coupled with an historical perspective and consideration of local knowledge.

Box 9: Poor management of a mangrove wetland in Colombia risk its Ramsar status

Figure 13. Dead mangroves in the Ciénaga Grande de Santa Marta wetland on the Caribbean coast of Colombia. Photo: Lucia Licero, INVEMAR.

The Ciénaga Grande de Santa Marta wetland on the Caribbean coast of Colombia is one of the largest coastal lagoon delta ecosystems in the Caribbean with an approximate extension of 1,280km2. The wetland has been protected by the Ramsar Convention since 1998 and became a Unesco Biosphere Reserve two years later. However, it has lately become a symbol of the human-driven ecological degradation of coastal wetlands in the Americas. Its mangrove ecosystems experienced severe mortality episodes starting in the 1950s that reduced their coverage from more than 500km2 in 1956 to less than half, 226km2, in 1996. The wetland mortality has been related to a combination of drought conditions, blockage of the freshwater inputs and strong modification of the natural hydrological connectivity of the brackish waters with rivers and sea, due to the construction of two roads. Despite the degradation, it is estimated to be among the most productive wetlands in terms of water column primary productivity and as one of the most irreplaceable ecosystem on Earth for threatened species.

The cause for the hydrological isolation was the lack of initial adequate drainage systems in roads isolating the wetland from the sea and its main tributary rivers. Freshwater withdrawals for agriculture, flow regulation and heavy loads of suspended sediment from the Magdalena River, which drains almost half of the Colombian territory, have also drastically reduced the flow of freshwater, generating hyper saline conditions intolerable to the mangrove species. To restore hydrologic connectivity between the wetland and its original freshwater sources, various restoration projects aiming to dredge occluded channels were initiated. The effectiveness of such programs is still in doubt, since it has been difficult to demonstrate if dredging and not hydroclimatic change is the reason of increasing freshwater inputs and reducing salinity. Despite a slow recovery in mangrove coverage, a recent visit to the wetland by the Ramsar Convention has stated the possibility of the wetland losing its protection category. It is up to Colombian environmental authorities to improve environmental governance in the area, and to exert control on the actors taking the freshwater supply to the wetland for their own benefits.

The Ramsar Convention – an international agreement to protect and restore wetlands

Challenges in preserving, restoring and protecting wetlands for increased biodiversity, hydrological functioning and climate change mitigation are global. Wetlands are threatened in many parts of the world due to changes in flow regimes caused by, for example, drainage and increase in sediment loads. Climate change also increases the pressure on wetlands. The Ramsar Convention is the intergovernmental treaty that provides a framework for the conservation and sustainable use of wetlands and their resources. The Convention was adopted in the Iranian city of Ramsar in 1971 and today has 170 contracting parties and 2,314 designated Ramsar sites of which 65 are in Sweden.

A common problem in drained wetlands are peat fires. As wetlands are drained and the climate becomes drier, the risk of peat and tundra catching fire increases. Peat fires release large amounts of greenhouse gases from the soil, thereby accelerating climate change. The fires also represent a health hazard. It is therefore important to restore and protect wetlands in the vicinity of cities, so-called urban wetlands. In the future, objectives for management of wetlands should be more closely linked to the emission targets under the UNFCCC, as some drained fields are a major source of emissions. The importance of emission reductions could be used as arguments for more investments in wetlands. Improved governance of wetlands in the landscape should thus also consider links to climate policies.

Swedish governance experiences in water and landscape management

The Swedish government annually invests 200 million Swedish kronor in wetland restoration and construction. The main objective is to strengthen the landscape's own ability to maintain and balance water flows and improve water quality. LONA - the local nature preservation effort - was initiated in 2004 and provides support to area protection and restoration. All supported activities are detailed in the LONA registry, which provides the opportunity to learn from previous experiences and identify good practice. Despite these efforts, Sweden has difficulties in meeting the environmental target of diverse and teeming wetlands. During the nineteenth century, large areas of wetlands were drained to create better soils for agriculture and forestry (Figure 14). This contributed to Sweden's economic prosperity through improved agricultural yields and wood production, but technology implementation has not been optimal for storing water in the landscape.

