



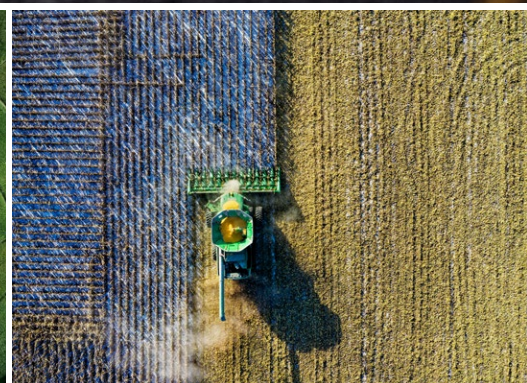
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Convention
on Wetlands

Agriculture and wetlands

Maintaining and restoring wetlands for sustainable
food production and ecosystem health



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Foreword

Wetlands and agriculture are closely linked. Wetlands support agriculture by providing essential ecosystem services, such as regulating water flows, maintaining soil fertility and sustaining biodiversity and habitats, as well as filtering pollutants. When managed sustainably, agriculture occurs alongside wetland conservation and wise use. However, in many regions, unsustainable agricultural practices remain a leading cause of wetland degradation, which undermines food security, climate resilience and biodiversity conservation.

This publication, *Agriculture and Wetlands: Maintaining and Restoring Wetlands for Sustainable Food Production and Ecosystem Health* (Technical Report 13) was developed under Task 3.3 of the Scientific and Technical Review Panel (STRP) of the Convention on Wetlands. It was co-led by the Food and Agriculture Organization of the United Nations (FAO) and IHE Delft, and contributions were made by experts from across the world.

This report brings together the latest scientific and technical knowledge, it defines agriculture-wetland interactions and synthesises global case studies to offer Contracting Parties and practitioners clear guidance on harmonising food production with wetland conservation. It provides an in-depth review of the direct and indirect drivers of wetland change in agricultural settings, a typology of farming systems, and practical recommendations to enhance the efficiency of resource use, strengthen multi-stakeholder governance and deploy nature-based solutions across catchments.

Spanning every Convention on Wetlands region, the 18 case studies reveal shared lessons: effective institutional coordination, supportive policy frameworks and tailored technical and financial support for farmers are indispensable for success. The case studies, ranging from peatland value chains in Germany to traditional rice-wetland systems in Sri Lanka, collectively illustrate the five sustainability principles at the heart of this report, guiding us towards agricultural landscapes in which wetlands and crops can flourish side by side.

We invite Contracting Parties, national and local authorities, agricultural and environmental agencies, and all partners to embrace the recommendations for sustainable agriculture. By integrating wetland values into planning, mobilising innovative finance and encouraging public-private cooperation, we can ensure the productivity of our fields and the resilience of our wetlands. In doing so, we honour the wise-use mandate of the Convention and set out a sustainable path for both food production and ecosystem health.



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Table of Contents

Foreword	4
Summary	6
1. Introduction	9
2. Wetlands and agriculture	11
2.1. Wetlands and Agriculture and the Convention on Wetlands	11
2.2. Wetland management and restoration	14
2.3. The role of wetlands in catchment hydrology and ecology	15
2.4. Food production and the impact of agriculture on wetlands	20
2.5. Sustainable agricultural systems and practices	23
2.6. Sustainable food systems	25
3. Global case studies on agriculture-wetland interactions	28
3.1. Background	28
3.2. Sustainability analysis	28
3.3. Agriculture-wetland interactions: case study evaluation	30
3.4. Case study summaries	33
4. Synthesis and lessons learnt from case studies results	51
4.1. Key insights in wetlands and agriculture	51
4.2. Recommendations for action	54
5. Conclusions	60
Annexes	66

Summary

Wetlands provide essential ecosystem services to agriculture, including regulation of water quantity and quality, biodiversity conservation, and soil fertility. However, unsustainable agricultural practices significantly contribute to wetland degradation, leading to biodiversity loss, altered hydrological cycles, degradation of water quality, and reduced resilience to climate change, ultimately having a negative impact on agriculture itself. The Convention on Wetlands recognises the need for an integrated approach to managing wetlands and agriculture, ensuring sustainable food production while maintaining and enhancing the ecological integrity of wetlands. This report synthesises scientific and technical knowledge on agriculture-wetland interactions and provides guidelines for harmonising agricultural practices with wetland conservation.

Agriculture is both a beneficiary of and a risk to wetland health. Wetlands provide and store water, regulate floods, sequester carbon, regulate temperature, cycle and remove nutrients from agricultural runoff through storage and denitrification, and provide habitat for pollinators and pest predators, directly benefiting agricultural productivity. Despite these benefits for agriculture, agricultural expansion, intensification, and unsustainable practices (such as overgrazing, excessive water abstraction for irrigation, and pesticide and fertiliser runoff) drive wetland loss, habitat fragmentation, and ecosystem degradation. Sustainable agricultural practices that integrate wetland conservation are crucial for achieving long-term food security, climate adaptation, and biodiversity conservation. Managing agriculture and wetlands within a catchment-scale framework enables the balancing of water use, soil conservation, and biodiversity protection.

Interventions must consider variations in farming practices, wetland types, and governance structures to ensure effective implementation. Tailored support for farmers is crucial. Small-scale farmers need assistance to adopt sustainable practices, while large-scale agricultural enterprises must implement Nature-based Solutions (NbS) to minimise their impact on wetlands. Addressing wetland conservation within broader food system policies, including market incentives and value chain adjustments, is essential for long-term sustainability. Multi-sectoral collaboration across agriculture, water, environment, and climate sectors is crucial for aligning policies and management strategies to conserve wetlands effectively.



Rice terraces © Quang Nguyen Vinh

The report presents case studies across all regions of the world that illustrate relevant principles and practices in balancing agriculture and wetland conservation. Examples include the integration of traditional rice farming with wetland restoration in Sri Lanka, where wetland restoration benefits shrimp aquaculture; the adoption of organic farming in Thailand's Yom River Basin; conservation tillage in Türkiye; and restoration in Canada's Prairie Pothole Region, which supports biodiversity and carbon sequestration while maintaining agricultural productivity.

To foster sustainable agriculture-wetland interactions, several actions are recommended. There are multiple options for increasing resource use efficiency in conventional agriculture and reducing its impact on wetlands. A more transformative shift to agroecology, regenerative agriculture and organic farming is expected to have positive effects on wetlands. Financial and technical support for farmers should be enhanced through reforms of subsidies and knowledge-sharing initiatives. Strengthening governance frameworks through multi-stakeholder collaboration is essential. Aligning national policies with international sustainability frameworks will further support the conservation of wetlands.

Protecting wetlands contributes to achieving Sustainable Development Goals (SDGs), particularly those related to food security, climate action, and biodiversity conservation. Healthy wetlands buffer against climate extremes such as floods and droughts, enhancing the resilience of both ecosystems and human communities. Strengthening monitoring and data collection on the impacts of agriculture on wetlands will improve decision-making and policy development.

Sustaining wetlands in agricultural catchments requires a transformative approach that integrates conservation and food production objectives. By adopting sustainable practices, enhancing governance frameworks, and fostering collaboration among stakeholders, it is possible to achieve a balance that ensures both agricultural productivity and the health of the catchment ecosystem. This report provides the scientific foundation and practical guidance necessary to support decision-makers in advancing wetland-friendly agriculture and promoting the wise use of wetlands globally.

Key messages

Wetland wise use and sustainable agriculture

- **Wetlands are crucial for both ecosystem health and food production.** They provide critical ecosystem services, including water quality and quantity regulation, biodiversity support, and temperature modulation, all of which are essential for sustainable agriculture.
- **Wetlands enhance resilience to climate change and other shocks to food systems:** Healthy wetlands mitigate risks such as floods, droughts, crop failures, or market fluctuations, benefiting both ecosystems and human communities.
- **Agriculture impacts wetland ecosystems:** Agricultural practices, such as land conversion, water abstraction, and the use of fertilisers and pesticides, are key drivers of wetland loss and degradation globally.
- **Recognising and managing diversity in wetlands and farming systems is important,** as farming systems and sizes, as well as the ecological function of different wetland types, together shape the context for interventions.
- **The wise use of wetlands supports global priorities:** Aligning wetland management with the Sustainable Development Goals (SDGs) and climate change goals advances food security, climate adaptation and mitigation, biodiversity conservation, and sustainable livelihoods.

Recommendations for action

- **Promote sustainable agricultural practices in conjunction with wetland conservation, tailored to the local context:** Sustainable agricultural practices must be adopted to mitigate pressures on wetlands while enhancing their ecological health and resilience.
- **Support farmers transitioning to sustainable practices:** Small, resource-poor farms require support to enhance productivity and connect to markets, thereby avoiding expansion into wetlands. Larger farms require solutions to mitigate wetland impacts through nature-based approaches, improved efficiency, and sustainable practices.
- **Adopt a food systems approach:** Actions must extend beyond the farm to the entire value chain, including promoting wetland-friendly product labelling, revising incentives and subsidies, and enhancing food system governance.
- **Strengthen catchment management and support policies at national and local levels:** Collaboration across sectors—including agriculture, water, environment, and climate—and at different scales is necessary to harmonise wetland conservation with sustainable agricultural development. This includes establishing robust monitoring frameworks to detect ecological changes early and guide responsive interventions.
- **Promote stakeholder participation and collaboration:** Participation of stakeholders is indispensable for success, and collaboration across the agriculture, water, environment, and climate sectors is essential to harmonise wetland conservation with sustainable agricultural development.

Case studies from all regions of the Convention on Wetlands provide real-world examples that demonstrate practical strategies to balance agricultural productivity with wetland conservation efforts, offering replicable solutions to make agriculture-wetland interactions more sustainable.

1. Introduction

Background

During the 2019-2022 triennium, the Scientific and Technical Review Panel (STRP) of the Convention on Wetlands published Briefing Note 13 - Wetlands and Agriculture: Impacts of Farming Practices and Pathways to Sustainability and Policy Brief 6 - Transforming Agriculture to Sustain People and wetlands. A key advancement of these publications was the recognition of diverse interactions between food production systems and wetland types, necessitating context-specific responses to promote the transition to sustainable, wetland-friendly agriculture.

Resolution XIV.14 requested the STRP to include Task 3.3. "Agriculture and wetlands: maintaining and restoring the ecological character of wetlands in agricultural settings" as a high-priority task, which also contributes to achieving Target 14 of Goal 4 in the 4th Strategic Plan (2016-2024) of the Convention (Enhancing implementation - scientific guidance and technical methodologies at global and regional levels for policymakers and practitioners). Technical Report 13 presents scientific and technical information on the impact of agriculture on wetlands, while Policy Brief 8 summarises the recommendations for policymakers.

The ongoing global trend of wetland loss and degradation has not been reversed in many regions despite the efforts of the Convention's Contracting Parties (Convention on Wetlands 2018a; Davidson et al. 2018; Fluet-Chouinard et al. 2022). This loss impacts not only the area of wetlands but also their biodiversity, including species such as birds and other critical organisms. It also affects human well-being because wetlands provide vital ecosystem services and enhance resilience against climate change. Continued efforts to reverse wetland degradation are crucial to avoid further negative impacts on both ecosystems and human livelihoods (Convention on Wetlands 2018c). A recent analysis of the Convention's guidance and publications on wetlands and agriculture highlighted the need to identify more effective policy responses to address agricultural drivers of adverse changes in wetlands (Finlayson et al. 2024).

Even though functioning wetlands are vital for agricultural development, the expansion of agriculture often poses serious threats to wetland ecosystems. While the underlying causes of wetland loss and degradation are numerous, agriculture is recognised as a major driver (Convention on Wetlands 2018a; Fluet-Chouinard et al. 2022; van Dam et al. 2023). Managing agriculture-wetland interactions is complex because, on the one hand, wetlands play a crucial role in food production by storing and supplying water for crops, livestock and aquaculture, as well as providing habitat for rice and fish production and performing other ecosystem functions. On the other hand, agrifood systems exert significant pressure on wetlands through a variety of pathways and practices, including structural conversion for food production, such as transforming wetlands into cropland or aquaculture ponds or draining them altogether, and through changes in catchment water and nutrient flows, pollution from pesticides, and other forms of degradation (Convention on Wetlands 2022b; van Dam et al. 2025; see section 7.5 below).

While food production is essential, there is a growing consensus on the need for a transformation in agriculture that yields better outcomes in terms of health and nutrition, environmental sustainability, climate resilience, and social equity (e.g., Willett et al. 2019; Webb et al. 2020). A key challenge in addressing wetlands and agriculture has been the diversity of both wetland types and agricultural systems (van Dam et al. 2025), making it difficult to establish universal guidelines or describe 'best practices'. Wetland-agriculture interactions are highly context-specific, requiring recognition of the direct and indirect drivers of change associated with specific agricultural systems in their socio-cultural and political settings. Wetlands are social-ecological systems in which people, ecosystems, and their interactions need to be considered simultaneously, using interdisciplinary approaches (Redman et al. 2004; Partelow 2018). Food production is increasingly understood as embedded in wider social, cultural, economic, and environmental contexts, or food systems, which need to be understood to transform food production into more sustainable directions (van Bers et al. 2019; Ruben et al. 2021; FAO 2022). These insights call for a highly integrated, interdisciplinary approach at multiple scales to mitigate agriculture-related wetland loss and degradation. Briefing Note 13 acknowledged this diversity and context-specificity of wetland-agriculture dynamics (Convention on Wetlands 2022b). The Technical Report presented here builds on and reinforces that principle, offering case studies that demonstrate the lessons learnt and practical implications of this diversity.

The primary objective of this Technical Report is to provide guidance for sustaining the components, processes, and ecosystem services of wetlands (i.e., their ecological character) in agricultural catchments, addressing drivers of change to promote wetland-friendly agricultural practices.



Harvesting Flowers, Vietnam © Quang Nguyen Vinh

The specific objectives of this report are:

- a. Summarise the current knowledge: outline the state-of-the-art of wetland-agriculture interactions, focusing on key food production systems, their interactions with various wetland types, their ecological characteristics and drivers of change originating from these systems.
- b. Identify and analyse case studies: highlight case studies across all regions representing diverse agriculture-wetland systems, wetland types and other key characteristics.
- c. Comparative analysis and synthesis: provide a comparative analysis of case studies and synthesise general lessons learnt and guidelines to promote sustainable agriculture-wetland interactions.

The case studies on key agriculture-wetland systems presented in this Technical Report are relevant to many Contracting Parties (CPs) for identifying management and policy options to promote sustainable agriculture, such as enhancing resource use efficiency, reducing the impact of food production on wetlands, strengthening governance, and addressing institutional constraints to achieve a sustainable transformation. The case studies provide CPs with practical examples to address agriculture-wetland interactions within their unique agroecological and institutional contexts, supporting the maintenance or restoration of 'Wetlands of International Importance' ecological character and promoting wise use while also balancing national priorities such as food security and climate adaptation.

This report begins by introducing the current state of knowledge on the relationship between wetlands and agriculture. It describes the classification of agricultural systems used here and summarises the Convention on Wetlands Classification System for Wetland Type. The role of agricultural systems and wetlands in catchments is described, both in biophysical terms (e.g. the water and nutrient flows, ecosystem functions of wetlands, biodiversity) and concerning the benefits for humans (wetland ecosystem services). An overview is provided of the drivers of change in wetlands, with a focus on those originating from agriculture and food production. Sustainability in food production, the need for transformation, and what would be required to achieve it are also reviewed.

The second part of the report introduces the case studies. It presents a comparative and synthetic analysis, leading to several recommendations for taking steps towards greater sustainability in wetland-agriculture interactions.

2. Wetlands and agriculture

Wetlands play a dual role, supporting both agriculture and the environment while facing pressures from agricultural practices such as land conversion, nutrient runoff, and water extraction. Briefing Note 13 (Convention on Wetlands 2022b) emphasised the need for integrated management, highlighting successful sustainable practices. It calls for policy support, institutional changes, and financial incentives to promote sustainable agriculture that conserves wetlands. Addressing global food demand, climate change, and water scarcity requires transforming agricultural systems to minimise environmental impacts and support wetland conservation.

2.1. Wetlands and Agriculture and the Convention on Wetlands

The Convention on Wetlands has long recognised the intricate relationship between wetlands and agriculture. Over the years, several resolutions and guidelines have been developed to address the sustainable management of wetlands in agricultural contexts. Between 1996 and 2018, the Convention adopted 10 resolutions aimed primarily at integrating wetland conservation with agricultural practices (Finlayson et al. 2024). Some examples are:

- Resolution XIII.19 encourages Contracting Parties to develop sustainable agricultural practices for the conservation of wetlands and guidance tools for the co-management of wetlands, assess the effects of agricultural policies on wetlands and their sustainability, and adapt incentive schemes for the sustainable use and conservation of wetland biodiversity (Convention on Wetlands 2018b).
- Resolution XI.15, which called on parties to ensure that groundwater recharge and flood control services of rice paddies are considered in Integrated River Basin Management (IRBM) processes, to review or formulate national policies for regulating pesticides in rice production, to integrate biodiversity conservation and wise use in rice paddy into national and international policies and strategies, and requested rice and pesticide industries to address inappropriate practices and perverse incentives (Convention on Wetlands 2012).



Fish Farm © Quang Nguyen Vinh

Other resolutions refer to agriculture more indirectly, such as Resolution XIII.25, which emphasises the cultural values and practices of indigenous peoples and local communities in wetland management, which includes sustainable agricultural practices.

In 2022, Briefing Note 13 described the role of wetlands in agricultural catchments, underscoring the importance of maintaining wetland functions to support agricultural productivity and resilience, particularly in the face of climate change and other environmental pressures (Convention on Wetlands 2022b). A key point was the unpacking of wetland-agriculture interactions by recognising the diversity of both agricultural production systems and wetland ecosystems and identifying the need for context-specific responses to promote the transition to sustainable, wetland-friendly agriculture (Convention on Wetlands 2022b; van Dam et al. 2025).

Another significant contribution has been the Convention's participation in global assessments that have addressed the impacts of agriculture on wetlands (e.g., Finlayson et al. 2005; Falkenmark et al. 2007). An important initiative was "Guidelines on Agriculture, Wetlands and Water Resource Interactions" (the GAWI project, 2008-2009), which promoted synergies between agriculture, wetlands and water resources management through the development of guidance on the joint management of agricultural and wetland systems for food production, poverty reduction, livelihoods support and environmental sustainability (Falkenmark et al. 2007; Wood and van Halsema 2008). The GAWI project advocated for a 'landscape approach' which recognises the contribution of wetland agriculture to a range of livelihoods and development goals but also identifies the threats of agriculture to the maintenance of wetlands and their ecosystem services. In this vision, agriculture plays a crucial role in providing essential ecosystem services. Still, these need to be considered within the full set of ecosystem services in a catchment, including the trade-offs with regulating and cultural ecosystem services, as well as biodiversity (see also Wood et al. 2013; Everard and Wood 2018).

While the Convention has recognised the importance of agriculture as a driver of wetland loss and degradation but also for food security and livelihoods, a deeper and broader understanding of the drivers of change in wetlands emanating from agriculture is needed, including the further development of agricultural systems that are aligned with wetland wise use and of the enabling environments for this. In particular, technical guidance is necessary to effectively implement measures that foster sustainable interactions between wetlands and agriculture.

Table 1. Overview of international resolutions, decisions, goals and targets related to ecosystem-based approaches and wetland conservation.

Convention/ Framework	Selected goals, targets and decisions related to ecosystem-based approaches
CBD (UN Convention on Biological Diversity), The Kunming-Montreal Global Biodiversity Framework, adopted at CBD COP15	The Kunming Framework commits to reversing biodiversity loss and establishing a sustainable path for humanity's relationship with nature. The framework outlines four main goals and 23 targets for 2030, enabling sustainable resource use while safeguarding wetland health and agricultural systems critical to biodiversity and human well-being: ■ Target 1: Ensure all areas are sustainably managed through inclusive planning to halt biodiversity loss by 2030 while respecting Indigenous and local community rights ■ Target 2: Effectively restore at least 30% of degraded terrestrial, inland water, and coastal and marine ecosystems to enhance biodiversity and ecosystem functions ■ Target 3: Conserve at least 30% of global land and sea areas, especially biodiversity hotspots, through well-connected, equitably managed protected areas ■ Target 7: Reduce pollution to safe levels for biodiversity and ecosystems, addressing nutrient and pesticide runoff ■ Target 10: Ensure sustainable management of agricultural, aquaculture, and forestry areas to support ecosystem resilience and biodiversity ■ Target 11: Maintain and enhance nature's benefits to people, including ecosystem services vital for agriculture and wetland health, such as water quality, soil health, and pollination

Convention/ Framework	Selected goals, targets and decisions related to ecosystem-based approaches
UNCCD (UN Convention to Combat Desertification), Strategic Framework 2018-2030	The UNCCD addresses land degradation and desertification, focusing on sustainable land management practices. It promotes restoration of degraded lands, including wetlands, as part of its Land Degradation Neutrality (LDN) targets. ■ Strategic objective 1: “To improve the condition of affected ecosystems, combat desertification/land degradation, promote sustainable land management and contribute to land degradation neutrality.” ■ Decision 8/COP.15 # (6): “Invites Parties to explore complementarities within relevant MEAs, within their respective mandates and goals, in the achievement of the objectives of the UNCCD at the national level, including, as appropriate, in the implementation of sustainable land management, ecosystem-based approaches or nature-based solutions”.
UNFCCC - Paris Agreement	Although primarily focused on climate change, the Paris Agreement actively promotes Ecosystem-based Approaches for adaptation and mitigation, recognising the crucial role of healthy ecosystems, including wetlands, in climate resilience. It encourages countries to incorporate nature-based solutions into their climate action plans. ■ National Adaptation Plans (NAPs): UNFCCC promotes ecosystem-based adaptation (EbA) within NAPs, guiding countries to use biodiversity and ecosystem services - such as wetland restoration for flood control and coastal ecosystem management for storm protection - to strengthen climate resilience ■ UNFCCC promotes Nature-based Solutions (NbS) as a key strategy for mitigation and adaptation, including reforestation, wetland restoration, and sustainable agriculture practices that enhance carbon sequestration and improve ecosystem health. ■ Glasgow Climate Pact, adopted at COP26, underscores the necessity of protecting, conserving, and restoring nature and ecosystems as integral to climate action, recognising their role as vital carbon sinks. In support of this, the UNFCCC promotes local and regional initiatives that implement ecosystem-based approaches, focusing on community-based resource management, restoration of degraded lands, and sustainable agricultural practices to enhance resilience to climate impacts.
ITPGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture)	ITPGRFA aims at ensuring the conservation and sustainable use of plant genetic resources, which are crucial for food security and sustainable agriculture. It supports the restoration of agricultural biodiversity, including wetland ecosystems.

