

Scoping agriculture– wetland interactions

Towards a sustainable multiple-response strategy



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Scoping agriculture– wetland interactions

33

Towards a sustainable multiple-response strategy

Coordinated and edited by
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and
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With substantive contributions by the partner organizations of the project
Guidelines on Agriculture, Wetlands and Water Resource Interactions
(GAWI):

Food and Agriculture Organization of the United Nations (FAO)
Ramsar Convention on Wetlands (Ramsar)
Wageningen University and Research Centre (WUR)
International Water Management Institute (IWMI)
Wetland Action (WA)
Wetland International (WI)

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Documents available on CD-ROM

Using the DPSIR database

1. Opening the database
2. Adding a new case to the database
3. Entering data for new case(s)
4. Running queries
5. Viewing reports
6. Compacting the database

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Summary

Agriculture–wetland interactions (AWIs) are becoming more important as rising demand for food production exacerbates pressures on wetlands. The Millennium Ecosystem Assessment (MA) identified agriculture as the major cause of wetland degradation and loss. However, while some ecosystem services, such as regulating and supporting services may be reduced, agricultural development has considerably increased the provisioning services of wetlands. More recently, the Comprehensive Assessment of Water Management in Agriculture (CA) concluded that the pressures on wetlands will probably increase, with the prospect of serious loss of wetlands and their ecosystem services. This is a major challenge as the regulating and supporting ecosystem services that wetlands provide are essential for the functioning of river basins, the maintaining of ecological flows, and the sustainability of agricultural production. Hence, there is a need to explore how to improve the nature of AWIs in order to ensure an appropriate balance in ecosystem service use, i.e. a sustainable supply of all services, and not only provisioning ones.

In 2002, the Ramsar Conference of the Parties (COP) 8 requested the Ramsar Scientific and Technical Review Panel to “identify, document and disseminate good agriculture-related practice” with respect to wetlands. At the following Ramsar COP, the Guidelines on Agriculture, Wetlands and Water Resource Interactions Project (GAWI) was launched to help progress this work. This report is its first official output. As such, it is part of an initial knowledge consolidation phase, to be followed by guideline development, field testing, outreach, dissemination, and capacity building.

This report explores the nature of AWIs through the application of the drivers, pressures, state changes, impacts and responses (DPSIR) framework to 90 cases drawn from around the world. The analysis is set within the context of a literature review and a conceptualization of AWIs. The review concludes that economic and population pressures have been the major driving forces in wetland transformation. The drive to increase economic output (especially food production) has led to excessive emphasis on provisioning services, frequently crop-specific, at the expense of regulating and supporting services and involving excessive water use. The outcome has been wetland degradation and situations where water resources in a river basin are overallocated and where environment flows are inadequate. These pressures will increase and continue for the next three decades at least.

The MA stresses that a rebalancing of ecosystem services is needed in order to sustain productivity, but that a perfect balance is not always feasible owing to priorities such as the Millennium Development Goals (MDGs). The CA focuses on the provisioning services and the need to make them ecologically sensitive, with attention to agro-ecological opportunities, multiple-cropping systems, and achieving diversity within agricultural landscapes.

The MA and CA provide vital guidance for the GAWI work, drawing attention to different concepts and scales of analysis, including: ecosystem services; the functioning of linkages within river basins; multiple use in agro-ecosystems; and the landscape scale of management.

The report discusses the role of wetlands in attaining the MDGs, especially poverty reduction. It stresses the need to see wetlands as potential contributors to development in many ways and, hence, the need to enhance their functioning as multiple-use resources providing a range of ecosystem services.

The DPSIR framework was used to analyse the 90 cases in order to scope out the dynamics of AWIs and their concomitant impacts in socio-economic and ecosystem

services terms. The major trends and occurrences identified in the DPSIR elements confirm the findings of the MA and CA, i.e. ecosystem services tend to be skewed towards overexploitation of provisioning services at the expense of regulating and supporting services.

The main drivers operating towards the exploitation of ecosystem services are natural resources dynamics and market demands (global and local). Another substantive driver is government policy – covering a wide range of issues not only regulation of wetland use. Drivers with regard to climate change and natural variability are conspicuously low or absent, except for Africa.

