SIWI

Comprehensive assessment of water management in agriculture

water for food, water for life issuebrief#1

Reaping what we sow:

Acting now to reduce the negative environmental consequences of agriculture

Historically, agriculture has been a major driver of ecosystem loss and degradation (Box1). But the Comprehensive Assessment suggests that by changing how we manage water and land resources for agriculture, we can mitigate or even avoid many of these negative impacts.

What is often not considered in decision-making and management is that agricultural systems can generate valuable 'ecosystem services'—besides food, fiber and fuel. These include nutrient-cycling and soil-formation processes, as well as flood, erosion and water-quality control, and cultural and aesthetic benefits. These services generally go unrecognized, with the result that development choices and management regimes may result in unwitting tradeoffs between services. Yet in many cases these multiple services could be maximized to provide more productive and sustainable agro-ecosystems.

To avoid further damage to the environment, a new integrated and adaptive approach is needed to manage the water used by agro-ecosystems. This should maximize the number of ecosystem services that farming landscapes supply (Box 2). This will require efforts to make people more aware of the benefits that ecosystem services provide (Box 4) and informed consideration of the trade-offs between producing food and sustaining other ecosystem services.

Box 1: How agriculture can negatively impact ecosystems

- River depletion and consequent degradation of downstream aquatic ecosystems, including effects on estuaries, groundwater and fisheries.
- Drainage of wetlands and run-off or discharge of wastewater to surface and groundwater-dependent ecosystems.
- Groundwater depletion by over-exploitation for irrigation, causing damage to groundwater-dependent ecosystems.
- Pollution from overuse of nutrients and agro-chemicals with consequences both for terrestrial and aquatic ecosystems and for human health because of water pollution.
- Introduction of invasive species that can displace native species and adversely change nutrient and energy cycles.
- Combined situations where river depletion exacerbates water pollution problems by decreasing possible river dilution.

(Based on the Millennium Ecosystem Assessment www.maweb.org)

Tools already exist to help decision-makers assess such trade-offs. Using these, policy-makers and land and water managers can exploit opportunities for increasing production while reducing environmental impacts—an approach that will bring more benefits than focusing on either goal alone.

In the past, agricultural and environmental conservation goals have been seen as oppositional, rather than complementary, but now awareness is growing on both sides of the fence that this is not the best way forward. International initiatives such as the Ramsar Convention on the Conservation of Wetlands and the Convention on Biological Diversity (CBD) are leading the way—adding the promotion of synergies between agriculture and ecosystems management to their agendas.

Box 2. Maximizing ecosystem services: A new approach

Manage agro-ecosystems in the context of the larger landscape—integrated management

Manage agro-ecosystems for a range of ecosystem services—not just crop production

Manage agro-ecosystems to cope with uncertainty and to retain their ability to recover after damage ('ecosystem resilience')

Agricultural development: Why take an ecosystem approach?

Over the last century, people have primarily managed agro-ecosystems to optimize crop production—without considering the larger landscape. But, changing water flows through diversion for irrigation and agricultural drainage, clearing natural vegetation, and polluting water with fertilizers, herbicides and pesticides all reduce the ecosystem services an area can provide (Fig. 1), and in some cases can even jeopardize food production.

The Aral Sea is a dramatic example of consequences from a narrow focus on crop production. Due to water diversion for large-scale irrigation, the Sea shrank by 75%, large areas of wetlands were lost, and fisheries collapsed with a loss of 60,000 jobs. The effects are on-going—huge quantities of toxic wind-blown dust containing agro-chemicals are now killing crops and causing serious lung disease in the region.

Comprehensive Assessment findings suggest that meeting food needs of a growing population should be 'eco-sensitive' with intensification—growing more on existing farmlands with less water and continuously monitoring potential impacts. If done carefully this should lead to fewer ecosystem services being lost than in the past. We can also reduce these impacts by placing new focus on better managing agro-eco systems and their services (Box 2). But such an approach requires difficult trade-offs to be made between conservation, economic growth or optimal food production in a given system. Governance systems are a key to make such choices and need to be revisited to meet the challenge.