Several other international policy frameworks address wetland-related issues (Table 1). The Convention on Biological Diversity (CBD) promotes the conservation of biodiversity, including wetlands, through the adoption of sustainable agricultural practices. The Kunming-Montreal Global Biodiversity Framework, in particular, includes targets for ecosystem restoration and sustainable use of biodiversity (Convention on Biological Diversity 2022). The UN Convention to Combat Desertification (UNCCD) addresses land degradation and promotes sustainable land management practices, which are crucial for wetlands in agricultural areas (Critchley et al. 2021). The UN Framework Convention on Climate Change (UNFCCC) supports ecosystem-based approaches to climate adaptation and mitigation, recognising the role of wetlands in enhancing climate resilience. This includes integrating wetland restoration into National Adaptation Plans (NAPs) and promoting nature-based solutions (UNFCCC 2012; UN-Habitat 2023). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) provides scientific assessments and policy recommendations, emphasising the crucial role of wetlands in sustainable agriculture and ecosystem health.

The IPBES Global Assessment (IPBES 2019, Chapter 2.2) highlights this interdependence by underscoring that:

- Wetlands provide essential biodiversity and ecosystem services, including water purification, flood control, and nutrient cycling, which are vital for sustainable agriculture;
- Sustainable agricultural practices like agroecology and wetland restoration enhance biodiversity and ecosystem resilience;
- Aligning and integrating agricultural policies with biodiversity goals under frameworks like CBD, UNCCD, and UNFCCC is essential for balanced growth and conservation;
- Wetland restoration serves as an effective nature-based solution, supporting carbon sequestration and climate resilience;
- There is a critical need to protect and restore wetlands for the sake of sustainable agriculture and ecosystem health.

2.2. Wetland management and restoration

The Convention on Wetlands Classification System for Wetland Types includes 42 types of wetlands in three main categories: inland wetlands (20 types, about 80% of all wetlands in the world), coastal-marine wetlands (12 types, 10%), and human-made wetlands such as rice paddies, fishponds, constructed wetlands, or reservoirs (10 types, about 10%) (Convention on Wetlands 2010b; Davidson and Finlayson 2018, 2019). About half of inland wetlands consist of marshes, river floodplain swamps, and natural lakes, while one-third (about 5 million km²) are peat wetlands (UNEP 2022).

Human-made wetlands, which are valuable for water management, food production, and other purposes, can play a dual role by functioning as both wetlands and agricultural systems simultaneously. However, data on the extent of human-made wetlands is limited, as the existing estimates are incomplete. In addition, the conversion of natural wetlands for agricultural production often reduces natural wetlands while increasing human-made wetlands. The current estimate of known human-made wetlands is approximately 1.80 million km² (Davidson and Finlayson 2018).

In response to the global decline of wetlands and waterbirds, efforts to protect these ecosystems grew in the 1950s and 1960s, culminating in the signing of the Convention on Wetlands in 1971, which now has 172 Contracting Parties. The Convention has supported wetland conservation through the network of Wetlands of International Importance (Convention on Wetlands 2010b; 2022a), stimulating policy development for wetlands and guiding Contracting Parties on the conservation, sustainable management, and restoration of wetlands. In some world regions, efforts to curb wetland loss and degradation, including those in response to impacts associated with agriculture, have been successful; yet, globally, wetlands remain seriously threatened (e.g., Convention on Wetlands 2018a; Fluet-Chouinard et al. 2022).

The Convention is based on two key concepts: ‘ecological character’ and ‘wise use’. Ecological character refers to “the combination of the ecosystem components, processes and benefits/ services that characterise a wetland at a given point in time” (Convention on Wetlands 2005). This revised definition expands on the original, which focused on ecosystem components and processes, by recognising the role of humans and the benefits they derive as integral parts of wetland social-ecological systems (Pritchard 2018; Kumar et al. 2020). Ecological character is central to ‘the wise use of wetlands’, defined as “the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development” (Finlayson et al. 2011). The sustainable and wise use of wetlands for food production, other forms of livelihood support, and their contributions to human well-being are firmly embedded in the Convention’s goals (Convention on Wetlands 2005).

Box 1. Wetlands, catchments and landscapes

The Convention on Wetlands defines **wetlands** as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres”. Within catchments, wetlands are areas where the soil is saturated with water, either permanently or seasonally, and where the hydrology, vegetation, and soil characteristics are adapted to these wet conditions.

A **catchment** is defined as an area of land where all rainfall drains into a common outlet, such as a river, lake, or sea. Water reaches this outlet by surface flow (overland or in streams) or, after infiltrating into the soil, by sub-surface and groundwater flows. Other terms for catchment are ‘drainage basin’ or ‘watershed’. A river basin is a catchment but can consist of several sub-catchments if the river has tributaries. ‘Catchment’ is a well-defined hydrological term and, therefore, preferred by scientists when they talk about water flows for ecosystems or agriculture.

Landscape is a less rigorous term, usually referring to the visible, physical characteristics of an area of land. The landscape could refer to a part of a catchment but could also refer to several catchments (e.g. when a large river basin consists of several sub-catchments). In this report, the terms ‘catchment’ and ‘landscape’ are both used. We use ‘catchment’ whenever possible, but sometimes ‘landscape’ is more convenient or was cited from a source document.

At the wetland or catchment scale, spatial planning of the use of land and water resources, including for agriculture, helps prevent wetland loss and degradation while supporting river and catchment health. This can lead to wetland management plans (Convention on Wetlands 2010c) or to broader catchment and river basin management plans (Convention on Wetlands 2010a). Key elements of wetland management planning to be considered within agricultural systems include:

- A supportive policy and institutional framework;
- Sites and threats assessments based on available data;
- Clear long-term vision with well-defined shorter-term objectives and action plans;
- Financial and administrative backing;
- Stakeholder participation to enhance support and benefits;
- Monitoring for adaptive management as conditions change (Convention on Wetlands 2010c).

Wetland management spans a continuum. Management focus depends on the condition of wetlands, with restoration of degraded wetlands followed by conservation and wise use of intact wetlands. When severe degradation makes full ecological restoration difficult, efforts may prioritise nature- or ecosystem-based solutions that enhance key ecosystem services. Highly engineered human-made wetlands, such as constructed wetlands for wastewater treatment (Vymazal 2018), serve similar functions. Wetland restoration also supports catchment sustainability by restoring wetland functions in the broader landscape (e.g. Björk 2014).

2.3. The role of wetlands in catchment hydrology and ecology

Wetlands and natural vegetation cover regulate water and nutrient cycles, dissipate solar energy and provide habitats for diverse species. These functions underpin wetland ecosystem services (MEA 2005; Díaz et al. 2015; Convention on Wetlands 2018a). However, the loss of wetlands and vegetation cover has reduced soil moisture and fertility, as well as reduced water quality and ecosystem biodiversity, contributing to climate change. Restoring wetlands requires an understanding of their roles within catchments, which can be categorised into hydrological, biogeochemical, and ecological functions (de Groot et al. 2010; Evenson et al. 2018; Reddy et al. 2022).

Hydrological functions include groundwater recharge, floodwater retention, and sediment retention. Vegetation influences water and nutrient flows, as shown, for example, by early palaeolimnological studies of Sweden's Lake Trummen (Digerfeldt 1972). Catchments with intact vegetation retain water and nutrients efficiently, minimising losses. Clearing vegetation and draining wetlands accelerate the decomposition of soil organic matter, releasing excessive nutrients and reducing water retention. These dissolved inorganic ions then flow into water bodies such as rivers, lakes, groundwater, and ultimately the sea (Ripl 1992). The hydrological functions of wetlands depend on their position in the catchment and water source. Isolated wetlands rely on groundwater or rain, while floodplain wetlands receive surface flows, floods and sometimes groundwater. The interaction of freshwater, estuarine and marine processes shape coastal wetlands. Hydrological pathways influence sediment and nutrient flow, with wetlands storing water, recharging or discharging aquifers, and retaining or exporting sediment. These functions vary with location, landscape geomorphology, topography, and seasonal rainfall (Bullock and Acreman 2003; Acreman and Holden 2013; Ross and McKenna 2023).



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Locally, wetlands and forests increase water infiltration, reducing overland flows and flood risk. Virgin forest retains water efficiently, with runoff occurring only when rainfall exceeds 30–50 mm d⁻¹, as most water is lost to evapotranspiration (Ripl and Eiseltová 2010). Their deep litter layer acts as a moisture-retaining sponge, sustaining the ecosystem. Regionally and globally, wetlands and forests enhance atmospheric moisture, stimulating cloud formation and precipitation (Makarieva et al. 2022). Both long-distance (ocean-to-land) and short water cycles are crucial for sustainable vegetation. Overheated land surfaces draw moisture away, and hot air rises to high atmospheric levels, drawing even more water away and further drying wetlands. While the influence of wetlands on streamflow and flood peaks is variable, floodplain wetlands generally reduce or delay floods. Overall, catchments with wetlands and intact forests have steadier water flows year-round than deforested catchments with drained wetlands (Bullock and Acreman 2003; Acreman and Holden 2013).

Increasing evidence shows that human disruption of vegetation cover and water flows has altered water circulation and temperature distribution. The high heat capacity of water allows it to absorb solar energy through evapotranspiration and release it via condensation. In wetland-rich catchments, up to 80% of solar radiation is stored as latent heat of water vapour (the heat energy needed to change a unit mass of liquid water from liquid to gas at the same temperature and pressure), which is subsequently released on condensation (Pokorný et al. 2010). In contrast, drained and sparsely vegetated areas convert more solar energy into sensible heat, leading to hotter days and cooler nights. Studies using thermal imaging confirm the cooling effect of wetlands and water-saturated soils, highlighting evapotranspiration as key to catchment sustainability (Figure 1; Ripl et al. 1996; Ripl and Eiseltová 2010; Eiseltová et al. 2012; Hesslerová et al. 2018).

The **biogeochemical functions** of wetlands encompass nutrient export and retention, carbon retention, trace element storage and export, and the regulation of organic carbon concentration through processes such as the sedimentation of particulate organic matter, nutrient uptake and storage in vegetation, and microbial activity. Surface flows can transport dissolved nutrients and nutrients adsorbed to sediment particles. Nutrients can be imported by surface or sub-surface inflows or by aerial deposition and exported by streamflow or release to the atmosphere. Nutrients can also be stored by adsorption to soil or in vegetation biomass. Water erosion, wind erosion and human activities (e.g. tillage) can cause the detachment and transport of soil and sediment particles (Montgomery 2007; Labrière et al. 2015).

Subsurface flows can transport dissolved compounds, including nutrients, metals, and dissolved organic matter, thereby affecting the surrounding environment. The residence time of water often increases as it passes through catchments and wetlands, and subsequently, biological processes increasingly influence the water's composition. As these biological processes are strongly controlled by the oxygen content of the sediment and by vegetation processes, they are influenced by the degree of waterlogging, hydraulic retention time, and hydraulic loading (Burt and Pinay 2005; Lohse et al. 2009; Pärn et al. 2012). A synthesis of studies in prairie pothole wetlands showed average removal rates from agricultural runoff of 53% nitrate and 68% phosphate (Ross & McKenna 2023). Another key N export pathway is denitrification, occurring in floodplain wetlands with available NO₃ and wet (anaerobic) conditions (Piña-Ochoa and Álvarez-Cobelas 2006; van Cleemput et al. 2007). A loss of wetland area due to agricultural expansion is likely to reduce the nitrogen removal capacity of a catchment (Yousaf et al. 2021).

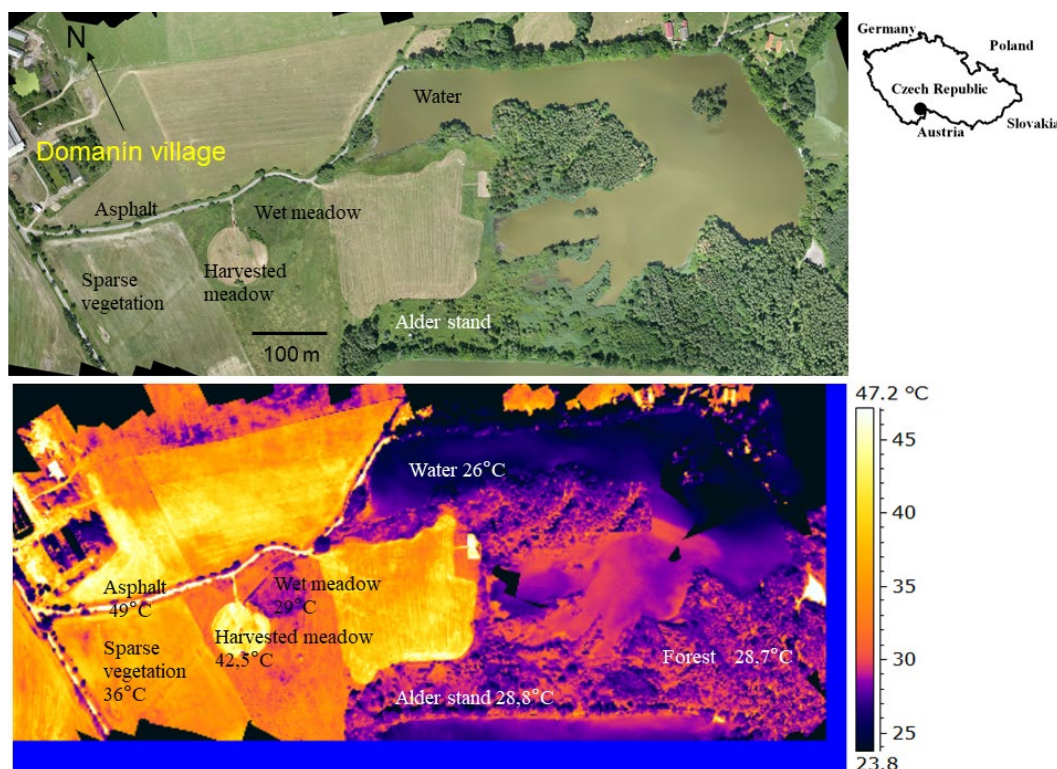
Box 2. Global changes in natural vegetation cover

The expansion of agriculture is the primary cause of the destruction of natural vegetation cover on Earth and has accelerated dramatically during the 20th century. The proportion of natural land decreased from 70.1 % in 1900 to 46.5 % in 2000). Of all habitable land, 45 % (48 million km²) has been converted to agricultural land, of which 80 % is used for livestock production (livestock grazing and feed production for livestock). In comparison, only 16 % is used for crops for human consumption, and 4 % for non-food crops (biofuels and textiles). Animal farming is responsible for most of the loss of the Earth's natural vegetation cover. Yet, in terms of human nutrition, it provides only 17% of the global food caloric supply and 38% of the worldwide protein supply. Agriculture takes the largest share of freshwater consumption: the irrigation of farmland amounts to around 70 % of the water that people withdraw from rivers, lakes and groundwater aquifers.

Sources: UNCCD 2017; Ritchie and Roser 2019; Monbiot 2022, p. 47.

Figure 1.

Thermal picture showing the impact of latent heat flux over wetlands and forests in comparison to sensible heat flux over cropland and bare surfaces. Source: adapted from Hesslerová et al. (2013), Huryna and Pokorný (2016), Ellison et al. (2017), and Ellison et al. (2024).



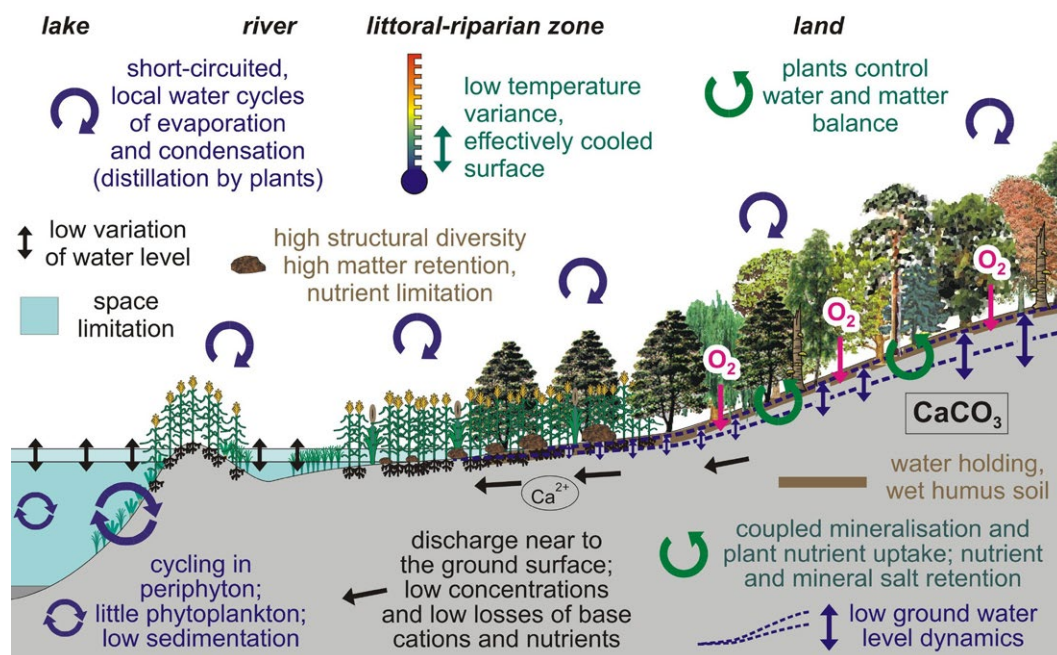
Carbon and nutrients are stored in soils, particularly organic soils where decomposition is slow and in vegetation. Changes in flooding conditions can release stored nutrients, such as when wetlands are drained, accelerating soil organic matter decomposition and flushing out accumulated materials. Dissolved organic carbon (C) and nitrogen (N), along with inorganic nitrogen (NO_3 , NO_2 , NH_4), are transported via surface and sub-surface flows, with streams exporting around 25% of N inputs regardless of catchment size and land use (Howarth et al. 1996; Durand et al. 2011; Galloway et al. 2021). Agricultural catchments lose 50-100 times more dissolved inorganic matter to lakes and streams than unmanaged virgin forest (Ripl and Eiseltová 2010), with losses in Germany reaching 1-1.5 mt ha⁻¹ y⁻¹ (Ripl et al. 1996; Ripl and Hildmann 2000). Organic matter decomposes faster under alternating wet and dry conditions typical of arable and drained land (Ripl et al. 1995). Reduced organic matter lowers soil retention capacity, increasing runoff speed and volume after rainfall.

The **ecological functions** of wetlands include habitat provision to a wide range of species, food-web support, and ecosystem maintenance (De Groot et al. 2010; Convention on Wetlands 2018a). In catchments, permanent and diverse vegetation covers host a rich assemblage of soil organisms, from bacteria and fungi to earthworms. In contrast, fields with annual crops and monocultures (where soils can remain bare for several months per year) have significantly lower diversity and activity in their soil microbiome. The diverse soil organisms also play a crucial role in soil aggregate formation, which has a positive impact on both ecosystem hydrological functions and soil fertility (Mendes et al. 2013; Lavelle et al. 2016). Wetland plants and animals are important for the cycling and storage

of nutrients. The dispersal of species and the natural maintenance of network populations are strongly influenced by streams and wetlands that provide essential connectivity in catchments (USEPA 2015; Boudell 2018; Cosentino and Schooley 2018). The dispersal of plant propagules, fish and macroinvertebrates often occurs through water. Migratory birds, amphibians and reptiles also depend on wetlands for reproduction and foraging (Horn et al. 2011; Rittenhouse and Peterman 2018).

Figure 2.

Water and matter flows, water table fluctuations, and temperature amplitudes in an intact catchment, where water and matter losses are minimal and landscape integrity is sustained over the long term. Source: Ripl and Eiseltová (2010). Reproduced with permission from Springer Nature.



In an intact catchment, water and matter losses are minimal, and landscape integrity is sustained over the long term (Figure 2). In a catchment where soil, water, and vegetation are impacted by human activities, including agriculture, water and matter flows are more open, leading to higher water table fluctuations and temperature amplitudes (Figure 3).