These drivers translate into pressures on wetlands related to increased agricultural activities such as: expansion (especially in Africa and the Neotropics), intensification (especially in the Neotropics and Asia), and increased water use/depletion. The pressure of increased water depletion is highly divergent across the regions, depending mainly on overall water resources availability. Pressures stemming from nature conservation remain limited to Europe.

The resulting biophysical state changes are mainly changes in water resources (from diminishing resources to altered flood regimes) and a general loss in biodiversity. Changes in soil characteristics (fertility loss and erosion) are predominantly an African phenomenon. Deteriorating water quality is less widely reported except in Europe (where it is the second-most severe state change).

The consequent socio-economic impacts are diverse and multiple. The most frequent impact is losses in subsistence agriculture, which are offset by substantial gains in market-oriented agriculture. This indicates a transformation, with increased market-oriented agriculture generally being associated with a monoculture of intensive water and resources use. The third-most frequent impact is increased social-economic differentiation and associated conflicts over resource use. The transformation in agriculture often represents a differentiation in access to natural resources and the associated benefits. For example, aquaculture and crop intensification in Asia lead to the loss of inland and coastal fisheries. The fact that additional gains in subsistence agriculture are limited is a reflection of a negative feedback cycle in which productivity losses drive further expansion. Europe forms an exception with regard to impacts, as the loss in regulating services (e.g. flood control and water purification) is reported as the dominant impact. This is because its agriculture is in decline, and because of the explicit valuation of these services in European Union (EU) policies and regulations.

The valuation of regulating, cultural and supporting services and their economic management/exploitation at the local context is generally low in the cases analysed. This hampers response options considerably as few concrete economic reasons are being presented and developed that can effectively counter the pressures for market-based agriculture. Exceptions are mostly limited to countries of the Organisation for Economic Co-operation and Development (OECD), where specific services (e.g. flood control, water purification, and recreation) are being revitalized and exploited. There is urgent need to enhance the options for valuing and exploiting non-provisioning ecosystem services whose economic benefits can accrue within the local context, especially in non-OECD economies.

The database analysis of DPSIR elements confirms the general trends depicted by the MA and CA. However, in devising response strategies to rebalance ecosystem services through revitalizing regulating and cultural services, curbing multiple *in situ* provisioning services, or fostering good agricultural practices (GAPs), the DPSIR analysis will need to be conducted in detail for each site and case. To be effective, responses must be geared towards the specific drivers, pressures, states and impacts that operate in each case and setting.

In order to show how the DPSIR framework can highlight key and multiple areas for responses in moving towards sustainable AWIs, the report explores its application in five case studies:

- (i) swamp wetlands in Ethiopia – responding to multiple livelihood and food security pressures;
- (ii) river floodplains in Europe – revitalizing the regulating services of flood control;
- (iii) peat forests in Southeast Asia – the need to respond in terms of global market trends and local management practices;
- (iv) tropical river basins with aquaculture and irrigated agriculture in Asia – concerted approaches in multiple responses in crop, fish/aquaculture and lagoon restoration; and
- (v) integration of rice–fish systems in Thailand.

Response scenarios for all 90 cases were studied separately. Some 63 percent of the cases had responses that attempted to address AWIs, while 7 percent showed evidence of an established sustainable-use regime (usually low-intensity subsistence agriculture). However, 7 percent of the cases showed evidence of increasing agricultural exploitation.

The identified response scenarios were grouped into four categories:

- (i) conservation (33 percent);
- (ii) livelihood development and conservation (33 percent);
- (iii) water resources and river basin planning (26 percent); and
- (iv) payments for environmental services (PES), financial and market mechanisms (5 percent).

In regional terms, the dominant approaches are: conservation in Europe; livelihood development and conservation in Africa, the Neotropics and North America; and water resource management in Oceania. Asia shows the most balanced pattern of responses. These variations reflect the different socio-economic conditions of the regions.