Conventional drainage-based land use of wetlands and peat soils causes a large array of problems, such as land subsidence, increased greenhouse gas emissions, eutrophication and soil degradation. One way to prevent these problems is by re-wetting the drained peat soils. Lands that are too degraded to be restored to wetlands for nature conservation, can instead secure biomass production through continued cultivation with wetland plants. This cultivation process is called paludiculture. Paludiculture biomass can substitute fossil raw materials, which leads

Figure 14. Draining of farmlands in Skaraborg, western Sweden, in 1941. Museum of Västergötland. Photo: Anders Karlsson.

to further reductions of greenhouse gas emissions. As in the case of Västra Götaland (see chapter 4), there is an increased interest in implementing NBS to address climate change challenges, and to reduce flood risk in the landscape, which may also contribute to improved functioning of wetlands in the long term. Another good example from Sweden is the "Greppa Näringen" programme, a Public Private Partnership (PPP), which uses a stakeholder participatory approach to reduce nutrient loads to water bodies in agricultural landscapes (see Box 4 in chapter 2).

Source-to-Sea management

The case described above of the threatened coastal wetland in Colombia illustrates the need to apply a systems perspective to address key drivers and issues within landscapes. It is necessary to engage stakeholders and together find common objectives and solutions. It is also important to manage upstream and downstream challenges in the landscape in an integrated way. Land and oceans are connected by water flows, and to ensure healthy coastal zones, management practices upstream at the water source need to consider the effects downstream on coastal and marine areas. To address these challenges, to identify best practice, and learn from successful experiences, SIWI has initiated the "Action Platform for Source to Sea", a multi-stakeholder platform on Source-to-Sea (S2S) management where stimulating partnerships and catalysing action is the main focus. For more information: www.siwi.org/source-to-sea/

The application of integrated S2S approaches are still limited, and management strategies often focus on either freshwater or oceans, but the S2S approach is being operationalised in bodies such as the Swedish Agency for Marine and Water Management (SwAM), and the Canadian Atlantic Coastal Programme. However, S2S potential is still not realized in most parts of the world.

Market-based instruments

In production landscapes it is important to also work with the private sector to improve water and landscape governance. For example, the global food sector uses more than 70 per cent of the world's freshwater supply to produce the groceries we consume. The food industry is thus sensitive to changes in water supply and quality, while it also has a great responsibility and potential to improve the water situation by using water more efficiently, recycling water, reducing food waste and water pollution. By assessing water risks and addressing water in their own operations and supply chains, companies can safeguard business operations, save money through efficiency gains, and, simultaneously, contribute to more sustainable societies.