To restore the landscape's functionality, the necessary 'cooling spots' can be recreated by restoring vegetation and enhancing the water retention capacity of the soils. Wetlands, trees and forests are essential for this (Kramer and Sheil 2024). Management measures contributing to catchment restoration include:

- Re-establishing the vegetation cover in the upper parts of catchments (e.g. mixed forests with little or no management) since these areas are most sensitive to erosion, soil loss and overheating;
- Restoring wetlands as hydrological buffers in water-source areas, such as spring areas and sites at the confluences of rivers, to regulate water discharges, prevent floods and maintain water flows in dry periods;
- Restoring riparian wetlands along rivers as buffer/retention zones to slow down surface and subsurface water flows and retain nutrients;
- Limited harvesting of vegetation biomass for energy production, building materials, or to improve soil fertility of agricultural land in other reaches of the catchment;
- Restoring hydrology, sediment accretion and natural seed dispersal; and minimising human impacts in catchment deltas and coastal zones (e.g. mangroves, saltmarshes).

Figure 3. Water and matter flows, water table fluctuations, and temperature amplitudes in a catchment impacted by human activities, where water cycles are more open, and temperature regulation through evaporation and condensation is lost, leading to higher fluctuations in water tables and temperature. Source: Ripl and Eiseltová (2010). Reproduced with permission from Springer Nature.

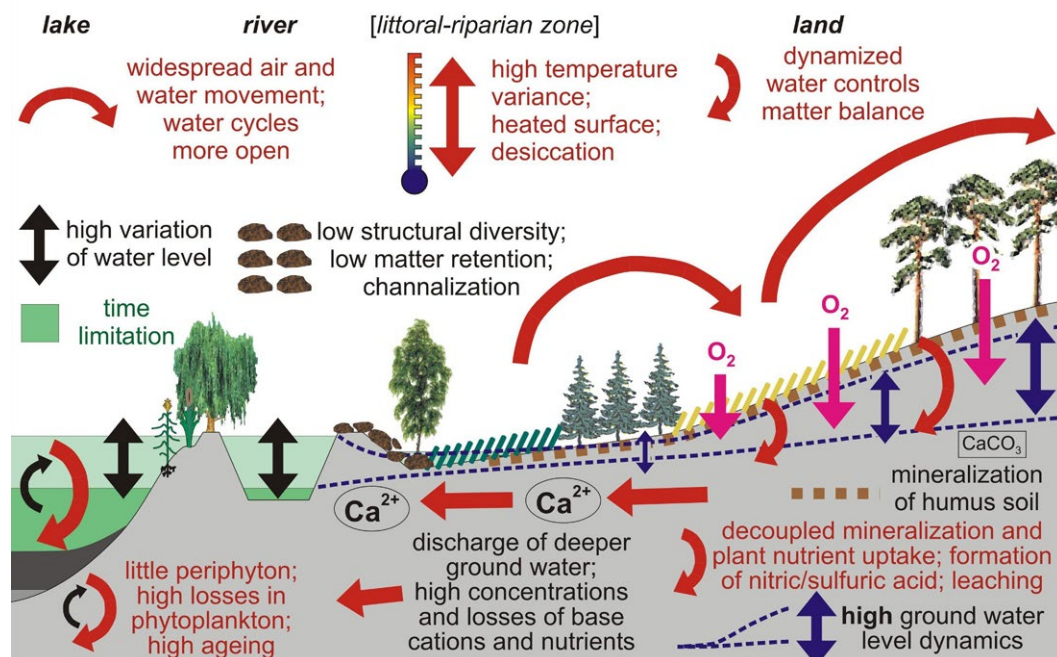
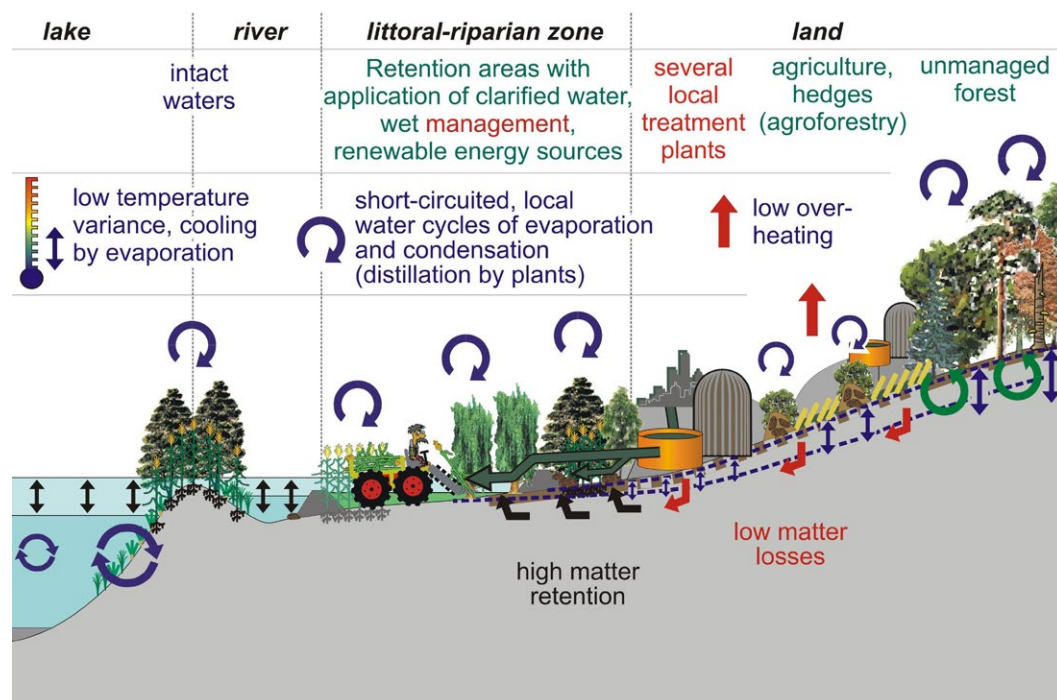


Figure 4. Schematic diagram of a catchment where the criteria for sustainable land use are implemented. Source: Ripl and Eiseltová (2010). Reproduced with permission from Springer Nature.

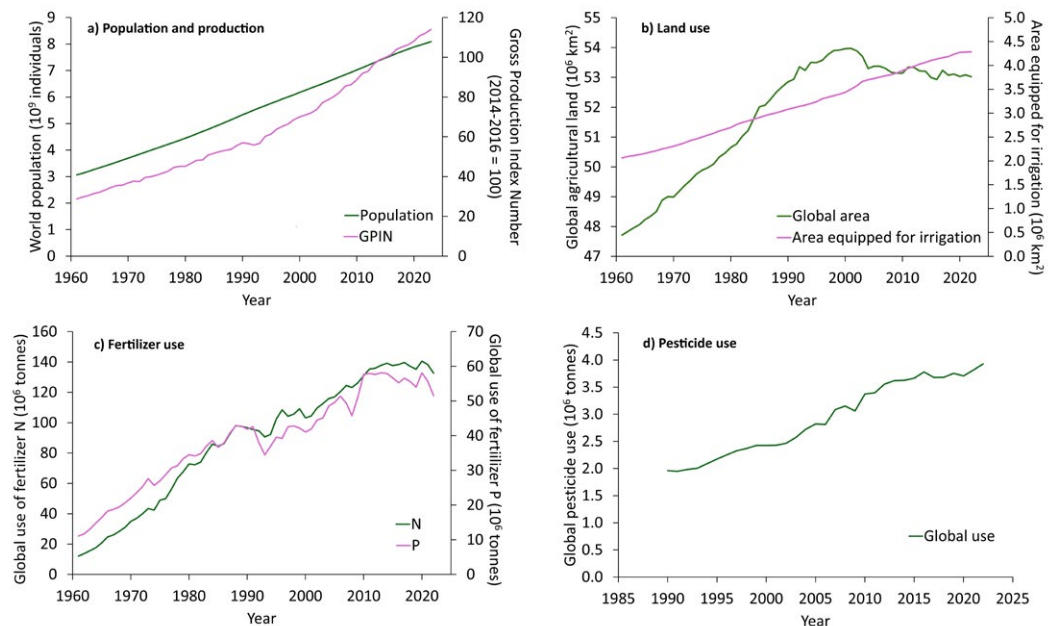


In a catchment where the criteria for sustainable catchment management have been implemented, natural soil fertility is maintained by increasing recycling and reducing the losses of water and nutrients and by preventing nutrient pollution and eutrophication of waters (Figure 4). Another key goal is to increase evapotranspiration; this minimises water and particulate matter runoff from the land to surface waters, helping to retain nutrients. To achieve sustainable land use, matter flows need to be decoupled from water flows, as high losses of particulate matter often result from excessive water discharge from catchments. Given that low soil moisture and insufficient nutrient supply usually limit plant growth, improving soil water-holding capacity is essential through strategic distribution of crop production and natural vegetation in the catchment. Perennial crops provide permanent soil cover and often have deeper root systems, enabling them to access water and nutrients from deeper soil layers and develop symbiotic relationships with the soil microbiome. This makes perennial crops highly competitive, even under erratic rainfall patterns and moisture deficits (Culman et al. 2013).

2.4. Food production and the impact of agriculture on wetlands

Agricultural production encompasses crop cultivation, livestock rearing, aquaculture, and the production of food, feed, fibre or biomass from natural ecosystems (Lewandowski et al. 2018). The Food and Agriculture Organization (FAO) of the United Nations defines agriculture to include capturing animals from wild populations and harvesting resources from oceans or forests. These practices are particularly relevant to wetlands, as many communities, particularly indigenous peoples or rural communities, rely on ecosystems for food, water, and other essential services. Integrating sustainable agricultural practices with wetland conservation is crucial for ensuring food security while preserving biodiversity and maintaining ecosystem health (Ericksen 2008; FAO 2018c). A sustainable food system provides food and nutrition security for all while ensuring socio-cultural well-being within the planetary boundaries (Stefanovic et al. 2020).

Figure 5. Growth of global food production and population (a), with concomitant changes in the use of land (b), fertilisers (c) and pesticides (d). Data source: FAOSTAT, accessed March 2025.



Since 1950, global agricultural production (including crops, livestock, and fish) has increased significantly. This has been achieved through technological advancement in farming, including the widespread use of fertilisers and pesticides, genetic improvement in crops, livestock and fish, and the expansion of irrigated land (Pellegrini and Fernández 2018). This ‘intensification’ has led to a tripling of global food production, coinciding with a worldwide population increase from 2.5 billion to over 8 billion people (Figure 5) (FAO and WHO 2023).

Agricultural intensification and agricultural sprawl, largely driven by the expansion of animal farming, have significantly altered global land use and land cover (Monbiot 2022, Box 2). Global fertiliser use surged, leading to nutrient runoff, eutrophication, and soil degradation (Tilman et al. 2002). Similarly, global water use for agriculture has dramatically increased, placing pressure on freshwater resources and wetland ecosystems (Tilman et al. 2002; FAO/IWMI 2018). Pesticide use also escalated by 73% between 1990 and 2015, with total agricultural pesticide use now exceeding 3.5 million tonnes annually, posing risks to both human health and ecosystems (FAO and WHO 2023). Intensification also involved the development and use of genetically improved crops and animal strains, farm mechanisation, and drainage of wetlands (Hazell and Wood 2008; Alexandratos and Bruinsma 2012).

Agriculture is often cited as a driver of change in wetlands, but the term ‘agriculture’ encompasses a wide range of production systems with diverse characteristics. To better understand the interactions between agriculture and wetlands, it is useful to categorise agricultural production systems based on factors such as climate, landscape characteristics, resources and their use (e.g., topography, water availability, soil quality), and market integration (Tow et al. 2011). Various frameworks to classify farming systems were incorporated into one classification using three key criteria (Convention on Wetlands 2022b; van Dam et al. 2025), leading to the following broad farming system categories (Figure 6):

- Crop systems: rainfed and irrigated, ranging from extensive to intensive, including horticulture (a, b, c, d in Figure 6).
- Livestock systems: covering both extensive pastoralism and intensive (landless) animal farming (e, f).
- Aquaculture systems: freshwater and coastal/marine, encompassing both extensive and intensive fish farming systems (g, h).

Agricultural system	Key characteristics*							
	Geographic location	Water use	Fertilizer use	Nutrient efficiency	Chemical use	Agricultural diversity	Potential erosion	Impact on biodiversity
a) Rainfed extensive	close to high productive and arid areas	mainly for livestock	also organic fertilizer	with good practice				
b) Rainfed intensive	mainly temperate, lowlands	processing of harvest, livestock		depends on practice				
c) Irrigated	arid areas, basins, lowlands	irrigation; processing of harvest		often				
d) Horticulture	areas with good water access, high productive regions							
e) Livestock extensive	arid or mountainous areas		indirect (fodder)	because of low inputs	or indirect	usually		
f) Livestock intensive	lowlands with good water availability		indirect through feed and fodder	depends on practice	indirect through fodder		depends on practice	
g) Aquaculture extensive	areas with good freshwater access; coastal areas							
h) Aquaculture intensive	areas with good freshwater access and terrain for ponds; coastal areas	depends on practice	also indirect through feed	depends on practice and system				

* Color legend:

LOW	LOW-MEDIUM	MEDIUM	MEDIUM-HIGH	HIGH	LOW OR HIGH
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Figure 6. Key qualitative characteristics of eight agricultural system categories. Water use refers to “blue” water use (water sourced from e.g. rivers, lakes, wetlands or groundwater); does not refer to “green water” from rainfall and soil moisture. Based on: Convention on Wetlands (2022b); van Dam et al. (2025).

Food production is realised on farms, and the primary level of decision-making is related to resources and farming practices. Decisions made at the farm level determine the impact of farming on wetlands and catchments. The global farm count is estimated at 608 million, with over 80% being small farms (<2 hectares), which cover only 12% of farmland and produce 36% of the world's food (Lowder et al. 2016, 2019). In contrast, more than half of the world's farmland is managed by farms over 100 hectares, particularly in high-income countries where farm sizes are increasing due to consolidation. Meanwhile, in many low- and middle-income countries (Sub-Saharan Africa, East and South Asia and the Pacific), farm numbers are rising while average farm sizes are shrinking (Anseeuw and Baldinelli 2020). Family-run farms dominate, accounting for 90% of farms and 75% of farmland, whereas corporate entities manage the remaining share (Lowder et al. 2016, 2019).

The changes caused by agricultural practices to wetland ecosystems and their immediate environment are part of the direct drivers originating from agriculture. Direct drivers are defined as “natural or human-induced causes of biophysical changes at a local to regional scale” (van Asselen et al. 2013). Four categories of direct drivers of change in wetlands are considered (Convention on Wetlands 2018a):

- Changes to the geomorphology, hydrology or vegetation of wetlands, such as drainage, conversion, burning or removal of wetland vegetation (*structural change* drivers);
- Changes in water inflow quantity and frequency, sediment load, salinity and temperature (*physical regime* drivers);
- Partial or complete removal of wetland ecosystem components, such as water, plant or animal species, and soil or peat (*extraction* drivers);
- Addition to the wetland of fertilisers (nutrients), pesticides, invasive species, solid waste, or through atmospheric deposition (*introduction* drivers).

Figure 7.
Expert analysis of direct drivers of change in wetlands originating from different agricultural systems. Blue cells indicate the type of agricultural system that generates the driver types in the rows. The intensity or scale of impact is not shown because these are strongly local-context specific (adapted from Convention on Wetlands 2022b; van Dam et al. 2025).

Direct driver		Agricultural system type											
		a) Rainfed extensive	b) Rainfed intensive	c) Irrigated intensive	d) Horti-culture		e) Livestock extensive		f) Livestock intensive		g) Aquaculture extensive		h) Aquaculture intensive
					open	glass	pasture	pasture	landless	ponds	coastal	ponds	
Structural change	Drainage												
	Conversion												
	Burning												
Physical regime	Water quantity/frequency												
	Sediment												
	Salinity												
Extraction	Water												
	Soil & peat												
	Biota												
Introduction	Nutrients												
	Chemicals												
	Invasive species												
	Solid waste												

The impact of the farm system on different wetland types showed impacts from agriculture across all direct driver categories (Figure 7). Most inland wetland types were affected either directly by wetland conversion or through modification of water, sediment, and nutrient flows in catchments. Coastal wetlands were affected by nutrients, sediments and pollution carried by rivers and runoff, by groundwater pumping in coastal areas (leading to salinisation and subsidence) and by structural changes and introductions from coastal aquaculture. Intensive crop and livestock systems, including horticulture, had the most significant impact through their management of water and soil, fertiliser application, pesticide use, and control of invasive species. In the extensive farm systems, the effects on soil, vegetation and other biota were important, but the impacts of fertilisers and pesticides were generally less because of lower application rates (Convention on Wetlands 2022b; van Dam et al. 2025).

Indirect drivers of change are defined as ‘the broader, more diffuse mechanisms and processes that influence the direct drivers of wetland change’ (Convention on Wetlands 2018a). Indirect agricultural drivers are all factors in the food system that influence the decision-making about which food is produced and what production methods are used. Many indirect drivers of wetland-agriculture interactions are related to the government’s food security and food safety policies, the availability and use of farming technology and farming traditions, the global trade and pricing of agricultural products, the market demand for foods and food products, consumer preferences, and the operations of companies such as agribusiness (e.g. producers of agrochemicals) or food retail companies (e.g. supermarkets). Governments can use subsidies, taxation and regulation (licences, permits) to stimulate or discourage certain farming systems or practices (e.g. the use of fertilisers by providing subsidies or the production of certain crops through export subsidies). Because agricultural development also involves other resources such as water, processing and storage facilities, roads and transport, these other policy sectors also influence decision-making about food production (Convention on Wetlands 2018a; van Dam et al. 2023).

2.5. Sustainable agricultural systems and practices

There is a growing consensus that conventional food production systems of the ‘Anthropocene’ have undesirable environmental, climate and social impacts (Steffen et al. 2015; Rockström et al. 2017). Prevention or mitigation of these impacts can be achieved by addressing both the direct and indirect drivers of change to wetlands originating from agriculture. The direct drivers of change can be addressed by modifying how food is produced at the farm level, specifically by altering agricultural systems and practices (discussed in this section). The indirect drivers need to be addressed by considering the food systems in which farms operate, including their governance and the roles of the different actors (discussed in Section 2.6).

To achieve sustainable agricultural practices at the farm level, a move is needed away from intensification methods that rely primarily on high external inputs of energy, fertilisers, pesticides, and irrigation water. A significant reduction in the environmental footprint of conventional agriculture could be achieved by more efficient use of resources. Research on over 900 non-organic farms in France found that pesticide use could be reduced by 42% without negatively affecting productivity or profitability on 59% of farms (Lechenet et al. 2017). The widespread adoption of Integrated Pest Management (IPM) and nutrient management strategies could further minimise resource wastage and environmental contamination (Vreysen et al. 2007).



The question of how to meet the increasing demand for food without surpassing several planetary Earth boundaries (Steffen et al. 2015) led to the concept of sustainable intensification (SI), which can be summarised as increasing food production without damage to the environment and without cultivating more land (or converting more natural areas) (Pretty and Bharucha 2014; Berg 2018). SI is focused on the outcome and does not necessarily exclude any technologies needed to achieve this, such as the use of chemical fertilisers or genetic improvement (Wezel et al. 2015). In the debate about SI, strong connections between different scale levels are recognised, e.g. between sustainable practices at the farm level and regional processes like rainfall and biodiversity support, as well as the social and human aspects of SI (outcomes include not only crop and livestock yields but also good nutrition and human well-being) and its food system context (Rockström et al. 2017). It has been argued that SI is necessary in areas with large yield gaps; however, deintensification may be required in certain regions of the world where intensive farming is unsustainable (Struik and Kuyper 2017; van Grinsven et al. 2015).

Besides improving the efficiency of conventional farming, a transformative shift in how we manage natural resources and food production has been promoted. Approaches like organic agriculture (Eyhorn et al. 2019), agroecology (Altieri 2002; FAO 2018a), regenerative agriculture (Lal 2020), permaculture (Mollison 1988), conservation agriculture (FAO 2017a), along with integrated and ecological practices (Wu and Ma 2015; FAO 2018c) are based on holistic ecological principles. These approaches treat agriculture as an integral component of nature, emphasising the integrity of ecosystems and the environment as essential for the sustainability of food systems. Moreover, they recognise humans as part of the natural world, leading to broader social objectives such as promoting human health and well-being, social equity, inclusion and justice, fair labour practices, support for local communities, the preservation of cultural heritage, and the promotion of local and Indigenous knowledge (IPES-Food 2016; HLPE 2019; Anderson et al. 2020; FAO 2021).

Sustainable intensification (SI) and other approaches for sustainable agriculture generally involve the following farming practices:

- Improved soil management, including reduced or zero tillage that can help reduce erosion and promote regeneration of the soil microbiome, mulching, crop rotations to help break pest cycles, and cover crops that can reduce erosion and increase organic matter content (Lal 2014; FAO 2017b);
- More efficient water use by making irrigation more efficient (reducing water conveyance losses, applying drip irrigation) or harvesting rainwater and using drought-resistant crops (Rockström et al. 2010; FAO 2017c);
- Improved nutrient management, e.g. by using organic fertilisers, reducing chemical fertiliser use, promoting nutrient cycling and re-use within farm systems, and reducing nutrient runoff into surface water or emissions into the atmosphere (Palm et al. 2014);
- Increasing energy efficiency, e.g. by using efficient farm equipment and using less fossil fuel and more renewable energy sources like solar and wind power (Pretty et al. 2018);
- Integrated weed and pest management by using a combination of chemical (if not banned), biological, cultural and physical control methods (Parsa et al. 2014; FAO 2018d);
- The integration of farming subsystems, such as crop-livestock integration (Martin et al. 2016), aquaculture integration (Prein 2002), and agroforestry (Nair and Garrity 2012; Arunachalam et al. 2014; FAO 2017b), among others, facilitates the recycling of nutrients and organic matter (Walia and Kaur 2023).