The overall picture shows there are combinations of country-specific or site-specific factors that have made particular responses feasible or led to particular responses being implemented. These multiple factors may relate to: public awareness and support; community motivation and local organization; government policies; national or international legislation; resource availability; and interest from international agencies, non-governmental organizations (NGOs), and interest groups.

Building on the above analysis, a number of courses of action can be identified:

- Reduce pressures from agriculture and negative state changes and impacts by diversifying provisioning services used.
- Diversify demands on wetlands so that different ecosystem services can generate income, especially through PES.
- Manage basin-level land use to facilitate the maintaining of ecosystem services.
- Make agricultural practices more sensitive to ecosystems and their requirements.
- Redirect the drivers of change to meet specific needs in ways that do not create negative state changes.

These activities need to be undertaken *in situ* (within a wetland site) and basinwide (including catchments and wetlands). However, for these actions to be applied, knowledge needs to be developed in a number of areas, especially:

- carrying capacities of wetlands under different agro-ecological and socio-economic conditions in order to identify the ecological bounds for different provisioning uses;
- GAPs in wetlands or basins for agriculture as the primary provisioning service, practices to address negative pressures and state changes (especially for indirect basin-level AWIs) and maximize production in a sustainable manner;

- GAPS for secondary provisioning services, where agriculture is assigned a secondary role in a wetland and is subservient to regulating or cultural services – primarily for *in situ* interactions;
- developing regulating services, especially hydrological ones, as the primary ecosystem services in wetlands;
- enhancement of biodiversity and cultural services as a secondary livelihood support or supplement to the income for wetland agriculture.

The report concludes that:

- AWIs are governed by diverse and situation-specific configurations of DPSIR elements, with particular diversity in the state changes and impacts reflecting how drivers translate into agricultural exploitation.
- The DPSIR analysis provides a new and informative conceptual approach to AWI analysis by incorporating the ecosystem services concept. In addition to showing how AWIs lead to negative impacts in state changes, this method also shows there are direct trade-offs between stakeholders and livelihoods that benefit from different provisioning services within wetlands.
- Restoring ecosystem services and obtaining a symbiotically beneficial balance in ecosystem services has little evidence-based information or experience. It is an intricate and difficult issue as it entails a redistribution of economic benefits among stakeholders.
- Agricultural intensification in wetlands is leading to socio-economic and ecosystem service differentiation, with specific groups benefiting and those who rely on subsistence uses of wetlands losing out. This is a negative feedback loop where losses in subsistence agriculture and uses lead to further pressures and wetland conversion.
- Responses need to be case-specific and address the DPSI elements of that case in their particular context with recognition of specific facilitating factors.
- The real driving forces in AWIs need to be addressed. Action will be more effective if there are interventions at multiple levels based on the DPSIR analysis to identify key elements at the different levels, e.g. with GAPS to address impacts, and policy changes to redirect drivers.
- Responses need to:
 - foster GAPS to reduce negative state changes at basin and wetland site level;
 - restore and economically exploit regulating and cultural services, whereby economic benefits can be tapped for associated compensation measures and benefits redistributed among stakeholders;
 - invigorate permissible multiple provisioning service exploitation, such as fishing, agriculture and gathering, to enlarge livelihood benefits while staying within the ecological resilience boundary.

While different organizations need to be engaged in taking this work forward, it is suggested that the GAWI initiative take up for immediate elaboration:

- (i) guidelines for DPSIR application in AWI response strategies;
- (ii) a compendium of GAPS for responses of indirect interactions as scoped out in this report;
- (iii) guidance for good practices in economically revitalizing regulating and cultural services; and
- (iv) ways to address socio-economic impacts through diversified livelihood responses.

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Any mistakes or omissions in the final text remain solely the responsibility of the authors.