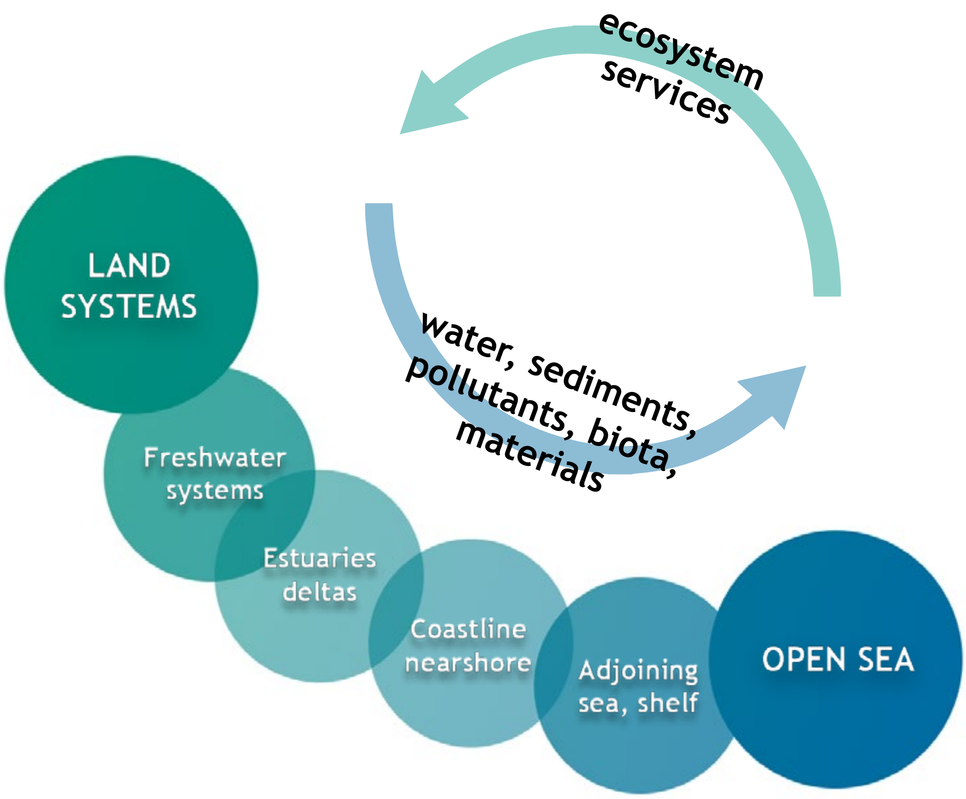


Figure 15. Conceptual model of S2S flows. Granit, Liss Lymer, Olsen, Tengberg, Nömmann and Clausen. 2017. Water Policy Int.

Two key challenges for food companies are to increase awareness of water risk within the sector, and to consider water in business strategies. Initiatives such as the CEO Water Mandate, which is a UN Global Compact initiative, has been initiated to mobilize business leaders to advance water stewardship, and thereby highlight water issues. Several international food companies endorse the CEO Water Mandate and thereby recognize that they can identify and reduce critical water risks to their businesses. The mandate offers a platform to share best and emerging practices and the initiative is open for all different business sectors, why the focus is on water management and stewardship in general.

There are several tools available to support companies in their water management strategies, and specifically to evaluate water challenges and to map water risk. Some of the best-known tools for water risk mapping are Aqueduct, WWF Water Risk Filter, and Water Footprint Assessment Tool. These tools can be used by companies to understand water context in different geographies, and in which they operate. The tools consider parameters such as overexploited water resources, contamination of water, ecosystem health, and people's access to improved drinking water sources.

Food companies can work with water issues in different ways, but the approach of water stewardship is a commonly referenced framework for companies that go beyond risk mapping. The concept of water stewardship serves to unite a wide set of stakeholders in water management, and stewardship often refers to business action on water challenges. To work with water stewardship means improved water use and a reduction in the water-related impacts of internal and value chain operations. The stewardship approach is also focused on a sustainable management through collective action with other businesses, governments, NGOs and communities.

There are several guides available to help companies develop meaningful water strategies, such as SIWI SWH's "Water Journey" (Box 10), or WWF and Ceres "AgWater Challenge".

Box 10: SIWI Swedish Water House's Cluster Group on Food and Water

For several years, SIWI SWH has worked with Swedish food and beverage companies and retailers to identify water issues in food production. Popular standards and tools used by food and beverage companies and retailers globally have been evaluated. Important water issues are listed below, and a water relevance guide to standards and tools can be accessed through the SWH website.

It is a stepwise, interactive process, where the first step is to understand the context in which a company operates, and identify where in the value chain a company impacts water resources. The next step is to prioritize efforts and conduct feasibility analysis to provide clear definitions and outline expectations. Based on risk mapping and assessments, policies with clear targets and indicators can be developed. The next step is to take action, and as water is often a shared resource between different users, a collective "water stewardship approach" is recommended. The last important step is to follow up performance and to report results to stakeholders.

Conclusions

- Landscape approaches need to work with nested governance arrangements, from multilateral environmental agreements to local level customary or statutory law and take gender and power relations into consideration.
- Public participation in landscape governance has evolved over time and more inclusive and participative approaches have been adopted by Swedish institutions and in the EU Water Framework Directive, as well as in many developing countries, such as Lesotho.
- Wetlands are threatened in many parts of the world from changes to flow regimes caused by e.g. drainage and increase in sediment loads where the ultimate drivers are linked to poor governance. The Ramsar Convention is important for the governance of wetlands, but its implementation needs to be strengthened through, for example, linking it to emission reductions under the UNFCC as well as S2S management governance frameworks.
- Private sector companies are important actors in landscape approaches and can play a positive role through different tools and instruments, including water stewardship to reduce water-related impacts of internal operations and value chains.