Sustainable practices provide clear environmental and climate benefits, including enhanced biodiversity, improved soil and water quality, and reduced greenhouse gas emissions (Smith et al. 2008; HLPE 2019). There are concerns about the ability of sustainable farming to match the productivity of conventional farming (e.g., Kerr et al. 2021). Some studies indicate that organic yields can be comparable to those of conventional methods under specific conditions (Gomiero et al. 2011). Other research suggests that organic farming yields 20–40% less, particularly in cereal production, making it more labour-intensive (de Ponti et al. 2012). Other concerns include the potential for implementing agroecological practices on large-scale farms (Titttonell et al. 2020). The feasibility of sustainable agriculture varies by context, emphasising the need for tailored approaches that optimise both environmental and economic performance.

Before the “Green Revolution”, traditional food production systems around the world had been making use of sustainability principles for a long time (Altieri 2002; Prein 2002). For example, in Mexico, the chinampas were human-made islands (‘floating gardens’) built on shallow lakes or wetlands, primarily used by the Aztecs and other cultures in central Mexico for farming (Merlín-Urbe et al. 2013; see also case study #13). In Eastern Europe, wetland landscapes with fishponds, constructed around monasteries in the 10th and 11th centuries, are still functional today (Pechar et al. 2002; Pokorný and Květ 2018). Similar agri-aquacultural landscapes exist in China (Ruddle and Zhong 1988; Lang et al. 2009; see also case study #8). In West Africa, mangrove swamp rice production systems with intricate water and salinity management have a long tradition (Adams 1993; Sané et al. 2018).

Changing social and economic conditions (e.g., the migration of young people to cities, shifting markets) in combination with climate change (e.g., changes in rainfall patterns) have led to the degradation or loss of many traditional integrated systems. Often, the intensification of production has led to disintegration (Schut et al. 2021). Besides the technical knowledge needed, attempts to reintroduce integrated farming systems as a sustainable technology are often constrained by socio-economic, cultural, and institutional factors that are prerequisites for successful adoption (Stevenson et al. 2014; Liebig et al. 2017). Indigenous Peoples and local communities can contribute critical knowledge to the transformational processes of food systems (Loch and Riechers 2021; Ward et al. 2024).

2.6. Sustainable food systems

The resource use (land, water, inputs, labour) and farming practices discussed in the previous section are the ultimate result of decision-making by farmers. These farm-level decisions are influenced by a broad range of other actors in food systems (Table 2). Numerous connections and interactions exist among these actors, whose interests, actions, and perspectives may align or conflict with one another. What happens at the farm and wetland levels is strongly influenced by the actions of governments, businesses, other societal organisations, and consumers.

Governments and multilateral organisations influence the decision-making of other actors through policies using legal and economic instruments. Agricultural policies focus on food security and market stability, addressing price fluctuations or food shortages (Peterson 2009). Environmental policies are often separate from agricultural policies, making it hard to integrate wetland conservation into decision-making about food production (ten Brink and Russi 2018; ten Brink et al. 2018). Governments implement policies through legislation and regulatory frameworks but can also utilise economic instruments such as subsidies or taxes. Agricultural subsidies have been highly successful in promoting food security but are often criticised for promoting inefficiencies, environmental harm, and inequities (FAO/UNDP/UNEP 2021). Harmful subsidies include direct financial support and tax exemptions, but the lack of enforcement of environmental laws can also be viewed as a harmful subsidy (Withana et al. 2012; Dempsey et al. 2020). Reforming agricultural subsidies is challenging due to the strong lobbying from agricultural stakeholders and the effectiveness of subsidies in achieving food policy objectives. However, support funds can be repurposed to support environmental and social objectives (FAO/UNDP/UNEP 2021). Other methods that governments use include awareness campaigns to guide actor behaviour, investment support, research, and training and extension programmes.

Non-governmental actors, including parliaments, civil society organisations, and private sector or civil society entities or individuals, can influence policy decisions through lobbying and advocacy. Large globally operating agribusiness corporations exert significant influence, often shaping regulations in their favour (Clapp and Fuchs 2009). Higher-scale drivers, such as global commodity prices, consumer preferences, agribusiness marketing, NGO campaigns and cultural traditions, further influence local-level decision-making. Indigenous knowledge can also play a crucial role in shaping food system governance (Loch and Riechers 2021; Ward et al. 2024).

Table 2. Actors in the global food system (adapted from van Dam et al. 2025).

Actor	Description
Farmers/producers	Including indigenous producers, clans or tribes, smallholder farmers (individuals or households), cooperatives, government agencies or large-scale commercial farmers.
Consumers	Individuals and households make food-related choices, including those influenced by advocacy groups promoting food sovereignty, nutrition education, or sustainable food practices.
Agribusiness companies	Include agrochemical companies that produce fertilisers, pesticides and seeds.
Food processing companies	Companies that transform agricultural products into food or beverages influence consumer demand through marketing.
Retail companies and supermarkets	Distributors of fresh and processed food, including large international chains and local markets.
National and local governments	Set policies on food safety and security, trade, health, and the environment using instruments such as subsidies, tariffs/taxes, and regulations, including licenses/permits.
Multilateral/international agencies and donors	Provide funding and expertise for agricultural development, food security, and environmental conservation programmes, including UN organisations and the Convention on Wetlands.
Non-Governmental Organisations (NGOs)	Address themes such as sustainability, organic farming, food waste reduction, labour rights, and environmental protection.
Financial institutions	Banks, investors, insurance, and credit cooperatives supporting agricultural projects.
Knowledge, research and educational institutions	Universities, research institutes, agricultural colleges and individual scientists conducting studies on agriculture, nutrition, and the environment.
Media and communication	Journalists, social media influencers, and other actors shaping public discourse on food and environmental issues.

Actor behaviour is strongly influenced by institutions, the rules and conditions that moderate interactions among food system actors and between the actors and the environment. These can be formal institutions, such as the policies, laws, and regulations enforced by empowered governments, or informal, such as traditional or customary arrangements that have evolved over time. Formal and informal institutions coexist but sometimes create conflicts, such as those regarding the use of wetlands (North 1990; Cleaver 2012).

In addition to institutions, discourses play a crucial role in policy-making, public perception, and the behaviour of actors. Discourses are the values and beliefs of different actors, often reflecting cultural values and social norms, that influence a wide range of food-related issues such as food choices (e.g. meat consumption), environmental priorities (e.g. wetland conservation), or what is considered 'good' farming. Power dynamics among actors determine which discourse dominates. Some actors, such as agribusiness corporations and advocacy groups, utilise media, marketing, and education to shape the discourses. The 'food security' discourse that resulted in the growth of agricultural production and productivity since the 1950s is now shifting towards a 'food sovereignty' model, which places greater emphasis on agricultural landscapes as integrated social-ecological systems and highlights the importance of inclusive decision-making among various food system actors, environmental sustainability, cultural diversity, and support for regional markets (Altieri 2002; Davila and Dyball 2017; Ruben et al. 2021).

Making wetland-agriculture food systems more sustainable with better outcomes for wetlands requires an integrated, adaptive approach to governance that considers people,

farms, and wetlands simultaneously, as well as their interactions. A transformation to sustainability involves not only technical and ecological solutions but also institutional change, fresh perspectives, multi-stakeholder collaboration, and the equitable distribution of benefits from farming and wetlands (van Bers et al. 2016; Leach et al. 2018; Scoones et al. 2020).



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3. Global case studies on agriculture-wetland interactions

3.1. Background

This Technical Report presents and evaluates a series of case studies on agriculture-wetland interactions. The objectives are to:

1. provide examples of how wetlands in agricultural settings can be understood, emphasising the need, but also the options for harmonising sustainable agricultural practices with ecological health and a balance of wetland ecosystem services in the landscape;
2. present different forms of wetland-agriculture interactions and interventions so that practitioners can identify options and approaches for promoting sustainable agriculture in their own countries and
3. Stimulate the dialogue between practitioners in different policy sectors and support more integrated approaches to agricultural development and environmental management.

The case studies encompass all Convention on Wetlands regions, a broad range of agricultural systems (including crops, livestock, and fish; intensive and extensive), and various wetland types (inland, coastal, and peatlands; Table 4). Each case study describes the ecological character of the wetland, the key drivers of change related to agriculture-wetland interactions, and opportunities for or constraints to achieving sustainable management. The information collated across case studies provides a systems perspective of wetland-agriculture interactions to support practitioners and policymakers working on water, environment, wetlands, food production, agriculture, or related topics. For example, to assist agronomists in understanding options for protecting wetlands and their ecosystem services and wetland practitioners in recognising possibilities for food production that do not adversely impact the ecological character of wetlands.

Summaries of the cases are presented in section 3.3. Full case descriptions can be found in the supplementary materials.¹

3.2. Sustainability analysis

To evaluate the sustainability of the agricultural system in each case study, the FAO principles and actions for sustainable agriculture (FAO 2018b) were applied in combination with guidelines on wetland-wise use (Convention on Wetlands 2005). The case study contributors were asked to analyse their cases using these principles, with a focus on the interactions between wetlands and agriculture. The main questions were: which actions have contributed to more sustainable outcomes for people and wetlands? What opportunities exist for actions leading to more sustainability? Which direct or indirect drivers of change were or can be addressed by these actions? The five principles emphasise the integrated social-ecological character of wetlands as components of food systems and are related to the natural system, the social system, and the institutions that connect these. The principles are strongly linked to each other, as the realisation of each principle often depends on actions taken under another principle. The five principles and actions related to wetlands are:

¹ See <https://www.ramsar.org/document/agriculture-wetlands-supplementary-materials-case-study-descriptions>.

Principle 1: Improving the efficiency of resource use is crucial to sustainable agriculture.

Efficient resource use is essential to meet growing demands for food while minimising environmental impacts. Key actions include efficient use of water resources and protection of water sources for wetlands; limited use of fertilisers and pesticides near wetlands to maximise crop yields while reducing losses of nutrients and chemicals; adoption of advanced technologies like precision agriculture to improve resource use efficiency; and implementation of sustainable practices such as conservation agriculture, water-efficient irrigation, integrated pest management and crop-livestock-fish integration. Capacity building plays a crucial role in supporting farmers in adopting these methods, e.g., by helping them acquire the necessary knowledge and skills. Supportive policies and incentives can also encourage resource-efficient practices. Through these approaches, agriculture can achieve greater productivity with fewer resources, safeguarding both the environment and food security.

Principle 2: Sustainability requires direct action to conserve, protect, and enhance natural resources

Sustainable agriculture relies on preserving ecosystems and the essential services and resources (such as water, soil, and biodiversity) they provide. Key actions include conservation initiatives, such as protecting rivers, wetlands, and forests and halting the conversion of wetlands, as well as restoration activities, including reforestation and the restoration of degraded wetlands. Improving agricultural practices (Principle 1) to reduce pressure on the ecological character of wetlands also contributes to this. Strengthening policies and institutions and global collaboration through international agreements and conventions (as supported by the Convention on Wetlands through Wetlands of International Importance and the ecological character and wise use concepts) are also important.

Principle 3: Agriculture that fails to protect and improve rural livelihoods, equity and social well-being, is unsustainable

Principle 3 emphasises the importance of ensuring that agricultural development directly benefits the farming households and rural communities that depend on it. This involves securing equitable access to land, water, and forest resources and addressing gender disparities, as women often face limited resource ownership and fewer opportunities despite their significant share in the labour force. By prioritising social and economic benefits, this principle ensures that agricultural development contributes to equity, empowerment, and the well-being of rural populations. Actions include applying financial mechanisms to promote sustainable practices and wise use of wetlands, recognising the role of local farmers in maintaining cultural and regulating services of wetlands and promoting diversification for economic, climate, and ecosystem resilience.

Principle 4: Enhanced resilience of people, communities and ecosystems is key to sustainable agriculture

Building resilience enables agricultural systems to withstand and recover from challenges such as climate variability, extreme weather events, and market volatility. Key strategies include proactive risk management through measures that anticipate and mitigate adverse events, as well as adaptation efforts such as adopting pest-resistant crop varieties and breeds to cope with evolving conditions. Social safety nets and insurance schemes provide support to communities during crises, and help ensure stability and recovery. Enhancing ecosystem health (healthy soils, good water quality, biodiversity) is fundamental to maintaining agricultural productivity and sustainability. Actions for wetlands include managing them to retain their natural capital and services for agriculture and people, supporting traditional agriculture to strengthen links between cultural identity, wetlands, and human well-being, and adapting agricultural practices for wetlands so that resilience-enhancing features (e.g., floodwater storage, carbon storage, more diverse livelihoods) are preserved.

Principle 5: Sustainable food and agriculture requires responsible and effective governance

This principle emphasises the need for strong policy and institutional frameworks that balance public and private sector efforts while ensuring accountability, equity, transparency, and adherence to the rule of law. Effective governance also requires inclusive stakeholder engagement, enabling diverse voices, including local communities and women, to participate in decision-making processes and ensuring legitimacy and fairness in resource management. Promoting the recognition and

allocation of rights to natural resources is vital for equitable access and sustainable use. Robust mechanisms for compliance and enforcement are essential to ensure adherence to regulations. International collaboration plays a key role in reinforcing governance by integrating global commitments into national policies and practices. Actions related to wetlands include building cross-sectoral partnerships (e.g. between water, agriculture, environment and business sectors), developing policy responses that set catchment limits on water use and pollutants, and improving institutional and finance frameworks to avoid, mitigate, and offset the adverse effects of agriculture on wetlands and promote sustainable food production. For wetlands, it is particularly important to develop governance with a catchment perspective to capture the important ecological and socio-economic links between wetlands and the whole catchment.

In the context of the theme of the current STRP Task 3.3 and this report ('Wetlands and Agriculture'), we could summarise the five sustainability principles as follows:

Principle 1 is about *food production and farming practices*;

Principle 2 is about *wetland conservation, restoration and wise use*;

Principle 3 is about *farmers and farming households*;

Principle 4 is about *resilience* to climate change and other shocks (e.g. from markets and crop failures);

Principle 5 is about *all individuals having a role in food systems and how they collaborate*.

3.3. Agriculture-wetland interactions: case study evaluation

This Technical Report presents a summary of 18 case studies (section 3.4), with at least one case from each Convention on Wetlands region (Table 3). A wide variety of farming systems are described, ranging from extensive to intensive, including irrigated and rainfed systems, as well as small to large farms across different latitudes and altitudes and in both urban and rural settings. All five sustainability principles were considered in each case study, helping to inform the assessment of options for enhancing agricultural sustainability and the wise use of wetlands. All case study authors ranked the priority (top 3) principles for determining the success or potential of actions to enhance sustainability (Figure 8). This provided a subjective assessment of the relative importance of the five principles. Given other limitations (e.g., a single coastal system with a limited number of cases focusing on livestock), the evaluation can be viewed as an exploration of practical sustainability options rather than a rigorous scientific analysis of sustainability.

Principles 2 ('Wetland conservation and wise use') and 5 ('Effective governance') were considered the most important globally for promoting sustainable agriculture-wetland interactions, followed closely by Principles 1 ('Resource use efficiency') and 3 ('Supporting rural livelihoods'). The analysis emphasises that enhancing the sustainability of agricultural systems worldwide depends not only on making food production technically (Principle 1) or socio-economically (Principle 3) more sustainable but particularly on ensuring that people work together in an effective governance context (Principle 5). The protection and restoration of wetlands remains crucial (Principle 2).

Figure 8.
Ranking of sustainability principles for the case studies on agriculture-wetland interactions (for an explanation, see text).

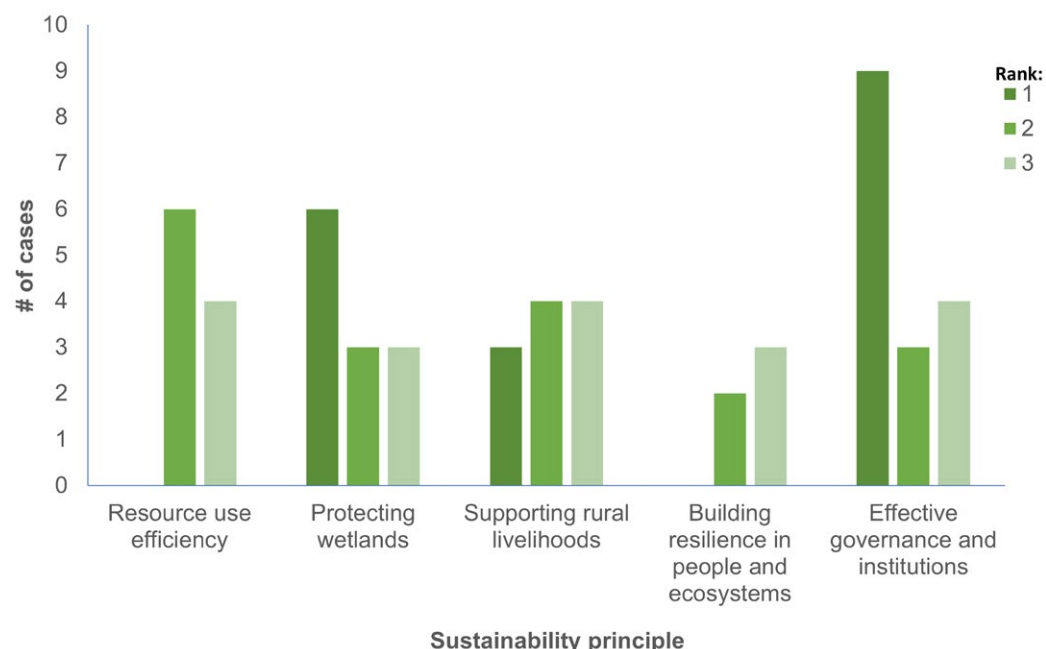


Table 3. Description of the 18 case studies presented in this Technical Report.

Case nr.	Region	Country	Case title	Wetland type ²	Agricultural system ³
1	Africa	Kenya	Sustainability options for extensive and intensive agriculture in Yala and Anyiko papyrus wetlands, Kenya	Rivers, streams, floodplains	Rainfed extensive, intensive Irrigated
2		Morocco	Diverse perspectives on sustainable agriculture in Merja Sidi Ameur, a temporary wetland in a semi-arid landscape of the Gharb Plain, Morocco	Rivers, streams, floodplains	Rainfed intensive Irrigated
3	Asia	Sri Lanka	Sustainable rice production in restored urban rice paddy fields, Colombo, Sri Lanka	Agricultural wetlands (rice paddy)	Irrigated
4		Sri Lanka	Accelerated natural regeneration of mangroves in Anawilundawa Wetland Sanctuary, Sri Lanka and its contribution to sustainable shrimp aquaculture	Mangroves Aquaculture ponds	Aquaculture extensive (ponds)
5		India	Sustaining agriculture-wetlands interactions in the management of Vembanad-Kol wetlands	Estuaries, tidal flats, saltmarshes, lagoons Rivers, streams, floodplains	Rainfed extensive Aquaculture extensive
6		Thailand	Supporting rice farmers to protect the endangered Eastern Sarus Crane (<i>Grus Antigone sharpii</i>) in Northeast Thailand	Water storage bodies (reservoirs) Agricultural wetlands (rice paddy)	Rainfed intensive Irrigated

² According to Convention on Wetlands Classification System for Wetland Types (see also section 2.2).

³ See section 2.4 and Figure 6.

Case nr.	Region	Country	Case title	Wetland type ²	Agricultural system ³
7		Thailand	Floodwater retention in paddy fields in Bang Rakam district of Phitsanulok province, Thailand	Rivers, streams, floodplains	Rainfed intensive Irrigated
8		China	Maintaining ponds in agricultural landscapes for the benefit of local communities and wetlands	Rivers, streams, floodplains Lakes	Rainfed intensive
9	Europe	Sweden	A constructed wetland and pond for improved water management in a seasonally water-scarce environment (Stora Tollby Organic farm, Sweden)	Water storage bodies (small farm ponds)	Rainfed intensive
10		Italy	Collaboration between farmers and conservationists to improve the status of the aquatic environment in a protected lake and wetland area in Sicily, Italy	Lakes	Horticulture (open)
11		Türkiye	Agrarian reform and environmental management to support farmers and protect the Sultan Marshes in Central Anatolia, Türkiye	Rivers, streams, floodplains Lakes	Rainfed intensive Irrigated
12		Germany	The toMOORow PaludiAlliance – How Developing Value Chains for Paludiculture Products Can Help Creating Large-scale Wet Peat Landscapes	Peatlands	Rainfed extensive Livestock (extensive)
13	Latin America & Caribbean	Mexico	The Xochimilco peri-urban wetland: a resilient agroecosystem of biocultural importance	Rivers, streams, floodplains Agricultural wetlands	Irrigated intensive; Horticulture (open, glass); Livestock intensive; Aquaculture intensive
14		Peru	Restoration of pasture in a high-altitude protected wetland area (bofedal) in Peru	Peatlands	Livestock extensive
15	North America	Canada	Wetland conservation and restoration in the Canadian Prairie Pothole Region	Marshes (on mineral soils)	Rainfed intensive Livestock extensive
16		Canada	Managing the wetland ecosystem services of drainage ditches in agricultural landscapes in Ontario, Canada	Agricultural wetlands (drainage ditches)	Rainfed intensive Livestock extensive
17		USA	The US Department of Agriculture wetland conservation reserve program: quantifying ecosystem services from wetland restoration to benefit water quality and climate	Marshes (on mineral soils)	Rainfed intensive
18	Oceania	Australia	Environmental water allocations to maintain the ecological character of wetlands in the Murray-Darling Basin, Australia	Rivers, streams, floodplains Lakes	Irrigated; Rainfed extensive, intensive; Livestock extensive, intensive; Horticulture

3.4. Case study summaries

For the full case study descriptions, see supplementary materials.