List of acronyms and abbreviations

AWI	Agriculture–wetland interaction
BHD	Birds and Habitat Directive (of the EU)
CA	Comprehensive Assessment of Water Management in Agriculture
CAP	Common Agricultural Policy (of the EU)
CBD	Convention on Biological Diversity
CDR	Complex, diverse and risk-prone
CGIAR	Consultative Group on International Agricultural Research
CO ₂	Carbon dioxide
COP	Conference of the Parties
CPWF	Challenge Program on Water and Food
DFID	Department for International Development (United Kingdom)
DPSI	Drivers, pressures, state changes and impacts
DPSIR	Drivers, pressures, state changes, impacts and responses
DU	Ducks Unlimited
EIA	Environmental impact assessment
EU	European Union
Euc	Eucalyptus
GAP	Good agricultural/aquaculture practice
GAWI	Guidelines on Agriculture, Wetlands and Water Resource Interactions Project / Guidelines on Agriculture and Wetlands Interactions
GBF17	Global Biodiversity Forum 17
IAASTD	International Assessment of Agricultural Science and Technology for Development
INGO	International non-governmental organization
IPM	Integrated pest management
IUCN	World Conservation Union
IVS	Inland valley swamps
IWMI	International Water Management Institute
IWMRA	Integrated water resource management
LNV	Ministry of Agriculture, Nature and Food Quality (the Netherlands)
LSRB	Lower Songkhram River basin (Thailand)
MA	Millennium Ecosystem Assessment
MDG	Millennium Development Goal
MWBP	Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development

ONREPP	Office of Natural Resources and Environmental Policy and Planning (Thailand)
PES	Payment for environmental services
Ramsar	Ramsar Convention on Wetlands
RDC	Rural Development Committee
SC	Sugar cane
STRP	Scientific and Technical Review Panel
TEV	Total economic value
UNDP	United Nations Development Programme
WA	Wetland Action European Economic Interest Grouping
WFD	Water Framework Directive
WI	Wetlands International
WTO	World Trade Organization
WUR	Wageningen University and Research Centre (the Netherlands)
WWF	World Wide Fund for Nature

General introduction to the report

The origins of the Guidelines on Agriculture and Wetlands Interactions (GAWI) initiative go back at least as far as October 2002. At that time and in two consecutive weeks, in Valencia (Spain), there were the Global Biodiversity Forum 17 (GBF17) workshop “Wetlands and agriculture” and Resolution VIII 34 at the Eighth Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar COP8) titled “Agriculture, wetlands and water resource management”. Together, these put the issue of the relationship between agriculture and wetlands clearly on the international agenda. In particular, the latter requested the Ramsar Scientific and Technical Review Panel (STRP), in the 2003–05 triennium, “to establish a framework for identifying, documenting and disseminating good agriculture-related practice, including site-specific and crop-specific information, and policies that demonstrate sustainable use of wetlands for agriculture” (Annex 1).

Since that date, further initiatives, such as the Joint FAO/Netherlands Conference on Water for Food and Ecosystems in the Hague in January 2005, have emphasized the need for new approaches to take into account water and water-related ecosystems in the search for more sustainable use of water in agriculture. This theme has been followed up most recently in the Comprehensive Assessment of Water Management in Agriculture (CA, 2007), which follows up on a number of themes raised by the Millennium Ecosystem Assessment (MA, 2005a). Other initiatives relevant to this area include the Challenge Program on Water and Food (CPWF) of the Consultative Group on International Agricultural Research (CGIAR), the International Assessment of Agricultural Science and Technology for Development (IAASTD) and the Ramsar – Convention on Biological Diversity (CBD) Joint Workplan.

The GAWI group consists of the Ramsar Secretariat, FAO, Wageningen University and Research Centre (WUR), International Water Management Institute (IWMI), and Wetlands International (WI). In addition, Wetland Action (WA) joined the group in September 2006. The group was set up at Ramsar COP9 in Uganda (November 2005) with support from the Netherlands and Swiss national delegations. These delegations and the GAWI partners wanted to support the Ramsar Secretariat and STRP in addressing the issue of the interaction between agriculture and wetlands. The GAWI group takes its title from the project in which it has agreed to collaborate: “Guidelines on Agriculture, Wetlands and Water Resource Interactions (GAWI)”.

The overall goal of the GAWI project is: “To promote synergies between agriculture, wetlands and water resources management, through the development and implementation of guidance on the joint management of agricultural and wetland systems for food production, poverty reduction, livelihoods support and environmental sustainability” (GAWI, 2006).