Chapter 6

Conclusions and recommendations

As we have seen in this report, landscape management is complex. It needs to deal with multiple objectives, and multiple stakeholders and governance levels. It is site-specific, and it is therefore impossible – even undesirable – to present a blueprint for water management in the landscape. However, what is emerging from our overview is that although landscape management strategies are knowledge- and capacity-intensive, as well as context-specific, good experiences from Sweden and elsewhere exist and can be shared. Degraded landscapes mean lost opportunities and negative impacts for people, society, and economies, and for ecosystem services and environmental flows. There are both global and local challenges that put specific landscapes at risk for becoming more degraded, or remain in degraded states, unless proactive management is implemented. The current use of water and land resources, population growth, changes in consumption patterns and diet, as well as climate change, are some of these challenges.

Regarding our initial questions for this report, about ***what hydrological aspects need to be considered when restoring landscapes***, we note that climate change impacts have increased the need to regulate and manage the use of water resources, especially when it comes to degraded landscapes. But more resources and efforts are needed to improve the basic understanding of how water moves in landscapes. Currently, critical landscape water data on availability and use is often lacking in public (open) data sources. There is a lack of data on water flows, storage and quality at landscape scale affecting the efficient use of water. And in particular, there is a need for integrated (cross-cutting) strategies that introduce evidence and science into decision-making on investment and management. This will ensure that land and water resources in degraded landscapes are used to work towards food security, healthy ecosystems and climate resilience. We need to make data and information available and conduct analysis of needs. The lack of data and capacity to analyse and support improved landscape water management, especially in degraded landscapes, is thus a serious barrier to the sustainable and productive use of land and water. Addressing this challenge also requires more trained land and water management expertise, especially in the global South.

Figure 16. SIWI's project around Lake Awassa in Ethiopia will strengthen water and landscape governance through capacity building and training of stakeholders from the local to national level. Photo: Anna Tengberg.

In terms of new knowledge generation, Sweden has contributed to research that shows the relationship between water and forest is context-specific, and that it must be understood at multiple spatial and temporal scales. For example, forests and their evapotranspiration, as well as other land uses, can have downwind effects on precipitation at the continental scale. There is thus a need to widen the geographical perspective from watersheds to whole continents and cross-regional perspectives to understand from where precipitation originates. This would allow a better integration of land use-driven water and energy cycles into regional, national, continental and global decision-making. Infiltration of water to the soil, and recharge of groundwater require that we also focus on trees rather than on forests, and their effect on infiltration. The specific tree density that maximizes groundwater recharge will depend on several factors including climate, soil characteristics, tree species, tree age and size, tree spatial distribution, as well as land use and management.

With respect to our second question, ***which governance arrangements and management approaches should be used***, we cannot give a simple answer. But inclusive and nested governance arrangements, which consider local perspectives while linking with global agendas for landscape restoration, human wellbeing and nature conservation, seem to be the most effective approach. Public participation is key to successful restoration. In Sweden, this has evolved over time, and land and water management and policy development have become increasingly inclusive and participative. There are many opportunities for landscape restoration, particularly in forest landscapes. International commitments, such as the Bonn Challenge and the New York Declaration of Forests, set ambitious targets for restoration of forest landscapes. Many countries in the global South have already committed to restore millions of hectares of land. The Ramsar Convention is important for the governance of wetlands, and we see opportunities to strengthen linkages to emission reductions under the UNFCCC, as well as to the source-to-sea management framework. Bottom-up and participatory approaches to monitoring and modelling of water flows and other ecosystem services can further support the inclusion of more perspectives and scenarios, and lead to the development of more informed and comprehensive solutions that will benefit local stakeholders. Another key factor for successful management of natural resources in the landscape is to work with partnerships. A forum which offers neutral arenas for dialogue between different interests seems to be an important tool to move forward and review results. The private sector is also an important stakeholder in landscape approaches and can play a positive role through different tools and instruments, including Public Private Partnerships, and water stewardship to reduce water-related impacts of internal operations and value chains. For example, in situations with rapid structural transformation of agriculture with the development of larger and fewer farms, which has been the case in Sweden, long-term and systematic support to farmers is crucial to success, and could be provided through Public Private Partnerships. Remaining challenges include financial sustainability and to build a resilient social network, which takes into consideration gender aspects and other power relations.