Case 1. Sustainability options for extensive and intensive agriculture in Yala and Anyiko papyrus wetlands, Kenya

Risper Ajwang' Ondiek¹, Julius Kipkemboi², Nzula Kitaka¹, and Anne A. van Dam³

¹Dept of Biological Sciences, Egerton University, Kenya; ²Kaimosi Friends University, Kenya; ³IHE Delft Institute for Water Education, The Netherlands

Yala Wetland, Kenya

Wetland type: River, streams, floodplains

Surface area: 20,756 ha

GIS: 34°02'0"E - 34°10'0"E; 0°04'0"S - 0°04'0"N

Agricultural system: Rainfed extensive; Irrigated intensive

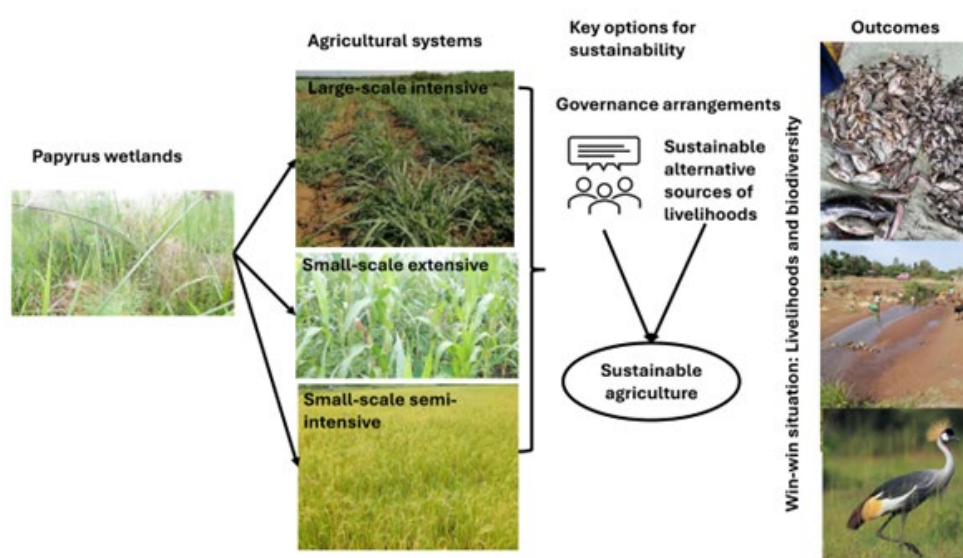
Anyiko Wetland, Kenya

Wetland type: River, streams, floodplains;

Surface area: 158 ha

GIS: 34°16'30"E - 34°18'0"E; 0°16'0"N - 0°14'30"N

Agricultural system: Rainfed extensive; Irrigated intensive



The agricultural systems in Yala and Anyiko papyrus wetlands and key options for sustainability leading to both livelihood support and biodiversity conservation (©Risper Ajwang' Ondiek)

Summary

The Yala and Anyiko wetlands in western Kenya are papyrus (*Cyperus papyrus*)-dominated inland wetlands that support both small-scale subsistence agriculture to produce rice, maize, and other food crops, as well as commercial intensive farming to grow sugarcane. Despite lacking formal protected status, they are governed by existing laws and regulations related to water, land, wildlife, and fisheries. These wetlands provide essential ecosystem services, including flood regulation, water purification, biodiversity conservation, and support for local livelihoods. However, agricultural expansion, driven by poverty, insecure land tenure, and weak governance, has led to significant degradation of ecosystems. Since the 1960s, 11.5% of the Yala wetland and 55% of the Anyiko wetland have been converted to agriculture. To promote sustainability, a multi-sectoral governance approach is necessary, encompassing the clarification of land rights, strengthening regulatory enforcement, rehabilitating irrigation infrastructure, and promoting sustainable alternative livelihoods. Large-scale agricultural operations should adopt corporate social responsibility (CSR) practices to mitigate environmental impacts. Long-term sustainability depends on striking a balance between agriculture and wetland conservation through inclusive planning and effective stakeholder engagement.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
2		1		3

Case 2. Diverse perspectives on sustainable agriculture in Merja Sidi Ameur, a temporary wetland in a semi-arid landscape of the Gharb Plain, Morocco

Hajar Choukrani¹; Marcel Kuper²

¹Consultant on water resources management & transdisciplinary education, Morocco;

²UMR G-EAU, CIRAD, Montpellier, France

Gharb Plain, Morocco

Wetland type: River, streams, floodplains

Surface Area: ~6,900 ha

GIS: 34°27'14.75"N , 6°19'48.14"E

Agricultural system: Rainfed extensive, intensive; Irrigated; Livestock extensive



Irrigated maize in the Merja Sidi Ameur (©Choukrani, 2021)



Cattle grazing area at the merja Sidi Ameur (©Choukrani, 2021)

Summary

Merja Sidi Ameur, a temporary wetland in Morocco's Gharb Plain, has undergone significant transformation due to drainage, dam construction, and drought, resulting in a shift from a rich ecosystem to an intensively farmed landscape. Historically, the unique wetland plant communities have deteriorated due to agricultural expansion and conflicting land-use priorities, which have affected their ecological character. Today, farmers cultivate rainfed and irrigated crops, such as wheat, maize, and vegetables, often relying on deep wells or drainage water to cope with waterlogging and drought, which exacerbates groundwater depletion and salinity. Despite its multifunctional role in supporting livelihoods, the Merja lacks legal protection and faces fragmented governance. Diverging perspectives on the wetland and conflicting priorities among farmers, environmental stakeholders, and government institutions hinder the sustainable management of the wetland. This case underscores the significance of integrated planning, inclusive governance, and legal recognition, such as designation under the Convention on Wetlands, in achieving a balance between agricultural use and ecological restoration, thereby preserving the wetland's resilience.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
		3	2	1

Case 3. Sustainable rice production in restored urban paddy field, Colombo, Sri Lanka

Chaturangi Wickramaratne¹; Radheeka Jirasinha^{1,2}; Priyanie Amerasinghe^{1,3}; Matthew McCartney¹

¹International Water Management Institute (IWMI);

²Department of Agrarian Development (DAD); ³Local wetland community

Colombo Wetland Complex, Sri Lanka

Wetland type: Agricultural wetlands (rice paddy)

Surface area: 32 ha

GIS: 79°57'49.75"E; 6°50'57.42"N

Agricultural system: Irrigated intensive



Cleaning and excavation of degraded paddy fields and canals
(©Padmini Perera/Manosha Welikala).



Paddy field preparation for planting rice seedlings
(©Padmini Perera/Manosha Welikala).

Summary

Rainfed urban rice paddies, once integral to the peri-urban landscape of the Colombo metropolis, were largely abandoned due to labour shortages and declining profitability. A project was launched to restore these degraded wetlands and revitalise their ecosystem services, including floodwater retention, food production, and habitat provision for birds, insects and invertebrates. The restoration involved the rehabilitation of canals, clearing of vegetation, improvement of land ownership registration, and provision of technical and financial assistance to farmers for rice cultivation. Institutional support and cross-sectoral collaboration among government and non-government agencies were strengthened. Farmers were encouraged to adopt sustainable practices, such as using organic fertilisers and traditional pest management methods. Some farmers integrated rice production with fruit and vegetable cultivation, thus increasing agricultural diversity and resilience. As a result, the restored paddies yielded 1,000-1,640 kg of rice per acre, generating income and improving the livelihoods of participating households. Enhanced water drainage also contributed to local flood mitigation. This initiative successfully demonstrated how restoring multifunctional urban rice fields can support the provision of ecosystem services, strengthen biodiversity conservation, and promote socio-economic development in urban and peri-urban settings, offering a model for sustainable food production and agricultural wetland restoration in rapidly urbanising regions.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
3	1		2	

Case 4. Accelerated natural regeneration of mangroves in Anawilundawa Wetland Sanctuary, Sri Lanka and its contribution to sustainable shrimp aquaculture

Sevvandi Jayakody¹, Chaturangi Wickramaratne², Manjula Amararathna³

¹Wayamba University, Sri Lanka; ²International Water Management Institute (IWMI); ³Department of Wildlife Conservation

Anawilundawa Wetland Sanctuary, Sri Lanka

Wetland type: Human-made wetlands (water storage bodies, aquaculture ponds, agricultural); Marshes; River, streams, floodplains

Surface area: 1397 ha

GIS: 7°42'N, 79°49' E

Agricultural system: Aquaculture extensive (ponds)



Newly excavated straight and contoured channels to restore hydrology and condition the soil. Active shrimp farms are on the other side of the sanctuary (© WNPS).



Planted vs naturally settled. *Avicennia marina* has naturally settled and is growing faster compared to planted *Rhizophora mucronata* (© Sevvandi Jayakody)

Summary

Between 1980 and 2000, intensive shrimp farming in Sri Lanka led to the destruction of mangrove forests. As a result of unsustainable practices, 90% of the farms were affected by disease and contamination, leading to the abandonment of farms. In response, best management practices (BMPs) for shrimp farming were introduced, along with scientific mangrove restoration. This was demonstrated in 45 ha within the Anawilundawa Wetland Sanctuary, where more sustainable shrimp farming in the surrounding area (with better zonation, environmental impact assessment, and better management practices) was combined with canal rehabilitation to improve water conveyance, nursery development for selected mangrove species, and planting of new mangrove stands in the sanctuary. Local residents benefited from the project through employment opportunities, facilitated field research, and new opportunities supported by the restored mangroves, including capture fisheries and ecotourism. The effort was supported by training and awareness campaigns. Mangrove restoration in Sri Lanka is supported by several policies, as well as multi-stakeholder platforms such as the National Mangrove Expert Committee, which involves government agencies, non-governmental organisations, local communities, and academia.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
	1	2		3

Case 5. Sustaining agriculture-wetlands interactions in the management of Vembanad-Kol wetlands

Kalpana Ambastha, Ritesh Kumar

Wetlands International South Asia,
New Delhi, India

Vembanad-Kol Wetlands, Kerala, India

Wetland type: Estuaries, tidal flats, saltmarshes, lagoons

Surface area: 151,250 ha

GIS: 9°15' - 10°36' N, 76°01' - 76° 34' E

Agricultural system: Rainfed extensive; Irrigated



Integrated rice-shrimp cultivation in Kol lands. (© Wetlands International South Asia)



Below sea level farming in Kuttanad Region. (© Wetlands International South Asia)

Summary

The Vembanad-Kol Wetland (VKW) is a Wetland of International Importance and a Globally Important Agricultural Heritage System (GIAHS) in Kerala state, located on the southwest coast of India. It comprises the Vembanad Estuary (with integrated deepwater rice-prawn farming, called *Pokkali*), the Kol agricultural floodplains (with paddy rice cultivation) and the below-sea-level rice systems of Kuttanad. The intricate VKW farming systems have evolved since the 18th century, supporting the nutrition and livelihoods of local and distant communities while also providing important regulating ecosystem services (e.g., flood storage) and promoting biodiversity (e.g., birds). Due to the impacts of climate change and economic development, these integrated farming systems are being replaced by more intensive farming practices, leading to ecosystem degradation, pollution, the introduction of invasive species (e.g., water hyacinth), flooding, and conflicts over resource use (e.g., with fishing communities). The decline is being addressed through integrated wetland management planning, combined with support for farmers and a robust institutional framework at both national and state levels (e.g., the designation of parts of VKW as a Special Agriculture Zone). The Kerala State Wetlands Authority (SWAK) incorporates a dedicated VKW Management Unit, which is responsible for coordinating the implementation of the Integrated Management Plan, including enforcement, fundraising, capacity building, and communication and outreach. Traditional farming is supported by technical and financial assistance (e.g., insurance schemes) and other forms of community support (e.g., improvements to water infrastructure and ecotourism). The VKW demonstrates that the success of a strong regulatory framework and integrated management plan depends on coordinated implementation with contributions from multiple stakeholders and support for local communities, who ultimately determine if the ecological character of the wetland system will be maintained.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
	3	2		1

Case 6. Supporting rice farmers to protect the endangered Eastern Sarus Crane (*Grus Antigone sharpii*) in Northeast Thailand

Li He¹; Yongyut Trisurat²

¹Food and Agriculture Organization of the UN; ²Kasetsart University, Thailand

Huai Chorakhemak non-hunting Area, Muang district, Buriram Province, Thailand

Wetland type: Water storage bodies (reservoir); Agricultural wetlands (rice paddy)

Surface area: 620 ha

GIS: 103°02'02.5"E ; 14°54'02.7"N

Agricultural system: Rainfed intensive; Irrigated



Sarus crane nesting in the buffer zone of Huai Chorakhemak Non-hunting Area. (©Preecha Norsingha)



"Sarus rice" (organic rice). (©Preecha Norsingha)

Summary

The Eastern Sarus Crane (*Grus antigone sharpii*) was once widespread across Southeast Asia, but its population and historic range declined significantly due to hunting, egg collection, and the degradation of wetlands habitats. A Saru's crane reintroduction project in Northeast Thailand integrated crane conservation with organic rice farming, promoting bird habitat-protected areas and adjacent agricultural lands. Farmers adopted environmentally friendly practices, such as using organic manure and manual weeding to replace chemical inputs. They received compensation for crop damage caused by cranes. Cameras were used to monitor crane nests to increase juvenile survival rates. The organic rice produced in this area was branded as 'Sarus rice', which fetched a higher price and further supported the biodiversity-friendly farming practices. Both government and private sector stakeholders endorsed the initiative, among other measures, by establishing the Wetland and Eastern Sarus Crane Conservation Centre, which supports projects for education, training, ecotourism, and community income generation. Strong legal frameworks ensure the project's longer-term success, continued funding from the government and private sector, and robust community engagement.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
	2	1		3

Case 7. Floodwater retention in paddy fields in Bang Rakam district of Phitsanulok province, Thailand

Li He¹; Yongyut Trisurat²

¹Food and Agriculture Organization of the UN; ²Kasetsart University, Thailand

Bang Rakam wetlands, Phitsanulok province, Thailand

Wetland type: River, streams, floodplains

Surface area: ~ 8,700 ha (Project phase 1)

~ 42,400 ha (Project phase 2)

GIS: 100°3'10"E; 16°56'30"N

Agricultural system: Rainfed intensive; Irrigated

Rice period													% of farmers
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
3x harvest before BRM 60	2 nd rice cultivation				3 rd rice cultivation				1 st rice cultivation				10%
2x harvest before BRM 60		1 st rice cultivation						2 nd rice cultivation					90%
2x harvest with BRM 60	1 st rice cultivation								2 nd rice cultivation				95%
3x harvest with BRM 60	2 nd rice cultivation				3 rd rice cultivation				1 st rice cultivation				5%

Cultivation calendar in Bang Rakam district. The rainy season is between August and October. The dry season is from January to April. The dark blocks indicate the period of prolonged water storage on the rice farms. (© Voogd (2019).

Summary

Farmers in the Bang Rakam floodplain of Phitsanulok Province, Thailand, have long faced the dual challenges of seasonal flooding and drought, both of which negatively affect rice yields, farm income, and overall agricultural resilience. Traditionally, farmers in this area cultivate two to three rice crops per year. Unpredictable water availability and increasing flood intensity have made this increasingly difficult. In response, an innovative water management approach (the BRM 60 scheme) was introduced to improve water retention and reduce flood risk. The BRM 60 model combines structural improvements with adaptive farming practices. Infrastructure upgrades such as elevated roads, reinforced dykes, and water gates help manage and retain floodwater more effectively. At the same time, the rice cropping calendar was modified: the first rice crop was advanced, and the second was postponed to create a mid-season window during which rice fields could serve as temporary floodwater retention basins. The use of fast-growing, short-duration rice varieties enables this calendar shift while maintaining productivity. During this extended flood period, some farmers raised fish as an additional source of income, thereby enhancing the multifunctionality of the land. However, the uptake of such practices remains limited, and greater incentives, such as payments for ecosystem services (PES), are needed to reward farmers for contributing to regional flood mitigation. The benefits of the BRM 60 scheme include reducing the risk and impact of floods downstream, improving water regulation, and increasing the resilience of local agricultural systems. It serves as a model for integrated, climate-smart water and land management that balances food production with ecosystem services. Continued support, community engagement, and incentive mechanisms will be key to scaling and sustaining this approach across other flood-prone regions.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
		1	3	2

Case 8. Maintaining ponds in agricultural landscapes for the benefit of local communities and wetlands

Lei Guangchun

Beijing Forestry University

Maoli Lake, Hunan Province, China

Wetland type: Rivers, streams, floodplains; Lakes

Surface area: 4,776 ha

GIS: 29°24'N 111°55'E

Agricultural system: Rainfed intensive



Migratory water birds habitat (© Lei Guangchun).



Pond near a town within Maoli Lake basin (© Lei Guangchun)

Summary

Over the past two centuries, the Dongting Lake Plain in Hunan Province, China, has undergone significant environmental changes due to altered rainfall patterns, rising temperatures, and large-scale wetland drainage for agricultural and urban development purposes. These pressures degraded traditional agroecological systems, reduced biodiversity, and impacted water quality and agricultural sustainability. Historically, farm ponds have been a vital feature of the landscape, serving as sources of irrigation, flood storage, aquaculture, and drinking water. Their sediments were applied as organic fertilisers, supporting crop productivity. The wetland system also provides important habitats for bird species and other wildlife. In response to increasing ecological degradation, a comprehensive restoration programme was launched in 2013. The initiative combined the rehabilitation of degraded farm ponds with the improvement of rural sewage treatment infrastructure. Eco-compensation schemes were introduced to incentivise farmers to adopt environmentally sustainable practices. Farmers received financial and technical support to maintain pond health, reduce agrochemical runoff, and contribute to biodiversity conservation. Community participation played a critical role in ensuring local ownership and long-term success. A decade after implementation, the programme has yielded significant results. Water quality in the ponds and surrounding water systems has markedly improved. The ponds now serve their original purposes more effectively in flood mitigation, irrigation, and aquaculture. Biodiversity has increased with the return of bird species and other aquatic life. The Dongting Lake Plain restoration demonstrates the value of integrating traditional practices, ecological restoration, and incentive-based policies to enhance rural resilience, ecosystem services, and sustainable agricultural livelihoods.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
	2		3	1

Case 9. A constructed wetland and pond for improved water management in a seasonally water-scarce environment (Stora Tollby organic farm, Sweden)

Örjan Berglund

International Peatlands Society, and
Swedish University of Agricultural Sciences

Wetland Fole Stora Tollby

Wetland type: Water storage bodies (small farm pond)

Surface area: 5.6 ha

GIS: 18°32'11.3"E; 57°37'26.7"N

Agricultural system: Rainfed intensive; Irrigated;
Horticulture; Aquaculture extensive



Pond before filling of water (© Andreas Wiklund)



View of the pond with water (© Andreas Wiklund)

Summary

A constructed wetland and irrigation pond at Stora Tollby Farm on Gotland Island, Sweden, offers an integrated response to water scarcity, nutrient runoff, and wetland degradation - challenges exacerbated by the island's mild maritime climate and intensive agriculture. Gotland frequently experiences summer droughts and limited groundwater availability, making water storage a critical concern for farmers. To address this, the farm designed a multifunctional pond system that captures and stores drainage water during high-flow periods and reuses washing water from the vegetable cleaning process. The pond not only secures water for irrigation, particularly for high-value crops such as vegetables and potatoes, but also supports biodiversity by creating a habitat for amphibians, insects, and birds. Additionally, it improves water quality by filtering nutrients and reducing eutrophication before the water reaches downstream ecosystems. The farm has also diversified its income through crayfish production and increased employment during the harvesting season. The initiative is part of a broader shift toward sustainable agriculture and was made possible with support from EU rural development funds. Sustainability measures include improved nutrient and soil management, reduced runoff, enhanced biodiversity, and a stronger climate adaptation capacity. The governance of the project involves coordination among farmers, local authorities, and national agencies, although challenges remain related to land-use trade-offs, financial investments, and administrative procedures. Stora Tollby's approach offers a replicable model of how nature-based solutions can support both agricultural productivity and ecosystem health. Continued investment and policy support are crucial for scaling such approaches and promoting long-term resilience and sustainability in agriculture-dependent landscapes.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
2		3		1

Case 10. Collaboration between farmers and conservationists to improve the status of the aquatic environment in a protected lake and wetland area in Sicily, Italy

Stefania D'Angelo¹, Susanna D'Antoni²

¹WWF Italia ETS; ²Institute for Environmental Protection and Research (ISPRA)

Convention on Wetlands Zone Laghi di Murana, Preola e Gorgi Tondi/

Integral Nature Reserve Lago Preola and Gorgi Tondi Wetland type: Marshes, pools;