Fig. 1 Ecosystem services

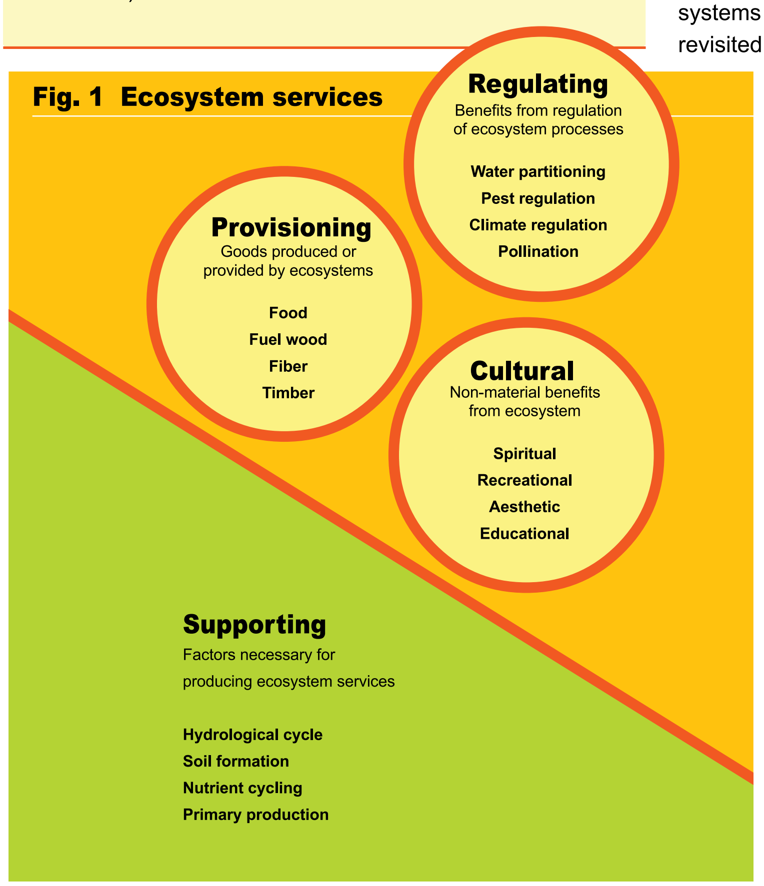
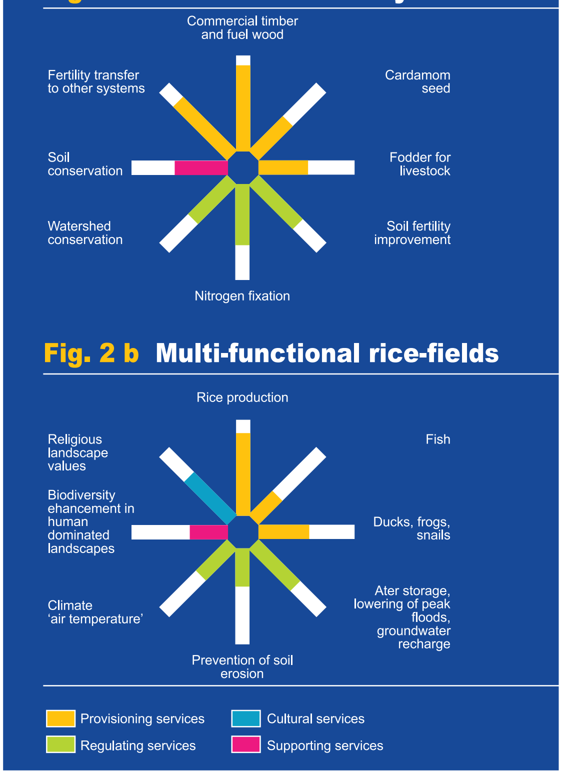


Fig. 2 a Alder-cardamom system

Fig. 2 b Multi-functional rice-fields



Box 3. What is needed to shift to managing for more ecosystem services?

Raised awareness of the role of ecosystem services through education, information dissemination, and dialogue between stakeholders, sectors and disciplines.