The specific purposes of the project are to:

- develop a supporting framework and associated guidelines for the sustainable management of different types of wetland–agriculture systems affected by the full range of water resources, agricultural and wetland policies, systems, and practices;
- build capacity to implement the guidelines;
- promote the use of the guidelines.

Specific areas of the COP8 Resolution that are to be addressed include the need to:

- enhance the positive role that sustainable agricultural practices may have *vis-à-vis* the conservation and wise use of wetlands;

- minimize the adverse impacts of agricultural practices on wetland conservation and sustainable-use goals;
- identify examples based on wetland-type specific needs and priorities that take into account the variety of agricultural systems;
- optimize services of wetlands for livelihoods (agricultural crops and other ecosystem services);
- provide guidance at the practical level that should receive priority, with additional guidance at the policy/planning level.

The GAWI group has identified six work packages:

- knowledge consolidation and guidance,
- guidelines,
- fieldwork,
- outreach and dissemination,
- capacity building,
- project management and public relations.

This present report is within the first work package of “knowledge consolidation and guidance” and has the following specific scope and purpose:

- to apply the drivers, pressures, state changes, impacts and responses (DPSIR) model to analyse cases of agriculture–wetland interaction (AWI);
- to identify the most pertinent issues affecting AWIs around the world;
- to identify the most appropriate responses to these issues/challenges (i.e. to encourage “good practice”),
- to illustrate through the presentation/application of a set of cases that the issues are “real” – i.e. valid to a wide set of biophysical and socio-economic settings.

This report is not a set of guidelines, nor is it a policy brief. Rather, it is a technical framework that is used to:

- scope out the relevance and nature of AWIs;
- identify the range of responses to AWIs that are occurring;
- determine gaps/limitations in current practices and so identify opportunities for comprehensive responses;
- set out the type, methodology and content of the AWI guidelines to be developed.

Overall, it illustrates the benefits and limitations of the proposed framework, concept and method, and meets the objective of scoping AWIs. As a result, the primary audience of the framework document are technical and professional staff, rather than policy-makers and managers.

In this document, the DPSIR model has been used to analyse 90 cases of AWI. The particular focus has been on the need to apply this analytical method to the assessment of AWIs and to identify issues and lessons that can inform future work on the development of guidelines for AWIs.

This report consists of four sections:

- Section 1 discusses AWIs and applies the DPSIR model to the analysis of the 90 cases.
- Section 2 provides examples of how the DPSIR model can be applied, using five cases with different AWIs.
- Section 3 reviews the response data in the light of the need to find specific interventions that can help achieve sustainable wetland use, and suggests ways of moving from this analysis toward guidance, both conceptually and practically.
- Annexes, including details of the case studies.

Section I

Agriculture–wetland interactions

Chapter 1

Exploring agriculture–wetland interactions: a framework for analysis

People have had an intimate association with wetlands from prehistory to the present day. Wetlands such as swamps, marshes and estuaries have been among the most attractive areas in the landscape, satisfying a variety of needs for hunting and gathering, spirituality, water resources and agriculture. However, some wetlands have been sources of disease and other hazards, and this has limited their use. There is evidence that wetland agriculture has made a significant contribution to the well-being of many societies around the globe over the centuries and even millennia. For example, archaeological work in Central America has indicated that Mayan wetland agriculture dates back 3 000 years (Denevan, 1982). Similarly, in Southeast Asia and the Pacific, staple crops that are adapted to wetland conditions have been cultivated and consumed for thousands of years (Bayliss-Smith and Golson, 1992), while more than half of the world's population is supported by rice (CA, 2007). Wetlands of different types (from rivers to coastal lagoons) also provide important areas for various types of fishing or fish culture. Agriculture in the montane bogs of the Andes is reported to have supported food production for 25 million people prior to the arrival of Europeans (Zimmerer, 1991). In Africa, agriculture has long been practised on the floodplains of major rivers, such as the Niger, Zambezi and Nile, and in other types of wetland such as dambos and bas-fonds or inland valley bottoms (Marie, 2000; Gluckman, 1941; Owen *et al.*, 1994; IVC/WARDA, 1997). Indeed, wetlands have been, and remain, a critical agricultural resource for people in many parts of the world.