Surface area: 335 ha

GIS: 12° 38' 58.58"E; 37° 36' 42.71"N

Agricultural system: Irrigated intensive (vineyards and olive groves)



Aerial photograph showing the lakes and surrounding agricultural areas (© WWF Italia archive) The Sicilian Pond turtle (*Emys trinacris*) (© Stefania D'Angelo)

Summary

Until 1999, the wetlands of Lake Preola and Gorgi Tondi in western Sicily suffered from severe ecological degradation due to intensive agriculture. As a Wetland of International Importance and Important Bird Area (IBA), the wetlands hold significant ecological value, providing habitat for rare species like the Sicilian pond turtle (*Emys trinacris*) and marbled duck (*Marmaronetta angustirostris*). However, decades of pesticide use, groundwater over-extraction, and land conversion led to water scarcity, pollution, and biodiversity loss. In response, WWF Italy launched a restoration programme focused on limiting agrochemical inputs, regulating irrigation, and acquiring ecologically sensitive lands. These actions improved water quality, restored groundwater levels, and enhanced habitat conditions, supporting the return of native species. Biodiversity monitoring confirmed increases in birds, amphibians, and aquatic plants. The initiative also promoted organic farming and sustainable practices to reduce pressure on wetlands. Farmers were actively engaged through education, participatory conservation projects, and eco-incentives. Governance reforms and strong collaboration among farmers, NGOs, and public authorities built trust and supported long-term ecological stewardship. The project transformed Lake Preola and Gorgi Tondi into a model for integrating agriculture and wetland conservation, demonstrating that biodiversity protection and rural development can be mutually reinforced when supported by inclusive governance and sustainable land management.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
2	1		3	

Case 11. Agrarian reform and environmental management to support farmers and protect the Sultan Marshes, Türkiye

Melike Kuş¹, Olcay Ünver²

¹Nature Conservation Centre Foundation;

²Arizona State University

Sultan Marshes, Central Anatolia, Türkiye

Wetland type: Lakes; Marshes; Rivers, streams, floodplains

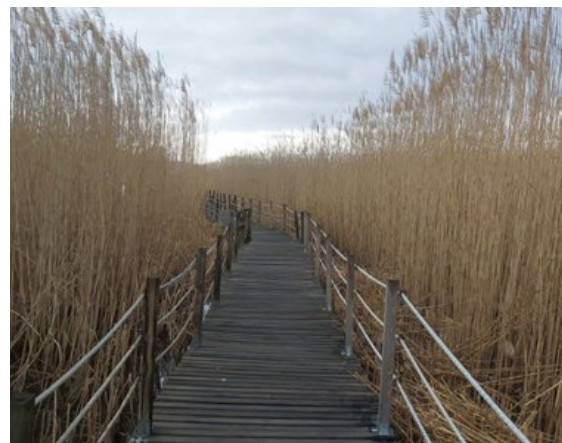
Surface area: 17,200 ha

GIS Coordinate: 38°20'N 035°17'E

Agricultural System: Rainfed intensive; Irrigated



Irrigated agriculture around Sultan Marshes National Park (© Melike Kus)



Walking trail in Sultan Marshes National Park (© Melike Kus)

Summary

The Sultan Marshes, a Wetland of International Importance in Central Anatolia, are vital for biodiversity, providing a critical stopover for bird migration and essential ecosystem services. However, they face significant threats from agricultural expansion, water overuse, pollution, overgrazing, and drought, resulting in a 50% reduction in their water surface since 1977. Conservation efforts include the “Sultan Marshes National Park and Ramsar Site Management Plan”, which targets the re-establishment of the disrupted ecological balance in the area, ensuring the sustainability of resource use and a participatory approach to removing the threats, and the Environmentally-Based Agricultural Land Protection (ÇATAK) Programme, an agro-environmental scheme promoting efficient irrigation, sustainable farming practices, and pollution reduction. Livelihoods are supported through nature tourism and government incentives. Restoring the water supply to the wetlands involved supplying the wetlands with water from the dams and implementing an interbasin water transfer project to provide irrigation water. This resulted in the wetland’s expansion to its largest extent in 22 years, although it raised concerns regarding water quality and the introduction of alien species. The success of the conservation efforts is the result of a combination of promoting resource efficiency, improving natural resource management, and reducing pollution and erosion. Providing incentives to farmers who applied conservation agriculture practices, in combination with training, led to behavioural change. Effective stakeholder engagement involving government agencies, local communities, farmers, non-governmental organisations, researchers, and businesses was fundamental to the decision-making processes. Effective water management and ecosystem restoration are essential to preserving the Sultan Marshes as a model for integrating agriculture with ecological conservation.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
	3	2		1

Case 12. The toMOORow PaludiAlliance – how developing value chains for paludiculture products can help create large-scale wet peat landscapes

Claudia Bühler¹, Franziska Tanneberger², Jan Peters³, Björn Köcher¹

¹Michael Otto Environmental Foundation; ²University of Greifswald, partner in the Greifswald Mire Centre; ³Michael Succow Foundation, partner in the Greifswald Mire Centre

Peat wetlands in northern and southern Germany

Wetland type: Peatlands

Surface area: NA

GIS: NA

Agricultural system: Rainfed extensive; Livestock extensive



Cattail harvest (© Tobias Dahms)



Prototype inner door panel made from paludiculture biomass. (© Baufriz)

Summary

In Germany, approximately 95% of the 1.8 million hectares of peatlands are drained, primarily for agricultural and forestry purposes. This extensive drainage leads to significant greenhouse gas emissions. To mitigate these emissions, an annual rewetting of 50,000 ha of peatland is needed. The toMOORow PaludiAlliance is a collaborative initiative involving industry, government, and research institutions, aiming to develop sustainable value chains for paludiculture biomass and support farmers willing to engage in its production. Biomass from wet peatlands has the potential to be utilised for producing paper, cardboard packaging, building materials, insulation, furniture, plastics, and chemical-based materials. The project focused on knowledge transfer and conducted a feasibility study to explore viable options for utilising paludiculture biomass and integrating it into existing value chains. The establishment of a digital paludiculture biomass exchange platform was a key element, facilitating connections between suppliers and buyers of renewable raw materials sourced from wet peatlands. This innovative approach not only supports sustainable farming practices but also encourages the restoration of degraded peatlands, which plays a critical role in mitigating climate change. By supporting the transformation to sustainable peatland farming, the toMOORow PaludiAlliance provides farmers with secure incomes through the production of valuable, eco-friendly products, contributes significantly to the rewetting of peatlands and the reduction of greenhouse gas emissions from this land use, and enhances resilience to climate change.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
	2	3		1

Case 13. The Xochimilco peri-urban wetland: a resilient agroecosystem of biocultural importance

Lakshmi Charli-Joseph¹; Patricia Pérez-Belmont²; Mariana Benítez¹; Marisa Mazari-Hiriart¹; Celic Sánchez González¹

¹Laboratorio Nacional de Ciencias de la Sostenibilidad, Instituto de Ecología, Universidad Nacional Autónoma de México (UNAM); ²Umbela Transformaciones Sostenibles A.C.

Xochimilco peri-urban wetland Mexico

Wetland Type: River, streams, floodplains; Agricultural wetlands

Surface area: ~2,657 ha

GIS: 19°16'N 99°04'W

Agricultural system: Irrigated intensive; Horticulture; Livestock intensive; Aquaculture intensive



Insufficient water of poor quality is supplied to the canals from water treatment plants by the Mexico City Water System authority (SACMEX); Informal settlements with varying degrees of consolidation present within the conservation area polygons (© P. Pérez-Belmont)



Agroecological farming vs. farming with agrochemicals and plastics (© P. Pérez-Belmont, 2019).

Summary

The Xochimilco peri-urban wetland, a Wetland of International Importance and UNESCO World Heritage site in Mexico City is a critical biocultural agroecosystem featuring “chinampas,” traditional floating gardens vital for food security, biodiversity, and ecological balance. Despite its importance, the wetland faces significant challenges, including urban encroachment, groundwater over-extraction, declining water quality, and the abandonment of traditional farming practices. These issues have reduced its capacity to support local livelihoods and maintain its ecological and cultural functions. Restoration efforts focus on reviving traditional agroecological practices, such as crop rotation and water sub-irrigation, while integrating modern sustainable techniques. Community empowerment initiatives promote knowledge sharing, agroecological transitions, and access to fair markets. Conservation efforts include ecological labelling programmes and wetland restoration projects to protect biodiversity, such as the endangered axolotl. Addressing governance fragmentation and strengthening multi-level collaborations are key to ensuring sustainable futures, emphasising community-driven strategies rooted in local heritage and needs.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
3		2		1

Case 14. Restoration of pasture in a high-altitude protected wetland area (bofedales) in Peru

Daniella Vargas Machuca¹, Ana María Planas^{2,3}, Mayra Mejía⁴, Beatriz Fuentealba⁴, Rodney Chimner³, Laura Villegas⁵, Matthew Warren⁵, Maria Nuutinen⁵

¹Instituto de Montaña, Lima, Peru; ²Programa SilvaCarbon, USA; ³Sustainable Wetlands Adaptation and Mitigation Program, CIFOR, Peru; ⁴Instituto Nacional de Investigación en Glaciares y Ecosistemas de Montaña, Peru; ⁵Food and Agriculture Organization of the UN, Rome.

Ancash region, Huari province, Chavín de Huantar district, Shirapata village, Peru

Wetland type: Peatlands

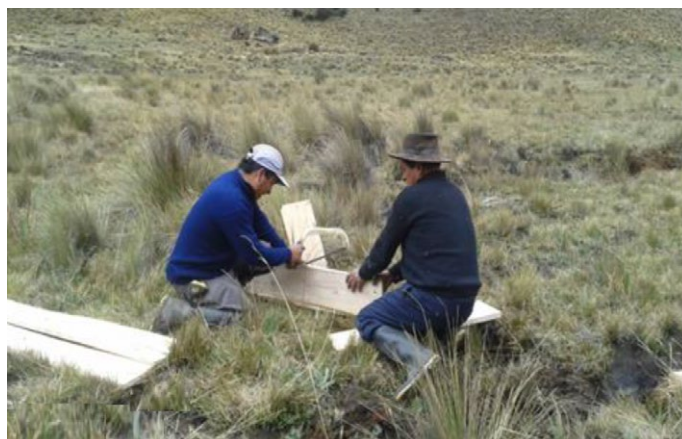
Surface area: 0.4 ha, part of the 340,000 ha Huascarán National Park

GIS: 9°41'21.80" S, 77°14'18.40" W

Agricultural system: Livestock extensive (sheep and cattle grazing)



Installation of dams to restore a peat bog (bofedal) in the Pucavado ravine, Huascarán National Park (© Beatriz Fuentealba)



Local residents building the newly installed barriers (© Mayra Mejía).

Summary

Bofedales are high-altitude (4,000–4,700 m asl) Andes wetlands, often classified as peatlands and characterised by the presence of cushion plants. They are crucial for biodiversity, water regulation and carbon storage but face pressures from climate change (reduced rainfall, glacier melt, higher temperature) and changing agricultural practices. For centuries, *bofedales* had been managed by indigenous agro-pastoral communities who diverted river water to irrigate valleys as grazing areas for alpaca and llama herds. They also served as sources of water for downstream agricultural and urban areas. More recently, population growth, higher water demand, the introduction of sheep and cattle, mining, and migration to cities made it difficult to maintain traditional management. Some wetlands were drained to expand sheep and cattle grazing, disrupting their ecology and reducing their capacity to store water and carbon. The restoration project involved blocking drainage canals and reverting to a more natural hydrological regime. The resulting increase in groundwater level benefited native plants and promoted soil carbon and water storage, enabling the irrigation of downstream feedstock systems to reduce grazing in the *bofedales*. It also improved the resilience of the Shirapata communities to droughts and intense rainfall events. Key to the project's success were technical and financial support to farmers, as well as coordination among stakeholders to ensure improved land management and governance while contributing to national climate policies.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
3	1			2

Case 15. Wetland conservation and restoration in the Canadian Prairie Pothole Region

Pascal H.J. Badiou; Stuart Slattery

Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research

Prairie Pothole Region (PPR), Canada

Wetland type: Marshes (on mineral soils)

Surface area: 467,000 km²

GIS: N/A

Agricultural system: Rainfed extensive, intensive;
Irrigated intensive; Livestock extensive



Photos of a prairie wetland (left) pre (drained) and (right) post restoration in the Canadian Prairie Pothole Region (© Ducks Unlimited Canada)

Summary

Over the last two centuries, the Canadian Prairie Pothole Region has experienced significant wetland loss and degradation due to large-scale drainage, agricultural expansion, and intensification of agricultural practices. In response, Ducks Unlimited Canada (DUC) has implemented various conservation and restoration programs aimed at recovering waterfowl habitats and the broader ecosystem services provided by these wetlands. DUC's initiatives include land acquisition, conservation easements, and the application of best-management practices to restore wetlands. A core aspect of these restoration efforts is the plugging of drainage ditches and the installation of water control structures, which help to restore the ecological and hydrological functions of the wetlands. In addition to wetland restoration, DUC provides financial incentives to farmers, assisting them with the costs of establishing forages and compensating for crop losses on fields that are prone to flooding or are less accessible. This financial support encourages farmers to adopt wetland-friendly practices while continuing agricultural activities. DUC also plays a vital role in contributing to the development of wetland policies at both provincial and federal levels, advocating for the protection and sustainable management of wetlands. The success of DUC's programs is built on collaboration with government bodies, private sector partners, and farmers working at a large scale across the region. By combining policy advocacy, direct financial support, and hands-on restoration efforts, DUC is making significant strides in reversing wetland loss and degradation, contributing to the restoration of vital ecosystems and improving waterfowl habitats in this agriculturally dominated region.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
2	1			3

Case 16. Managing the wetland ecosystem services of agricultural drainage ditches in Ontario, Canada

David R. Lapen, Mark Sunohara

Agroclimate, Geomatics, Earth Observation and Agroenvironmental Resilience Centre, Science and Technology Branch, Agriculture and Agri-Food Canada, Government of Canada

Agricultural drainage ditches, Eastern Ontario, Canada

Wetland type: Rivers, streams, floodplains; Marshes (on mineral soils)
GIS: 44°40'30"N; 75°42'00"W (near Fairfield East, Leeds and Grenville County)

45°34'23"N; 75°06'00"W (2 km east of Wendover, Prescott and Russell County)

Surface area: ~3,150 ha across; ~3,500 linear km of ditches within the South Nation River basin (~4,000 km²)

Agricultural system: Rainfed intensive; Livestock extensive



Agricultural drainage ditches, displaying wetland-type features. Clockwise from top left: ditch prior to dredging; ditch after brushing of woody vegetation and dredging; ditch regeneration post-brushing (©Agriculture and Agri-Food Canada)

Summary

Agricultural drainage ditches in Ontario are critical flow-through wetlands that cover a substantial surface area in watersheds and are the only (semi)aquatic ecosystems available for wetland-type flora and fauna. They provide essential ecosystem services within agricultural landscapes, such as refugia for wildlife, water filtering of agrochemicals, and provision of drainage required to optimise crop productivity. Though designed primarily to manage excess water and optimise crop productivity, these ditches can naturalise to support biodiversity, sequester carbon, and filter agrochemicals. Effective management balances agricultural needs with ecological benefits, including wildlife refugia and pest control habitats. However, intensive maintenance, including frequent dredging and vegetation clearing, can undermine these services. Reducing management intensity and increasing awareness of the value of these ditches can enhance sustainability and resilience for agriculture and the environment. Municipalities and drainage superintendents can promote minimal management of drainage ditches and support their wetland functionalities by communicating to producers the monetary savings achieved by dredging or clearing only when necessary to maintain flow efficiency. With minimal management, these ditches can act as flow-through type wetlands providing ecosystem services and functions within otherwise depauperate agricultural “field-scapes”.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
2		3		1

Case 17. The US Department of Agriculture wetland conservation reserve program: quantifying ecosystem services from wetland restoration to benefit water quality and climate

Siobhan Fennessy

Department of Biology and Environmental Studies,
Kenyon College, Gambier, Ohio, USA

Agricultural areas throughout the USA

Wetland type: Marshes (on mineral soils)

Surface area: N/A

GIS: N/A

Agricultural system: Rainfed intensive



Prairie pothole Conservation Reserve Program wetland (©Siobhan Fennessy)



Ohio farmland in former wetland (© Siobhan Fennessy)

Summary

Wetlands integrated into agricultural landscapes offer a range of social and ecological benefits, including improved water quality, carbon sequestration, biodiversity support, and enhanced water retention and storage. In response to environmental degradation and wetland loss, the US Department of Agriculture (USDA) established the Conservation Reserve Programme (CRP), initially to reduce soil erosion and later, along with the Wetland Reserve Programme (WRP), to promote conservation practices on private farmland across the US. To date, over 1.2 million hectares of wetlands have been restored. Under this programme, landowners receive financial and technical assistance from the USDA to take cropland out of production and restore wetlands that were lost or degraded by agricultural land use. Assessments of the impact of conservation programmes show a significant increase in the benefits that wetlands provide, including improved water quality, reduced climate change impacts, and enhanced biodiversity. The long-term benefits of these conservation programmes can be limited because of programme administration, which restricts contracts with landowners to 10-15 years, after which the land may be converted back to crop production. This case study focuses on the benefits that can be realised through a government-sponsored policy to reintegrate wetlands across large areas of farmland.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
3	2			1

Case 18. Environmental water allocations to maintain the ecological character of wetlands in the Murray-Darling Basin, Australia

C. Max Finlayson

IHE Delft Institute for Water
Education, Delft, The Netherlands

Murray-Darling Basin, Australia

Wetland type: Rivers, streams, floodplains, lakes, swamps, marshes

Surface area: 106,150,000 ha

GIS: N/A

Agricultural system: Irrigated; Rainfed extensive, intensive; Livestock extensive, intensive; Horticulture



Murray Darling Basin, with water management infrastructure on a river
©Max Finlayson



Irrigated agriculture in the Murray Darling basin, with nut plantations ©Max Finlayson

Summary

The Murray-Darling Basin contains three major and around 20 other rivers, most flowing into the Murray or Darling Rivers before the Murray reaches the Southern Ocean. Agriculture is a major driver of change, with large areas of native vegetation cleared and rivers regulated through weirs and dams. Irrigated land covers only 2% of the Basin but consumes 90% of extracted water and produces 70% of Australia's irrigated agricultural output. Climate change leads to extensive droughts, with evaporation four times higher than rainfall, resulting in only 6% runoff to streams and groundwater. Drought and water extraction have raised concerns about the health of rivers and wetlands, as well as the sustainability of irrigation. In response, the Murray-Darling Basin Plan was signed into law in 2012 to restore the ecological condition of rivers and wetlands through environmental water allocations. The plan provides for water sharing between users and the environment, setting limits (Sustainable Diversion Limits) on irrigation, urban, and industrial uses, among others. A major implementation mechanism was a market for water in which the government acquired water rights for wetlands. Additionally, engineering solutions were employed to enhance water use efficiency and distribution. Monitoring of physical, ecological, social, and economic indicators revealed that achieving the environmental water targets was a challenging task. Small producers faced negative consequences from the water market, as it affected their ability to deliver water to local farms. In contrast, larger producers could sell their water rights and invest in less water-intensive production. Engineering solutions did not deliver the expected results. Generally, farmers are against diverting water away from agriculture for the benefit of wetlands. The Sustainable Diversion Limits came into effect in 2019 and are due for review in 2026.

Sustainability analysis

Resource use efficiency	Protecting wetlands	Supporting rural livelihoods	Building resilience in people and ecosystems	Effective governance and institutions
2	3			1

4. Synthesis and lessons learnt from case studies results

The case studies encompassing all six Convention on Wetlands regions highlight the critical role of wetlands in supporting a transition to sustainable agriculture-wetland interactions and catchment health, demonstrating their importance for both food production and ecosystem resilience.



© Tom Fisk

4.1. Key insights in wetlands and agriculture

a. Wetlands are crucial for both ecosystem health and food production

Wetlands, when managed sustainably, enhance both agricultural productivity and ecological resilience, supporting a balanced approach to food security and environmental conservation.

- *Wetlands have direct benefits for agriculture*, providing essential resources such as water, nutrients, and sediment that sustain agricultural production. Several case studies provide examples of this, such as the Yala and Anyiko wetlands in Kenya (Case 1), where seasonal floods enrich the soils, and the Merjas in Morocco (Case 2), which support agricultural production, although this often leads to degradation. In Colombo, Sri Lanka (Case 3), human-made wetlands (urban rice paddies) provide multiple ecosystem services to the urban population, like flood mitigation, food production, and herbs and medicinal plants.
- *Wetlands have indirect benefits at the catchment level*: they perform key hydrological, biogeochemical and ecological functions that support both agriculture and catchment health. For example, the mangroves in Anawilundawa Wetland Sanctuary, Sri Lanka (Case 4), act as nurseries for finfish and shellfish, supporting artisanal fisheries of large socio-economic importance. Sultan Marshes in Türkiye (Case 11) play a crucial role in transboundary bird migration routes, while wetland restoration in Colombo, Sri Lanka (Case 3), enhanced flood control, groundwater recharge, and urban biodiversity. Restored wetlands in the US (Case 17) had positive effects on catchment nutrient retention and carbon sequestration.
- *There is not necessarily a contradiction between food production and wetland health*: when managed sustainably, wetlands can simultaneously support food production and catchment resilience. A few examples from the case studies: Huai Chorakhemak in Thailand (Case 6) functions as both a bird refuge and a floodwater retention area. Traditional chinampa systems, such as those found in the Xochimilco wetland in Mexico (Case 13), rely on the wetland's functioning for water and nutrients, thereby ensuring long-term food production. Restoration efforts in Canada's Prairie Pothole Region (Case 15) highlight the role of wetlands in sustaining catchment ecosystem functions. Agricultural drainage ditches in Canada (Case 16) can function as human-made wetlands, supporting biodiversity, carbon sequestration, and water quality regulation.

b. Wetlands enhance resilience to climate change and other shocks in food systems.