Greater scientific understanding of ecosystem services, inter disciplinarity, adaptivity and uncertainty.

More tools for assessing trade-offs—to help us decide which ecosystem services in a particular area most benefit society. Existing tools range from cost-benefit analyses and risk and vulnerability assessments, to 'desktop' models for estimating the water flows required by wetlands.

Better assessment and monitoring, especially of factors related to ecosystem resilience and thresholds that, once crossed, mean a system can no longer provide a particu-lars ervice.

New 'paths' for integrated, inclusive decision-making —currently a complex of policies and organizations governs environmental management.

Managing agro-ecosystems as part of the larger landscape

Seeing the big (landscape-level) picture is vital if managers are to avoid creating one problem when solving another, as has happened so often in the past. Dams built on the Zambezi River in Mozambique, for example, have reduced flows and caused losses of up to US$10 million per year in the country's coastal prawn-fishing industry. It is unlikely that these distant impacts were adequately considered when the dams were first proposed.

An integrated approach allows decision-making about land-use and water management to consider all potential benefits and costs—including effects on ecosystem services and social equity—and not just the effects on food production.

Such decision-making should be transparent and involve key stakeholders from all relevant institutions. Only then can a socially acceptable equilibrium be found when balancing health, environmental and development priorities.

Managing agro-ecosystems for multiple ecosystem services

Managing agricultural systems to provide a broader array of services brings a range of benefits. This affects the poor particularly, as they often depend directly on the ecosystems for small-scale farming, fishing, hunting, livestock grazing, and the collection of firewood and other products.

Women and children most often engage in these ecosystem-dependent activities. So, managing for multi-functional ecosystems can also benefit vulnerable social groups and reduce poverty.

Nepal's 'alder plus cardamom system' (Fig. 2a) is a good example of such multiple-benefit systems. The alder trees (which fix nitrogen and provide timber) are under-planted with a cardamom cash crop. The system prevents soil erosion and provides a habitat for forest species, by mimicking a forest's structure.

Irrigated rice (Fig. 2b; Box 4) also illustrates how changing management can maximize different services. Permanent flooding, for example provides many benefits, including enhanced soil processes and biodiversity, the breakdown of nitrates, and weed control. The mid-season drainage practiced in China and Japan, on the other hand, greatly reduces emissions of methane (a greenhouse gas). Alternately wetting and drying fields can control mosquitoes and snail numbers—which can transmit the parasites that cause malaria and schistosomiasis. And, in the USA (California), leaving rice-fields flooded in winter provides a habitat for waterbirds.

Box 4. Some ecosystem services provided by multi-functional rice-fields

Provision:	rice fish and ducks (sometimes frogs and edible snails)
Regulation:	large water storage capacity, which also helps to reduce flooding sediment and nutrient trapping (better water quality) soil erosion and landslide prevention greater groundwater recharge (increasing water availability to poor farmers who tap shallow aquifers)
Supporting:	high biodiversity, due to complex mosaic of flooded fields, canals and dry land
Cultural:	social cohesion (as community approaches needed to build and run irrigation systems) traditional festivals and religious rites scenic beauty

Managing agro-ecosystems for resilience and uncertainty

Addressing the loss of 'resilience' in human-dominated systems is crucial, as once they degrade past a certain ecological 'tipping point', ecosystems can change profoundly and suddenly, which results in certain services being lost. The fertilizer-pollution-caused algal blooms that 'kill' large stretches of rivers and coastal ecosystems are a good example.

Box: 5 Wetlands losing ground to agriculture

Drainage and conversion for agricultural use is the major, and most direct, cause of wetland loss globally. By 1985, it was estimated that 56-65% of available wetland had been drained for agriculture in Europe and North America, 50% in Australia, 27% in Asia, 6% in South America and 2% in Africa.