In terms of their benefits to human populations, the importance of wetlands goes beyond agriculture to include a range of other ecological functions and socio-economic benefits. The Millennium Ecosystem Assessment (MA) (2005b) introduced a new classification of these as: provisioning services (e.g. food, water, fibre and fuel); regulating services (e.g. water regulation and purification, erosion control, and climate regulation); cultural services (e.g. spiritual and recreational values); and supporting services (e.g. soil formation and nutrient recycling). These are discussed in more detail below.

In this discussion, wetland agriculture is interpreted in a wide sense to include not only cultivation and other “farming” types of activities (such as grazing) but also aquaculture and other forms of coastal and inland fishing.

Despite the importance of wetlands to society, recent research has drawn attention to a global trend in wetland degradation and destruction as a result of human interaction. According to the MA (2005b), more than 50 percent of specific wetland types in North America, Europe, Australia and New Zealand were lost, converted or degraded during

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the twentieth century. While wetland loss has been a historical process, going back many centuries, it has primarily been driven by agricultural use of these areas, and especially the industrialization of farming with the use of heavy machinery. Wetlands in many areas, especially in the developed world, have been completely drained for crop production, to the extent that they no longer retain any natural wetland characteristics. However, in some areas, less intensive agricultural practices have been implemented, and wetland characteristics have been conserved, albeit in a managed form. For example, in the lowlands of the United Kingdom and northern Europe, water-meadows have been managed as grazing and hay-producing grassland, or fen, with a system of sluices, ditches and embankments used to flood the land with nutrient-rich, silt-laden water (Etherington, 1983). Similarly, throughout Southeast Asia, many traditional rice production systems, especially those that incorporate aquaculture, have effectively and sensitively combined human manipulation of the environment with natural flooding regimes, thereby minimizing environmental degradation.

Throughout the world, population pressure, demand for food, and economic development have driven wetland agriculture and led to the overexploitation and pollution of wetland resources. These drivers of wetland agriculture will probably intensify as the demand for increased economic output and food production is set to grow substantially for the next three decades (CA, 2007). At present, such drivers are likely to be most severe in the developing countries with rapidly developing economies and growing populations. These countries will require the intensification of food production, often in previously marginal or little used areas.

The increased demands on wetlands are accompanied by a global shift towards intensive mono-agriculture. This is leading to the more complete conversion of wetlands to agricultural uses through drainage, water management, and vegetation clearance, with more freshwater being abstracted for irrigation, and a growing propensity for agricultural pollution. In effect, the provisioning services of wetlands are being increasingly exploited at the cost of the regulating, cultural and supporting services. While this is creating benefits for people in terms of food production, there is growing concern about whether or not this is sustainable, given the way regulating and supporting ecosystem services of the wetland environment have been altered or destroyed. Increasingly, it is recognized that these production systems have a negative impact on their natural environment, and on the natural resource base on which they depend.

This recognition of the interconnectedness of these wetland ecosystem services has led to attempts to conserve and rehabilitate wetland areas. For example, recognition of the way that regulating services of wetlands can mitigate flood events has led to the implementation of river basin management plans to restore and conserve wetlands. Moreover, as evidence of the ability of wetlands to purify contaminated water increases, more rehabilitation of existing wetlands and construction of new “artificial” wetlands has taken place (Denny, 1997; Gopal, 1999; Kivaisi, 2001). However, a key challenge for wetland conservation and rehabilitation, which is focused on regulating services, is the need to appreciate the wider socio-economic importance of wetland resources for provisioning services, particularly through wetland agriculture. This has been stressed recently in the CA, which noted the need to pay more attention to how ecosystem services can contribute to agriculture and how agriculture should recognize the need to contribute to ecosystem functioning (CA, 2007).