Healthy wetlands play a crucial role in adapting to climate change by mitigating the impacts of floods, droughts, and rising temperatures, benefiting both ecosystems and human communities. In some regions, they also buffer against other shocks in food systems, such as changes in markets.

- *Wetlands contribute to climate adaptation through water storage and regulation*. Many wetlands can buffer climate variability by storing water during wet periods to prevent flooding and releasing it during dry periods, thereby mitigating droughts. In Bang Rakam, Thailand, harvested paddy fields store excess floodwater for later use in irrigation. In the Anawilundawa Wetland Sanctuary, Sri Lanka (Case 4), the mangroves reduce flood and drought risks, while Colombo's restored urban paddy fields (Case 3) improved flood resilience and urban cooling. In Sweden (Case 9), the newly created farm ponds helped store water during long summer drought periods and increased irrigation efficiency.

- *Wetlands contribute to climate mitigation through carbon storage*, serving as carbon sinks that store carbon in vegetation biomass and organic soils, particularly in peatlands and coastal mangroves. If vegetation remains in wetlands and contributes to peat formulation, it enhances carbon sequestration, as in the high-altitude *bofedales* in Peru (Case 14). In Germany, the PaludiAlliance (Case 12) supports peatlands restoration by promoting paludiculture, creating economic incentives for farmers to cultivate rewetted peatlands while maintaining their carbon storage functions.
- *Wetlands support livelihood diversification and resilience to economic shocks*, providing alternative income sources, enhancing resilience to market fluctuations, and mitigating crop failures. During the COVID-19 pandemic, Colombo's urban paddy fields in Sri Lanka (Case 3) became a critical source of food and income when food transport was disrupted. Sustainable farming practices, such as crop diversification and integrating crops and livestock, further enhance resilience. In Maoli Lake in China (Case 8), traditional pond-crop integration was restored by using pond sediments as fertiliser. In several cases, livestock manure reduced reliance on chemical fertilisers, improving soil health and crop yields.

c. Agriculture impacts wetland ecosystems.

Despite the benefits of wetlands for agriculture and the many options for synergies between wetlands and food production, agriculture is still a major driver of wetland loss and degradation, primarily through conversion to cropland, water abstraction, drainage, and pollution. Unsustainable practices have significantly impacted the health of wetlands across all case studies. The case studies provide many examples.

- *Wetland loss due to agricultural expansion and water abstraction*: farming has led to the conversion of wetlands into cropland, settlements or infrastructure and to water abstraction and drainage, which disrupts natural hydrological cycles. In Morocco (Case 2), Italy (Case 10), and Türkiye (Case 11), irrigation, chemical inputs, and land expansion contributed to water scarcity, eutrophication, and habitat loss. In Sicily, Italy, agricultural water abstraction caused salinisation, eutrophication and oxygen depletion in wetland lakes. Similarly, in the Prairie Pothole Region of Canada (Case 15) and the United States (Case 17), large-scale, intensive crop and livestock production has led to extensive wetland drainage and pollution.
- *Degradation from agricultural inputs*, including fertiliser and pesticide runoff and leaching from intensive farming, pollutes water and damages wetland habitats. In Maoli Lake, China, traditional ponds once used for irrigation, flood storage, fishing, and drinking water were lost due to privatisation and intensified farming, leading to increased use of chemical fertilisers and pesticides, land degradation, and biodiversity decline. In Sri Lanka (Case 4), the expansion of shrimp farming in the 1980s and 1990s led to mangrove destruction and water pollution. Similarly, in Yala wetland, Kenya (Case 1) and Türkiye (Case 11), intensive farming and irrigation infrastructure disrupted the natural hydrological processes, causing pollution, erosion, overgrazing, and habitat loss. In Xochimilco, Mexico (Case 13), intensive commercial farming practices contributed to the degradation of the traditional chinampa farming system.
- *Trade-offs between agricultural and ecosystem services*: agricultural expansion enhances food production (provisioning services). Still, it reduces the functions of wetlands, such as water storage and nutrient retention, as well as habitat support (regulating services). While remaining intact wetlands can partially compensate for these losses, determining trade-offs at the catchment level and defining clear guidelines for sustainable agriculture remains a challenge.
- *A combination of agricultural practices and other drivers of change can accelerate wetland degradation*. In the highlands of Peru (Case 14), livestock and pasture management on the peat wetlands had been a sustainable system for years. Still, climate change and socio-economic changes led to irreversible changes in the wetlands. Similarly, climate change and economic development led to the decline of the integrated farming systems in the Vembanad-Kol Wetland in Kerala, India (Case 5). While local people often cannot influence these larger-scale drivers, they can help reverse the trend of wetland loss and degradation by transforming their agricultural practices, returning to traditional practices or combining them with sustainable innovations.

d. Recognising and managing diversity in wetlands and farming systems is important.

Interventions for sustainable agriculture-wetland interactions must consider the diversity in farming systems, wetland types and socio-economic contexts. The case studies provide examples of small-scale and large-scale farming systems, as well as a variety of wetland types (e.g., peatlands, high-altitude wetlands, floodplains, and coastal wetlands), demonstrating that sustainability can be pursued across all types of farms and wetlands.

- *Diversity in farming systems and sizes:* different farming systems (crops, livestock and fish systems) have varied environmental impacts and sustainability opportunities. Small farms often depend heavily on the services provided by wetland ecosystems but face limited financial and technical support. In contrast, larger farms typically have better access to technology and credit, are often supported by government subsidies, and maintain strong connections to national and global markets. Sustainable productivity improvements for small farms should increase yields and incomes while preventing further encroachment into wetlands. In contrast, large farms should optimise the efficiency of water and fertiliser use to minimise pollution (e.g. nutrient and pesticide) and greenhouse gas emissions.
- *Diversity in wetlands:* wetland types vary from inland to coastal, floodplain and delta wetlands to isolated high-altitude systems, and mineral or peat soils. Conservation efforts must recognise the vulnerability of the wetland types involved and ensure that agriculture activities respect the ecological character of each wetland type.
- *Diversity in indirect drivers:* wetland changes are influenced by non-physical factors such as technology, markets, institutions and policy frameworks. These drivers influence decision-making regarding wetlands and, consequently, impact their sustainability and resilience. Policy settings and socio-cultural contexts vary among and even within countries, influencing how communities manage wetlands and adopt conservation or agricultural practices.
- *Diversity in actors and perspectives:* conventional production-driven agriculture focuses on food security and market-driven intensification, whereas the food sovereignty paradigm emphasises social-ecological systems, sustainability and cultural diversity. A shift towards collaborative governance, equitable wealth distribution, and technological innovation is necessary to strike a balance between productivity and environmental conservation.

Understanding the diversity of wetland and agricultural systems is crucial for policymakers to develop locally adapted, context-specific solutions, as no single 'best' approach can ensure sustainable food production for all wetland landscapes worldwide.

e. The wise use of wetlands supports global priorities, including the Sustainable Development Goals (SDGs) and climate change goals.

The case studies offer numerous practical examples of the challenges confronting the global food system in terms of environmental sustainability, inclusivity and equity, human health and nutrition, climate impact, and the vulnerability and resilience of livelihoods and ecosystems to extreme events and market shocks. They also demonstrate how the wise use of wetlands can play a crucial role in addressing these challenges. There is a growing consensus on the need to transform the way food is produced, processed, and marketed (Willet et al. 2019; Webb et al. 2020). Numerous studies have explored sustainable food production methods and their effects on water management and wetland ecosystems (Molden 2007; Falkenmark et al. 2007; Convention on Wetlands 2022b). At COP28 of the UN Climate Change Conference, 134 countries signed a declaration acknowledging the urgent need for agriculture and food systems to adapt and transform in response to climate change (UN Climate Change Conference 2023). The wise use of wetlands contributes to achieving multiple Sustainable Development Goals (e.g., SDGs 2, 6, 13, 14, and 15) (Convention on Wetlands, 2018c) and sustainable agriculture-wetland interactions.

4.2. Recommendations for action

Here, we present recommendations for actions towards more sustainable wetland-agriculture interactions. Examples of actions from the case studies are presented in Table 4.

a. Promote sustainable agricultural practices in conjunction with wetland conservation tailored to the local context.

Sustainable agriculture can be achieved through efficient resource use, impact mitigation, and transitions to regenerative practices, as illustrated by the case studies:

- *Increasing resource efficiency in conventional farming:* improving water use, fertiliser application, pesticide application, and irrigation efficiency can reduce environmental impacts without compromising yields.
- *Mitigate the impacts of agriculture on wetlands:* buffer strips or constructed wetlands can help filter runoff and prevent pollution or treat farm effluents.
- *Transition to more regenerative and organic agriculture* by reducing reliance on chemical fertilisers and pesticides and improving wetland resilience. While transitioning to sustainable methods may involve higher risks and the need for training, it also offers opportunities to obtain better prices for produce and access niche markets.
- *Where possible, integrate crops and livestock for nutrient recycling.* This can be achieved at the farm level by using the residual nutrients from one subsystem as input for another subsystem or at the catchment level by reusing residuals from other farms.
- *Adopt a catchment-wide approach:* effective wetland conservation requires a catchment-wide approach.

A holistic, catchment-based approach to agriculture is essential for ensuring wetland conservation, ecosystem resilience, and sustainable food production.

b. Support farmers transitioning to sustainable practices

Helping farmers adopt sustainable agricultural practices while protecting wetlands requires targeted support through financial incentives, technical assistance, compensation, and knowledge sharing. There are various ways in which this can be achieved:

- *Use financial incentives and subsidies to encourage sustainable practices.* Reducing the costs of sustainable practices encourages their adoption.
- *Create an enabling environment with financial and technical support,* including access to credit, loans, and extension services, to facilitate sustainable transitions.
- *Compensate farmers for maintaining ecosystem services or for reduced yields:* paying farmers for environmental stewardship tasks, such as wetland management and conservation activities, or for yield reductions can reduce risks and encourage sustainable practices. Alternative income sources, such as ecotourism and premium pricing for sustainable products, can also incentivise change. However, cultural factors must be considered, as some farmers prefer independence and productivity over financial compensation. Without proper incentives, ‘sustainability fatigue’ or ‘nature fatigue’ may develop.
- *Promote information and knowledge sharing, and training:* extension services, study tours and training programmes equip farmers with the knowledge to adopt sustainable practices and drive behavioural change.

c. Adopt a food systems approach.

When promoting sustainable agriculture-wetland interactions, considering the entire value chain, including production, processing, distribution, consumption, and waste management, is important. Beyond farm-level practices, actions must target policies, infrastructure, market incentives, and consumer behaviour to create a more sustainable food system. Some specific recommendations:

- *Develop value chains for sustainable wetland produce:* Strengthening value chains for wetland-friendly products provides economic incentives for conservation.

- *Reduce food loss and waste:* Cutting post-harvest losses and food waste can ease pressure on wetlands by reducing the demand for expanded food production. Globally, one third of food is lost or wasted. Solutions include improved storage, enhanced transport infrastructure, and the recycling of crop residues (e.g., composting). Educating consumers on sustainable diets and food waste reduction can further minimise environmental impacts.
- *Promote sustainable consumption patterns:* reducing the overconsumption of resource-intensive foods, such as beef, can enhance food system efficiency and reduce greenhouse gas (GHG) emissions. Encouraging diverse, plant-based diets and responsible meat consumption supports both wetland conservation and climate goals.

By integrating value chain development, waste reduction, and sustainable consumption, a food systems approach can drive economic, environmental, and social benefits, ensuring that wetlands remain productive while supporting food security and biodiversity.

d. Strengthen catchment management and supporting policies at national and local levels.

Effective governance for sustainable agriculture-wetland interactions requires coordination across multiple sectors and scales, stakeholder engagement, capacity-building (e.g., technical training, policy mainstreaming, and financing instruments), and site-specific management strategies. Management needs to establish robust monitoring frameworks to detect ecological changes early and adapt interventions as required.

- *Strengthen formal sectoral policies:* while implementation, legislation, and regulation are important, their effectiveness varies by country and is influenced by factors such as political will, funding, institutional capacity, and policy coordination. Traditional agricultural policies prioritise productivity, but supporting farmers and rural livelihoods requires a shift towards a comprehensive, integrated approach that includes agricultural, social, and environmental policies. Agricultural subsidies should transition from production support to investment in research and development, extension services, and infrastructure, as well as promoting farmers' roles in landscape stewardship.
- *Embrace informal institutions to strengthen formal policy:* informal institutions can create tensions with formal governance structures, particularly when traditional or local practices are overlooked. To address these challenges, a concerted effort is needed to bring different actors and stakeholders together, create clarity about formal arrangements and recognise the potential of informal arrangements (including those of marginal groups) and traditional knowledge. Inclusive dialogue is crucial for bridging the gap between formal and informal governance, fostering mutual understanding and collaboration toward a shared vision.
- *Site-specific wetland or catchment management planning is an option for immediate action.* Most countries have sectoral legislation governing agriculture, water, and the environment; however, wetland-specific policies are less common and may require time to develop. Site-specific management plans can often be developed under existing policies and legislation, bringing together multi-sectoral stakeholders for action.

The insights and actions reported here support the implementation of several earlier Resolutions of the Convention on Wetlands, notably XIII.19 (sustainable agriculture), XIII.13 (restoration of degraded peatlands), XI.15 (rice paddies and pest control), X.25 (Wetlands and biofuels), and VIII.34 (agriculture, wetlands and water) (see Finlayson et al. 2024).

e. Promote stakeholder participation and collaboration.

- *Multi-stakeholder collaboration, participation, and collective action are essential for effective governance.* Collaboration across sectors, including agriculture, water, environment, and climate, at various scale levels is crucial to harmonise wetland conservation with sustainable agricultural development. In this process, it is essential to transfer responsibility to the stakeholders. Participation of stakeholders is not optional but indispensable for success. Farmers or business stakeholders should see tangible benefits, such as income opportunities or a clear business case.

Table 4. Examples of actions for sustainable wetland-agriculture interactions from the case studies (see Section 3.4 and supplementary materials).

Recommendation theme	Recommended action	Example
a. Promote sustainable agricultural practices along with wetland conservation based on the local context.	Increase resource efficiency in conventional farming	■ In Sri Lanka, shrimp farming was made more sustainable through zoning and better management practices (e.g. screening for diseases). (Case 4) ■ In Colombo, urban paddy farmers were provided with both organic and chemical inputs, along with clear guidance on application rates. (Case 3) ■ In Bang Rakam province in Thailand, floodwater storage in harvested paddy fields was enabled by adjusting crop calendars, upgrading infrastructure, and promoting short-duration rice varieties. (Case 7) ■ In Türkiye, farmers were supported in increasing irrigation efficiency, preventing erosion and adopting more rainfed crops to reduce demand. (Case 11)
	Mitigate the impacts of agriculture on wetlands.	■ In Sicily, agricultural lands near wetlands and lakes were acquired and taken out of production, reducing nutrient and pesticide runoff and allowing riparian vegetation to recover. (Case 10) ■ In Ontario, Canada, improved management of agricultural drainage ditches enhanced their functioning as carbon storage and as a filter for agrochemicals. (Case 16)
	Transition to more regenerative and organic agriculture	■ In Sri Lanka, mangrove restoration uses organic pesticides and fertilisers. (Case 4) ■ In Huai Chorakhemak in Thailand, organic rice farming was promoted using cattle manure and rice straw instead of chemical fertilisers. (Case 6) ■ China's Maoli Lake restored the traditional rice-pond-river system, incorporating pond sediments as organic fertiliser and improving sewage treatment. (Case 8) ■ In Italy's Laghi di Murana, Preola e Gorgi Tondi, systemic herbicides were restricted, and soil management and groundwater use were regulated to restore aquatic ecosystems while protecting biodiversity. (Case 10) ■ Conservation agriculture in Türkiye promoted zero tillage, crop rotations, cover crops, and integrated pest management, reducing chemical inputs. (Case 11) ■ In the Xochimilco wetland in Mexico, recovering traditional chinampa farming techniques —such as irrigation with canal water, crop rotation, and the use of local plant varieties —was crucial for wetland restoration. (Case 13) ■ In Canada's Prairie Pothole Region, financial support was provided for establishing forages for livestock feed and crop rotations, enhancing soil health and biodiversity. (Case 15)
	Where possible, integrate crops and livestock for nutrient recycling	■ In Türkiye, crop-livestock integration and sustainable grazing practices were promoted to enhance nutrient cycling and reduce fertiliser dependency. (Case 11)

Recommendation theme	Recommended action	Example
	Adopt a catchment-wide approach.	■ In the Xochimilco wetland in Mexico, restoring traditional chinampa agriculture alone is insufficient; urban wastewater treatment must also be improved to prevent wetland pollution. (Case 13) ■ In the Colombo wetlands, Sri Lanka, integrating organic fertilisers and traditional rice varieties enhanced ecological resilience and flood mitigation. (Case 3) ■ In Thailand's Yom River basin, shifting to organic rice farming and Nature-based Solutions reduced environmental pressures while maintaining agricultural productivity. (Case 6) ■ Sustainable practices in Türkiye's Sultan Marshes, such as efficient irrigation, conservation tillage, and integrated crop-livestock integration, improved soil health and water efficiency. (Case 11) ■ Additionally, in Ontario, Canada, well-managed agricultural drainage ditches demonstrated how farmland infrastructure can provide critical wetland functions, balancing productivity with conservation. (Case 16)
b. Support farmers in transitioning to sustainable practices	Use financial incentives and subsidies to encourage sustainable practices	■ The European Union subsidies in Sweden's Fole Stora Tollby and Italy's Laghi di Murana helped farmers implement eco-friendly practices. (Case 9) ■ Türkiye's Sultan Marshes promoted reduced tillage, efficient irrigation, and organic farming through tiered subsidies. (Case 11) ■ In Canada, financial aid supported wetlands restoration and forage establishment. (Case 15) ■ Assistance in navigating funding opportunities, such as EU support programmes in Sicily (Italy), further enhanced accessibility. (Case 10)
	Create an enabling environment with financial and technical support	■ In Colombo, Sri Lanka, farmers received financial aid, rice seeds, and modern farming technology. (Case 3) ■ In Türkiye, support included micro-irrigation equipment, fruit tree seedlings, seeds, and fertilisers, as well as beehives, enabling farmers to shift from basic conservation practices to a more sustainable farming system. (Case 11)
	Compensate farmers for maintaining ecosystem services or for reduced yields.	■ In Thailand, farmers received compensation for bird-friendly farming to offset crop damage from nesting or feeding birds. (Case 6) ■ In Sicily, Italy, the EU Common Agriculture Policy provided compensation for wildlife damage and supported sustainable land management and crop rotations. (Case 10) ■ In the high-altitude bofedales in Peru, the restoration project supported the Shirapata community in adopting alternative livelihoods through better irrigation systems, reducing their dependence on grazing in the peatland. Farmers and municipal authorities were actively involved in planning and implementing the restoration activities (Case 14) ■ Under the Conservation Reserve Programme (CRP) in the US, landowners receive financial and technical assistance to take cropland out of production and restore wetlands that were lost or degraded by agricultural land use, leading to significant improvements in water quality, carbon sequestration and biodiversity (Case 17)

Recommendation theme	Recommended action	Example
	Promote information and knowledge sharing and training	■ In Mexico City's Xochimilco wetland, community-led programmes revive traditional agroecological techniques. (Case 13) ■ In Türkiye, local communities were trained as tourist guides or security staff, linking conservation with economic benefits. Learning from both successes and failures ensures continuous improvement in sustainable agriculture transitions. (Case 11)
c. Adopt a food systems approach	Develop value chains for sustainable wetland produce	■ In Germany, the toMOORow PaludiAlliance connects a broad partnership of societal actors, including farmers, researchers, and businesses to develop paludiculture products and create a market for them, ensuring secure demand and stable incomes. (Case 12) ■ In Xochimilco wetland in Mexico, the Etiqueta Chinampera ecological label certifies sustainably produced wetland crops, while direct sales to consumers, organic markets, and restaurants further support local farmers. (Case 13) ■ In Thailand, organic rice produced from wetland areas was re-branded as "Sarus rice", fetching higher prices through on-site and online sales, which helped raise farmer incomes. (Case 6) ■ In Sicily, Italy, the restoration of wetlands has enhanced the region's ecological reputation, benefiting businesses that produce almonds, wine, and other local products. This ensures that all catchment businesses benefit from a healthy, resilient landscape that boosts productivity and market opportunities. (Case 10)
	Reduce food loss and waste.	
	Promote sustainable consumption patterns.	
d. Strengthen catchment management and supporting policies at national and local levels.	Strengthen formal sectoral policies.	■ The Yala Wetland Land Use Plan demonstrates a pathway to sustainable and equitable outcomes that balance food production and ecosystem health (Case 1) ■ The integrated wetland management plan for the Vembanad Kol Wetland in India, combined with the designation of parts of the wetland as a Special Agriculture Zone and the establishment of a dedicated wetland management unit within the state government, helps achieve effective coordination of wetland and agricultural policies (Case 5).
	Embrace informal institutions to strengthen formal policy	■ The Bang Rakam Model in Thailand, a collaboration across multiple sectors, demonstrates the potential of Nature-based Solutions in aligning agricultural development with wetland conservation and climate adaptation goals (Case 7) ■ The case study from the Anawilundawa Wetland Sanctuary, Sri Lanka, highlights the importance of collaboration between government agencies, academia, NGOs, and local communities, ensuring the harmonisation of wetland conservation and sustainable aquaculture practices (Case 4)