(Based on the Millennium Ecosystem Assessment www.maweb.org)

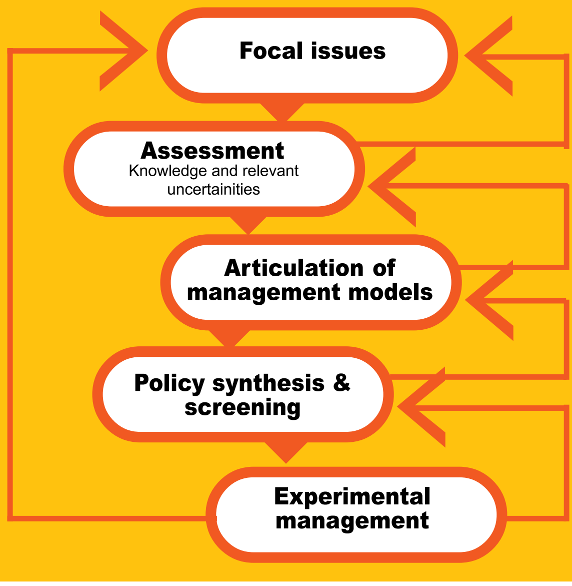
To avoid crossing these thresholds, more work is needed to identify them and to find early-warning indicators. We also need to recognize that degradation is not a linear progression, that it is not caused just by one factor, and that extreme events (such as droughts, storms and floods) can fast-forward ecosystem change. The potential impact of climate change on ecosystems and of ecosystem change on climate also needs to be considered.

Management to maintain biodiversity can increase ecosystem-resilience, as having more species acts as an insurance mechanism. For example, if one species is lost, another with similar characteristics may be able to replace it. What is more, species whose roles do not seem important when conditions are stable may play a crucial part in helping systems to recover after disturbance.

Ecosystems are complex and variable, and do not always act or react in predictable ways. We have to adapt our management to cope with this reality. While this is an area where more knowledge is needed, some tools do exist that can be used to take account of this uncertainty when managing agro-ecosystems. Adaptive management (Fig. 3) is one example. It is an essential component in a changing process—politically driven—to negotiate trade-offs between ecosystem sustainability and food security.

Fig. 3 Adaptive management

Some of the steps involved in 'adaptive management': a process which treats policies as hypotheses (not solutions) and management as experiments. This is effective in situations where many uncertainties exist and has proved useful in managing major river systems in South Africa and across the USA.



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Comprehensive assessment of water management in agriculture

For more information. Email: comp.assessment@cgiar.org **Visit: www.iwmi.cgiar.org/assessment**

CA - The Comprehensive Assessment of Water Management in Agriculture (CA) is a five-year initiative to analyze the benefits, costs, and impacts of the past 50 years of water development and management in agriculture, to identify present and future challenges, and to evaluate possible solutions. The main Assessment report *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* is published by Earthscan (forthcoming). More on the CA donors, co-sponsors (CBD, CGIAR , FAO, Ramsar), process and publications can be found at: http://www.iwmi.cgiar.org/assessment.

SIWI - Independent and Leading-Edge Water Competence for Future-Oriented Action. The Stockholm International Water Institute (SIWI) is a policy institute that contributes to international efforts to find solutions to the world's escalating water crisis. Many SIWI experts are part of CA writing teams.

Swedish Water House - Building Networks for Water Sustainability. The Swedish Water House supports international policy development and co-operation through knowledge generation and dissemination and partnership building primarily within the areas of sustainable river basin management and integrated water resources management. It supports the Ecosystem component of the CA.

References

This brief is based on the book *Water for food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*, 2006 (forthcoming). In particular, it draws on Chapter 7, "Agriculture, water and ecosystems: Avoiding the costs of going too far" by Malin Falkenmark, Max Finlayson, Line Gordon; Chapter 14, "Rice: Feeding the billions while providing unique ecosystem services" by B.A.M. Bouman, R. Barker, E. Humphreys, T. P. Tuong, and Chapter 15, "Conserving land, protecting water". It also uses findings of the Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-Being: Wetlands and Water Synthesis*, World Resources Institute, Washington, DC.

Figures

Fig. 1. Adapted from the Millennium Ecosystem Assessment, 2003. www.maweb.org

Fig. 2. Adapted from Foley et al. 2005. "Global Consequences of Land Use", *Science* 309: 570-574) in Chapters 7 and Chapters 15 of *Water for Food, Water for Life.*

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