While attention has been given to the relationship between agriculture and wetlands in parts of the MA (2005b) and the CA (2007) that consider the nature of the challenges faced in balancing the demands on the different ecosystem services provided by wetlands, the GAWI initiative seeks to take this a step further. GAWI seeks to develop guidelines that will help strike a balance in terms of the exploitation of wetland ecosystem services, and achieve sustainability in AWIs. It is intended that the guidelines

will effectively manage and reduce the negative impacts associated with productive¹ use of the natural resources base of wetland ecosystems. In addition, GAWI also seeks to identify the ways in which agricultural outputs from such sustainable AWIs can be maintained at levels that are compatible with the needs of society, and contribute to ecosystem use that is sustainable in economic, social and environment ways, whether at the *in situ* or basin level.

The sustainability envisaged by GAWI contains two management/development pathways that need to be explored:

- In selected areas of ecological importance, sustainability can be reached by permitting and stimulating “non-intrusive” productive use of natural resources within the wetland ecosystem, in other words *in situ* agrowetland systems that are non-intrusive in the sense that they are within the resilience and carrying capacity of the ecosystems. In such cases, productive use can be further enhanced by actively and explicitly valuing and rewarding beneficial ecosystem services that have traditionally not been valued and rewarded in the production and food economy (e.g. water regulation and purification, biodiversity, and carbon sequestration).
- At the larger and basin scale, specific trade-offs between provision and regulatory/nature conservation will be needed. Sustainability at the basin level can be increased by explicit management of the upstream and downstream impacts between production systems and wetland ecosystems, concentrating on minimizing negative impacts and mitigating strategies. This consists of a twin-track approach:
 - altering and managing production systems to minimize negative impacts, while allowing for production (output) maximization;
 - explicit, and conscious, landscape management that utilizes the revitalization and beneficial functioning capacity of natural ecosystems.

There are two other key points to consider in this initial orientation of the GAWI work: (i) valuing wetlands and creating markets for their services; and (ii) focusing on specific wetland–agriculture situations. With respect to the former, it is suggested that there is a need to move beyond the view that wetlands provide or render services, all of which should be valued by society – a view that has dominated conservationist approaches. Rather, it is proposed here that wetlands need to develop markets for their services, and that through these markets the rendering of these services will be stimulated. In other words, the ecosystem services need to be derived by local customers who can accrue concrete benefits. This then stimulates exploration of innovative approaches to identify which services, beyond provisioning ones, can develop markets and provide such concrete benefits.

In terms of the focus of the GAWI work, in the present situation, it can be argued that the biodiversity wetland hot spots are being addressed by Ramsar and its community, while the intensive agricultural use of wetlands is subject to efforts to sustain the productivity of these areas and that agriculture will always be the focus of such sites. Where the GAWI work is most relevant is in the “middle ground”, where agriculture is expanding into wetlands. According to the MA, these are the vast majority of “ordinary” wetlands, which are not dedicated to nature conservation or entirely converted to agricultural use already.

WETLANDS – DIVERSITY AND DEFINITION

Definitions and typologies

The definition and classification of wetlands has to be addressed, principally because it facilitates the task of developing management approaches and policy development for

¹ Productive use refers to the economic use and exploitation of provisioning (e.g. agriculture and fisheries), regulating (e.g. hydropower, water purification, etc.) and cultural services (e.g. recreation and tourism). In essence, the exploitation of any or multiple ecosystem services in economic terms.

wetlands. Wetlands are diverse environments; spatially and temporally, but also in terms of physical size, ecology, hydrology and geomorphology. The Ramsar Convention embraced this diversity in a single definition, grouping together a wide variety of landscape units whose ecosystems share the fundamental wetland characteristic of being strongly influenced by water. Since 1971, the Ramsar Convention has considered wetlands to be: “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.” (Davis, 1994).