This report highlights a number of ***best management practices and tools*** that can be used in landscape management with a focus on better integrating hydrological and water management aspects. For example, nature-based solutions for the management of climate risk and flooding are being tested in western Sweden. They have shown to be cost effective, in terms of overall benefits for restoring specific ecosystem services related to land, water and biodiversity. However, it is important to consider potential conflicts of interests between nature-based solution measures and pressing needs for farmland. In addition, several tools that can support landscape management at different scales have been developed, including geographical water balance models that can assist in the planning of adaptation measures in landscapes. Sweden has also contributed to development and testing of new technology for rainfall monitoring using microwaves

Figure 17. Landscape approaches that integrate water management aspects can contribute to several Sustainable Development Goals (SDGs), especially SDG 2 on Zero Hunger, SDG 6 on Clean Water and Sanitation, SDG 13 on Climate Action, and SDG 15 on Life on Land.

from telephone masts that could help inform management of landscapes in a changing climate, especially in low-income countries that do not have any other infrastructure to measure weather-related data. A range of more participatory tools have also been developed, such as forest and water monitoring frameworks and blue targeting online tools to enable practitioners to consider water in forest/tree-related projects and adopt best management practices. Citizen science takes participation one step further to co-generation of knowledge, which brings citizens into the democratic dialogue, something that has been spearheaded for biodiversity monitoring in Sweden and water monitoring in several developing countries. Under the right circumstances, the global South could thus benefit from leap-frog technologies, tools and practices to improve monitoring and management of water in the landscape.

Our final question is h***ow Swedish stakeholders could engage in international water and landscape dialogues and processes***. The updated Swedish Policy for Global Development (PGU, 2017) provides a platform for the Swedish resource base to develop an integrated and co-ordinated approach to bilateral and multilateral dialogues and programmes. Sweden could catalyse positive change in the management of landscapes at the global level by sharing its extensive experiences and knowledge on integration of land and water aspects when restoring and managing landscapes. Furthermore, Sweden adopted its first National Forest Programme in May 2018 with goals for both national and international forest use and management, and for forests to support ecosystem services such as water quality and flows. The programme states that Sweden shall support the role of forests and forest landscapes for sustainable development within EU, UN, and other international contexts but also in bilateral and multilateral programmes. If due considerations to hydrological aspects of trees and forest are considered, this could contribute significantly to improved water security in landscapes, and improved water flows and water quality in many parts of the world.

Finally, improved integration of land and water management aspects into the landscape approach is important to reach several of the Sustainable Development Goals (SDGs), notably SDG 2 on Zero Hunger, SDG 6 on Clean Water and Sanitation, SDG 13 on Climate Action, and SDG 15 on Life on Land. Sweden is an important bilateral donor to the SDGs through its bilateral aid as well as through international institutions and funds, such as the Global Environment Facility and the Green Climate Fund that are linked to the commitments under the Multilateral Environmental Agreements. In addition, the Swedish private sector has shown commitment to more integrated landscape approaches to water risk and value-chain management in Sweden and abroad. An intensified and more coherent Swedish engagement in restoration of degraded landscapes globally could thus become a substantial contribution to the fulfilment of the SDGs.