Recommendation theme	Recommended action	Example
	Site-specific wetland or catchment management planning is an option for immediate action.	■ In Colombo, Sri Lanka, the Colombo Wetlands Management Strategy includes specific regulations to prevent wetland infilling. (Case 3) ■ The Moroccan case emphasised the role of neutral coordination to align the interests of multiple stakeholders and resolve conflicts. (Case 2) ■ In Türkiye, the Sultan Marshes had six protected area designations, highlighting the complexity of formal arrangements and the need for clear, collaborative management plans. (Case 11)
e. Promote stakeholder participation and collaboration	Multi-stakeholder collaboration, participation and collective action are essential for effective governance	■ In Sri Lanka, the National Mangrove Expert and National Wetland Steering Committees involved the participation of government, academia and civil society, which was crucial for raising awareness and knowledge exchange. (Case 4) ■ In the Yala and Anyiko wetlands of Kenya, a multi-sectoral approach was employed to address land tenure issues and rights, as well as conflicts between local farmers and a private investor operating a commercial farm. (Case 1) ■ In the Morocco Merjas, different perspectives of different actors were highlighted: wetlands as agricultural land, as water storage, as cultural heritage, or as biodiversity hubs. (Case 2) ■ In Sicily, Italy, a continuous dialogue with farmers in the areas surrounding the wetland fostered trust, enabling the adoption of sustainable farming practices and the participation of farmers in biodiversity assessments on their own farms. (Case 10) ■ In Türkiye, local and national commissions facilitated cross-sectoral stakeholder collaboration, and farmer organisations joined local-level discussions supported by study tours and educational materials. (Case 11) ■ Likewise, in Canada, the non-governmental organisation “Ducks Unlimited Canada” collaborated with stakeholders, including governments, industry, and farmers, to reverse wetland loss and degradation, promoting sustainable practices while ensuring economic viability. (Case 15) ■ In Ontario, Canada, implementing alternative drainage ditch management required inter-sectoral coordination across government levels to deliver consistent messages and support to farmers. (Case 16)

5. Conclusions

Significant progress has been made in advancing the understanding and management of the interlinkages between agriculture and wetlands since the adoption of the Convention on Wetlands in 1971 (Wood and van Halsema 2008; Convention on Wetlands 2012, 2014, 2022b; Finlayson et al. 2024; van Dam et al. 2025). This technical report builds on that legacy by providing an up-to-date analysis of wetland-agriculture interactions and offering practical insights and tools for Contracting Parties and practitioners. The increasing understanding and acceptance of the need for greater sustainability and equity in food production provide an opportunity to highlight the importance of healthy wetlands for sustainable food systems, and climate resilience and to prioritise sustainable wetland-agriculture interactions.

The case studies underline that agriculture can be an integral part of the ecological character of wetlands. Wetlands and agriculture can be mutually supportive when managed sustainably. Wetlands offer essential ecosystem services, such as water regulation, nutrient cycling, and habitat for pollinators, which benefit agricultural productivity. Additionally, agricultural wetlands can play key ecological roles in urban and rural catchments. However, unsustainable agricultural practices continue to exert pressure on wetlands, threatening their ecosystem functions and services. Despite this trade-off, numerous options exist to both enhance food production and maintain critical regulating ecosystem services and biodiversity support in agricultural wetlands and catchments. The case studies demonstrate that, in addition to making agriculture more resource-efficient and less environmentally impactful, sustainability entails enhancing governance and providing technical and economic support to farmers during their transition towards more sustainable practices.

Recognising the diversity of wetland types, agricultural systems, and socio-cultural contexts is fundamental. Solutions must be context-specific and locally driven. This diversity creates challenges in formulating practical guidelines for practitioners on a global scale. Decisions on local actions should be based on careful consideration of the local environmental, social, and governance context. In this report, key general principles were derived from a set of case studies with global coverage. A large body of practical guidelines exists to promote sustainable agricultural practices and Nature-based Solutions (NbS) for mitigating the environmental impacts of agriculture and for the wise use of wetlands (Annex 1). Practitioners worldwide can leverage existing knowledge-sharing platforms and tools to adapt best practices to local conditions and priorities.

Diversity also exists in the needs of different farmers. For example, the differences between small-scale subsistence producers with limited resources for investing in new technology and large-scale, intensive producers with a commercial orientation need to be recognised when proposing measures for support or regulation. In the future, more detailed guidance on sustainable wetland-agriculture interactions could be beneficial, focusing on specific wetland or farming system types, such as irrigated rice systems, peat wetlands, or those in large agricultural catchments (e.g., Ross and McKenna 2023).



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While this technical report draws on diverse case studies and technical inputs, some limitations remain. Not all agricultural production systems and wetland types were represented. Also, there may be a need for more long-term and quantitative evidence on the outcomes of wetland-agriculture management approaches. Further efforts are needed to broaden the evidence base and ensure that underrepresented regions and systems are included in future assessments. Methods for quantifying the different ecosystem services at a catchment level can support trade-off analysis and decision-making to achieve a sustainable mix of provisioning, regulating, and biodiversity services (e.g., Tanner et al. 2013; Zsuffa et al. 2014; Freeman et al. 2015; Santos et al. 2017; Hambäck et al. 2023). Despite its limitations, this report outlines a systematic approach for wetland and agriculture practitioners to discuss, evaluate and address wetland-agriculture interactions more effectively, based on a shared understanding of the local agroecosystem and utilising the knowledge of all stakeholders.

Although the Convention on Wetlands is one of the largest Multilateral Environmental Agreements (MEAs), with 172 parties, many countries lack dedicated policies for the wise use of wetlands and instead have separate policies and implementing agencies for the water, environment, and agriculture sectors. Ideally, a more integrated policy approach would be taken based on recognising agroecosystems as integral parts of nature, in which agricultural, social, and environmental policies are more harmonised (Ruben et al. 2021). Often, however, existing environmental and agricultural legislation provides sufficient space to initiate integrated wetland or catchment management planning that can focus on implementing wise use approaches for agriculture-wetland interactions. In the meantime, the longer-term process for policy-making and legislation can be initiated and continued.

The successful implementation of wise use plans requires strengthening inclusive governance and integrating policies across the water, environment, and agriculture sectors while also highlighting the critical role of local communities, farmers, and indigenous knowledge holders. Wetland and agricultural officers involved in wetland sites or catchments with agriculture can facilitate this process of strengthening wetland-agriculture linkages in their own countries. Key steps include:

- *Starting with the context:* define the local wetland-agriculture interface, using systems analysis tools (see Annex 1) to understand the wetland and farming systems, the drivers and pressures of agriculture-wetland interactions, and the opportunities for transformation to more sustainability;
- *Engaging stakeholders:* involve and support farmers, Indigenous Peoples, and local communities in co-creating solutions, exchanging knowledge, and building ownership of sustainable practices;
- *Fostering dialogue:* identify and engage individuals from across policy sectors—agriculture, water, planning, and environment—to create partnerships for joint action;
- *Initiating management planning using existing policies and legislation:* planning for wise use and sustainable agriculture at wetland sites or catchment level can start based on existing policy frameworks;
- *Reviewing and adapting policies:* assess existing legal and policy frameworks to identify opportunities for integrating wetland-wise use principles into agricultural planning.

Another key requirement for the successful implementation of wise use is capacity development at multiple levels, ranging from agencies involved in policy formulation and implementation to societal partners, local communities, and farm households. New practices and collaborations require building competencies, acquiring new knowledge and skills, reconsidering existing attitudes and discourses, and reforming institutions and organisations. Both the case studies and earlier guidance (e.g., Gevers et al. 2012; see Annex 1) provide support for this.

This technical report serves as a call to action for Contracting Parties and practitioners to promote policies and practices that enable wetlands and agriculture to coexist, thereby supporting biodiversity, climate resilience, food and water security, and community well-being. The need for more evidence to support sustainable technological innovations, the need for more effective and integrated policies, and the challenges of changing the global food system do not have to stand in the way of working on sustainable wetlands and agriculture nationally and locally, utilising the knowledge and tools that are already available.

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The Convention on Wetlands



The Convention on Wetlands is a global inter-governmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Annexes

Please note that the full case study descriptions are available as supplementary material:

<https://www.ramsar.org/document/agriculture-wetlands-supplementary-materials-case-study-descriptions>

Annex 1. Selected resources for turning recommendations into action.

Recommendation	Action	Resource
Promote sustainable agricultural practices along with wetland conservation based on the local context	■ Increase resource efficiency in conventional farming	WRI (2013) Creating sustainable food futures: a menu of solutions to sustainably feeding more than 9 billion people by 2050. Chapter 4. World Resources Report 2013-02014: Interim Findings (p. 144). World Resources Institute, Washington. https://www.wri.org/research/creating-sustainable-food-future
		FAO (2014) Building a common vision for sustainable food and agriculture – Principles and Approaches. https://openknowledge.fao.org/server/api/core/bitstreams/cd7ebb4f-da7c-474d-83df-b5cc224d2ff8/content
	■ Mitigate the impacts of agriculture on wetlands	FAO (2020) Sustainable Wetland Agriculture and Water Management in the Mekong Region (policy brief). https://openknowledge.fao.org/items/c4ab3047-a5de-4f0a-b2c8-8923f2e642b5
		FAO/IWMI (2018) More people, more food, worse water? A global review of water pollution from agriculture (Eds J Mateo-Sagasta, S Marjani Zadeh, H Turrall) (Food and Agriculture Organization: Rome, Italy; and International Water Management Institute/CGIAR Water Land and Ecosystems Research Program: Colombo, Sri Lanka). http://www.fao.org/3/ca0146en/CA0146EN.pdf
	■ Transition to more regenerative and organic agriculture	FAO (2015) Harnessing the Benefits of Ecosystem Services for Effective Ecological Intensification in Agriculture. https://www.fao.org/fsnforum/consultation/harnessing-benefits-ecosystem-services-effective-ecological-intensification
		FAO (2018) The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems (Food and Agriculture Organization: Rome, Italy). https://openknowledge.fao.org/server/api/core/bitstreams/3d7778b3-8fba-4a32-8d13-f21dd5ef31cf/content
	■ Where possible, integrate crops and livestock for nutrient recycling	FAO (1983) Integrating Crops and Livestock in West Africa. FAO Animal Production and Health Paper 41. https://www.fao.org/4/x6543e/X6543E00.htm#TOC
		FAO (2010) The electronic Consultation on Integrated Crop-Livestock Systems for Development: The Way Forward for Sustainable Production Intensification. https://www.fao.org/fileadmin/templates/agphome/images/iclsd/documents/crop_livestock_proceedings.pdf
		FAO (2007) Tropical crop–livestock systems in conservation agriculture: The Brazilian experience. https://www.fao.org/4/a1083e/a1083e00.htm
		FAO (1999) Livestock in Mixed Farming Systems of the Hindu Kush-Himalayas: Trends and Sustainability. https://www.fao.org/4/x5862e/x5862e00.htm#TopOfPage

Recommendation	Action	Resource
	Adopt a catchment-wide approach	World Bank (2007) Integrated Watershed Management in Rainfed Agriculture. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/456171468762376949/integrated-watershed-management-in-rainfed-agriculture
		Wood AP, van Halsema GE (2008) 'Scoping agriculture–wetland interactions: towards a sustainable multiple-response strategy.' (Food and Agriculture Organization of the United Nations: Rome, Italy). FAO Water Reports 33. https://openknowledge.fao.org/items/a11ecb42-a330-46b3-8635-dc0c0dcca24a
		Bullock JM, Ding H (2018) A guide to selecting ecosystem service models for decision-making - Lessons from Sub-Saharan Africa. World Resources Institute, Centre for Ecology and Hydrology, Ecosystem Services for Poverty Alleviation. https://www.ceh.ac.uk/sites/default/files/ESPA%20Guide%20to%20Ecosystem%20Services%20Modeling%20final%20web.pdf
Support farmers in transitioning to sustainable practices	Understand the local context of wetlands and farming systems	McInnes RJ, Everard M (2017) Rapid Assessment of Wetland Ecosystem Services (RAWES): an example from Colombo, Sri Lanka. Ecosyst. Serv. 25, 89–105. https://doi.org/10.1016/j.ecoser.2017.03.024
		RRC-EA (2020) Rapid Assessment of Wetland Ecosystem Services: A Practitioner's Guide. Ramsar Regional Center - East Asia, Suncheon, Republic of Korea. http://rrcea.org/rawes-practitioners-guide/?ckattempt=1
		Fennessy MS, Jacobs AD, Kentula ME (2007) An evaluation of rapid methods for assessing the ecological condition of wetlands. Wetlands 27(3), 543-560. https://link.springer.com/content/pdf/10.1672/0277-5212%282007%2927%5B543:AEORMF%5D2.0.CO%3B2.pdf
		Learning for Sustainability (2025) Understanding the DPSIR framework: Linking human–environment interactions for sustainable decision-making. https://learningforsustainability.net/dpsir/
		FAO (1996) Participatory Rural Appraisal. Ch. 6, In: Rapid rural appraisal, participatory rural appraisal and aquaculture. FAO Fisheries Technical Paper 358. https://www.fao.org/4/w2352e/W2352E06.htm#ch6
		AfricaRice (2020) Participatory Learning and Action Research (PLAR). https://www.africarice.org/plar
		FAO (n.d.) Tool for Agroecology Performance Evaluation (TAPE). https://www.fao.org/agroecology/tools-tape/en/
	Use financial incentives and subsidies to encourage sustainable practices	FAO (2019) Incentives for Ecosystem Services in Agriculture: Supporting the transition to Sustainable Food Systems. https://openknowledge.fao.org/server/api/core/bitstreams/c8801b68-7f0e-451f-be6a-e8b5b3965c67/content
		FAO (2021) Guide on Incentives for Responsible Investment in Agriculture and Food Systems. https://www.fao.org/family-farming/detail/en/c/1396923/
	Create an enabling environment with financial and technical support	FAO (2020) Incentives for Transition to Sustainable Land Management. https://openknowledge.fao.org/items/56d672a5-6967-4390-b575-2b644d799a8d
		FAO (n.d.) Flexible Regulations: Incentives for Ecosystem Services. https://www.fao.org/in-action/incentives-for-ecosystem-services/toolkit/sources-of-incentives/flexible-regulations/en/

Recommendation	Action	Resource
	Compensate farmers for maintaining ecosystem services or for reduced yields	FAO (2011) Payments for Ecosystem Services and Food Security. https://www.fao.org/4/i2100e/i2100e.pdf
		FAO (2022) The State of the World's Forests 2022: Aligning Incentives, Regulations and Markets with Sustainability. https://openknowledge.fao.org/server/api/core/bitstreams/8f599970-661d-45f5-a598-2ea46ca1605f/content/cb9360en.html
		Smith S, Rowcroft P, Everard M, Couldrick L, Reed M, Rogers H, Quick T, Eves C, White C (2013) Payments for Ecosystem Services: A Best Practice Guide. Defra, London. https://www.cbd.int/financial/pes/unitedkingdom-bestpractice.pdf
	Promote information and knowledge sharing, and training	FAO (n.d.) FAO Knowledge Sharing Platform. https://www.fao.org/knowledge-sharing/en/
		FAO (2019) Agricultural extension manual for extension workers. https://openknowledge.fao.org/items/80306299-b4e3-49cc-acde-0e65469e710b
		Gevers I, Koopmanschap E, Desalos CB, Jansen P, van Vugt SM, Woodhill AJ, Ottow BW, van Dam AA (2012) Enhancing the wise use of wetlands - a framework for capacity development. Centre for Development Innovation, Wageningen University & Research Centre, Wageningen, The Netherlands. https://www.ramsar.org/sites/default/files/documents/pdf/cop11/doc/cop11-doc34-e-capacity.pdf
Adopt a food systems approach	Develop value chains for sustainable wetland produce	FAO (2014) Developing Sustainable Food Value Chains -Guiding Principles. https://openknowledge.fao.org/server/api/core/bitstreams/e47d2ad8-5910-435e-a6b4-92dda2367dc7/content
		IFAD (2018) Nutrition-sensitive value chains - A guide for project design (Volume I) https://www.ifad.org/documents/d/new-ifad.org/gfpd-nutrition-sensitive-value-chains-vol-1
	Reduce food loss and waste	FAO (2011) Global Food Losses and Food Waste – Extent, Causes and Prevention. https://www.fao.org/4/mb060e/mb060e00.pdf
		WWF (2017) Food Loss and Waste: Facts and Futures. Taking steps towards a more sustainable food future. https://wwfafrica.awsassets.panda.org/downloads/wwf_2017_food_loss_and_waste_facts_and_futures.pdf
	Promote sustainable consumption patterns	FAO (2021) Anthology of Sustainable Consumption. https://www.fao.org/agroecology/database/detail/en/c/1457744/
		FAO (2024) The State of Food and Agriculture 2024: Impacts of Consumption Patterns. https://openknowledge.fao.org/server/api/core/bitstreams/f0ae2b1e-f24c-4847-b1d5-0ce182b298f1/content/state-of-food-and-agriculture-2024/impacts-consumption-patterns.html#gsc.tab=0
Strengthen catchment management and supporting policies, at national and local levels	Strengthen formal sectoral policies	FAO (2014) Sustainable Food Systems: A Conceptual Framework. https://openknowledge.fao.org/server/api/core/bitstreams/b620989c-407b-4caf-a152-f790f55fec71/content
		FAO (2025) Multistakeholder policy dialogue to promote innovation in agrifood systems - A training guide. https://openknowledge.fao.org/handle/20.500.14283/cd4042en
		FAO (n.d.) Policy Support and Governance Gateway: Sustainable Food and Agriculture. https://www.fao.org/policy-support/en

Recommendation	Action	Resource
	Embrace informal institutions to strengthen formal policy	OXFAM (2013) The role of local institutions in adaptive processes to climate variability. https://www.oxfamamerica.org/explore/research-publications/the-role-of-local-institutions-in-adaptive-processes-to-climate-variability/ World Bank (2008) The Role of Local Institutions in Adaptation to Climate Change. https://documents1.worldbank.org/curated/en/234591468331456170/pdf/691280WP0P11290utions0in0adaptation.pdf FAO (2015) Strengthening Coherence between Agriculture and Social Protection to Combat Poverty and Hunger in Africa: Framework for Analysis and Action. https://openknowledge.fao.org/items/565f83a8-4f78-4df3-b35e-872c06381f97
	Site-specific wetland or catchment management planning is an option for immediate action	Convention on Wetlands (2010) River basin management: Integrating wetland conservation and wise use into river basin management. In 'Ramsar Handbooks for the Wise Use of Wetlands Vol. 9.' (Secretariat of the Convention on Wetlands: Gland, Switzerland). https://www.ramsar.org/sites/default/files/documents/pdf/lib/hbk4-09.pdf Convention on Wetlands (2010) Managing wetlands. In 'Ramsar Handbooks for the Wise Use of Wetlands, Vol. 18.' (Secretariat of the Convention on Wetlands: Gland, Switzerland). https://www.ramsar.org/sites/default/files/documents/pdf/lib/hbk4-18.pdf Convention on Wetlands (2010) Coastal management: Wetland issues in Integrated Coastal Zone Management. In 'Ramsar handbooks for the wise use of wetlands, Vol. 12.' Convention on Wetlands Secretariat, Gland, Switzerland. https://www.ramsar.org/sites/default/files/documents/pdf/lib/hbk4-12.pdf Wani SP, Rockström J, Sahrawat KL (2011) Integrated Watershed Management in Rainfed Agriculture. Taylor and Francis Group, London (UK). https://oar.icrisat.org/10628/1/Integrated_Watershed_Management_in_Rainfed_Agriculture.pdf
Promote stakeholder participation and collaboration	Multi-stakeholder collaboration, participation and collective action are essential for effective governance	Various Organizations (2024) Unpacking collective action in water stewardship: shared solutions for shared water challenges. https://www.panda.org/wwf_news/?11419466/Unpacking-collective-action-in-water-stewardship FAO (2016) Multi-Stakeholder Partnerships to Finance and Improve Food Security and Nutrition in the Framework of the 2030 Agenda. https://openknowledge.fao.org/items/059f4d0a-dc8c-4d6f-b6b5-427f40a4b03e FAO (2022) The State of the World's Forests 2022: Smallholders, Forest pathways for green recovery and building inclusive, resilient and sustainable economies. https://openknowledge.fao.org/items/4c8bd12f-d6b8-4755-a82f-1284c41bf012 Convention on Wetlands (2010) Participatory skills - Establishing and strengthening local communities' and indigenous people's participation in the management of wetlands. In 'Ramsar Handbooks for the Wise Use of Wetlands, Vol. 7.' (Secretariat of the Convention on Wetlands: Gland, Switzerland). https://www.ramsar.org/sites/default/files/documents/pdf/lib/hbk4-07.pdf