To sum up, we recommend combining the different aspects of landscape management discussed above in a flexible and adaptive manner. For the benefit of livelihoods, the environment and the climate, the following recommendations are especially important to consider for sustainable management and, when necessary, restoration of productive landscapes:

- Improved integration of land and water considerations and understanding of hydrological processes in landscapes, as addressing water management is often a key entry point to restore degraded lands and to enhance landscape resilience for the benefit of local people.
- Continuously support the development of new integrated knowledge of evidence-based management and strengthening of capacity for innovative and integrated solutions for landscape restoration.
- Strengthened multi-level governance arrangements that allow for genuine stakeholder participation in landscape management and decision-making.
- Identification and use of best management practices and innovative tools that provide practical on-the-ground solutions to sustainable management and monitoring of water in the landscape.
- Adequate and long-term financing from both the public and private sectors to sustain ecosystem services important for the long-term productivity and sustainability of landscapes.

Operationalizing existing national and intergovernmental governance frameworks and policies, in Sweden and internationally, coupled with application of the latest scientific and technical knowledge and co-production of knowledge with local stakeholders would thus provide a good starting point for sustainable management of water in the landscape, leading to productive and multifunctional landscapes that contribute to achieving the SDGs.

List of acronyms

AGWA	Alliance for Global Water Adaptation
ARCS	Arenas for Cooperation through Citizen Science
BMP	Best Management Practices
BR	Biosphere Reserve
BT	Blue Targeting
CBD	Convention on Biological Diversity
CEO	Chief Executive Officer
CS	Citizen Science
ELC	European Landscape Convention
ET	Evapotranspiration
EU	European Union
EWD	Ericsson Weather Data
FAO	Food and Agricultural Organization of the United Nations
Focali	Forest, Climate and Livelihood Research Network
GEF	Global Environment Facility
GGW	Great Green Wall
IUCN	International Union for Conservation of Nature
IVL	Swedish Environmental Research Institute
LONA	Local Nature Preservation Effort
LRF	Federation of Swedish Farmers
LUCSUS	Lund University Centre for Sustainability Studies
MEA	Multilateral Environmental Agreement
MF	Model Forest
NBS	Nature-Based Solutions
NGO	Non-Governmental Organization
NHB	Natural Heritage Board
PES	Payment for Ecosystem Services
PGU	Swedish Policy for Global Development
PPP	Public-Private Partnership
REDD	Reduction of Emissions from Deforestation and Forest Degradation
S2S	Source-to-Sea
SDG	Sustainable Development Goal
SEPA	Swedish Environment Protection Agency
SFA	Swedish Forest Agency
SIANI	Swedish International Agricultural Network Initiative
Sida	Swedish International Development Agency
SIWI	Stockholm International Water Institute
SLU	Swedish University of Agricultural Sciences
SMHI	Swedish Meteorological and Hydrological Institute
SRC	Stockholm Resilience Centre
SSC Forestry	Svensk Skogscertifiering AB
SwAM	Swedish Agency for Marine and Water Management
SWH	Swedish Water House
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on the Environ-ment
UNFCCC	United Nations Framework Convention on Climate Change
WASH	Water Sanitation and Hygiene
WFD	Water Framework Directive
WWF	World Wide Funde for Nature

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The report builds mainly on presentations and reports from the five seminars/meetings organised by the Cluster Group on Water in the Landscape:
www.swedishwaterhouse.se/water-landscape

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About the Swedish Water House Cluster Group on Water in the Landscape

SIWI Swedish Water House took the initiative to bring together Swedish expertise and stakeholders in Swedish and global/international landscape management and restoration. The aim has been that Swedish scientific and practical knowledge of hydrology and water-related ecosystem services, as well as restoration to productive multifunctional landscapes, are highlighted in Sweden's Global Development Policy and Sweden's Agenda 2030 Strategy, and inform global restoration initiatives. Core members of this group were representatives of SIWI Swedish Water House, the Swedish Forest Angecy, the Swedish University of Agricultural Sciences, DHI Group, Ecoloop, and Stockholm University/Stockholm Resilience Centre.

About SIWI reports

At the core of SIWI's work is sharing the research results and knowledge that the institute's experts generate. Our goal is that SIWI's reports will enlighten and inspire the global discussion about water and development issues, thus helping to build a water wise world.

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a water wise world

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