TABLE 1
Categorization by wetland type (Ramsar categories)

Code	Wetland type
	Marine/coastal wetlands
1	Permanent shallow marine waters
2	Marine subtidal aquatic beds
3	Coral reefs
4	Rocky marine shores
5	Sand, shingle or pebble shores
6	Estuarine waters
7	Intertidal mud, sand or salt flats
8	Intertidal marshes
9	Intertidal forested wetlands
10	Coastal brackish/saline lagoons
11	Coastal freshwater lagoons
12	Karst and other subterranean hydrological systems
	Inland wetlands
13	Permanent inland deltas
14	Permanent rivers/streams/creeks
15	Seasonal/intermittent/irregular rivers/streams/creeks
16	Permanent freshwater lakes
17	Seasonal/intermittent freshwater lakes
18	Permanent saline/brackish/alkaline lakes
19	Seasonal/intermittent saline/brackish/alkaline lakes and flats
20	Permanent saline/brackish/alkaline marshes/pools
21	Seasonal/intermittent saline/brackish/alkaline marshes/pools
22	Permanent freshwater marshes/pools
23	Seasonal/intermittent freshwater marshes/pools on inorganic soils
24	Non-forested peatlands;
25	Alpine wetlands
26	Tundra wetlands
27	Shrub-dominated wetlands
28	Freshwater, tree-dominated wetlands
29	Forested peatlands
30	Freshwater springs;
31	Geothermal wetlands
32	Karst and other subterranean hydrological systems
	Human-made wetlands
33	Aquaculture (e.g. fish/shrimp) ponds
34	Ponds
35	Irrigated land
36	Seasonally flooded agricultural land
37	Salt exploitation sites
38	Water storage areas
39	Excavations
40	Wastewater treatment areas
41	Canals and drainage channels, ditches
42	Karst and other subterranean hydrological systems

This definition reflects a hydrological perspective with water as the key factor. Other writers have stressed the link between hydrology and biology, and proposed “ecohydrological” definitions, while others have suggested geomorphological definitions (e.g. Dugan, 1990) or agricultural (crop) definitions (e.g. FAO, 2002 and 1998). Thus, a wide array of wetland definitions are in circulation that are informed by the perspective taken and the primary purpose for which they were defined (e.g. nature/ecosystem conservation, small-scale agricultural development, or hydrological classification).

At times, these different classifications may lead to confusion and misunderstanding as there is no clear overview of how they relate to one another. However, these different approaches to wetlands contain valuable insights and experiences of often specific wetland characteristics, uses and interactions. Here, the choice has been made to adopt the Ramsar classification of wetlands, but with explicit recognition of their wider interactions within the river basins in which they are situated. This analytical approach is equally suited to be adopted on any of the other wetland classifications.

Table 1 presents the Ramsar classification system for wetlands, and illustrates the diversity of wetland types that occur around the globe, focusing on a range

of characteristics, hydrological, ecological, geomorphological and economic. This classification has been used as the basis for the analysis and for creating a simplified categorization of the cases in this study identifying: inland flowing, inland still permanent, inland seasonal, inland peat, saline, brackish and human-made (Chapter 2). This is similar to the set of categories used by the MA. (The classification in Figure 1 is slightly different from that of the MA text, although this figure was used in the MA [2005b]).

Global diversity and distribution of wetlands

Recent studies suggest that wetlands occupy in excess of 12.8 million km² globally, although this is probably an underestimate as a result of variations in the definitions used for identification (Finlayson *et al.*, 1999). Although wetlands are a common landscape feature across all continents (Figure 1), there is an uneven distribution in specific types. For example, the cool wet climate of the temperate and subarctic zones favours the development of extensive areas of peatland, which arguably account for from one-third to half of the world's wetlands (Mitsch, Mitsch and Turner, 1994). In tropical areas, peatlands are not as widespread, with most located in highland areas that receive abundant rainfall or in specific low-lying areas of Southeast Asia – peat forests (Hughes, 1996). Similarly, mangrove forests are the tropical and subtropical equivalent of temperate saltwater marshes (Hughes, 1992).

ECOSYSTEM SERVICES

Ecosystem services concept

Attitudes towards the value of wetlands have changed significantly in the last 50 years. Throughout much of the developed world, there has been a growing recognition that, rather than being unproductive wastelands in their natural state that benefit from conversion, wetlands are in fact multifunctional natural resources that provide a range of services of inherent value to human well-being (Maltby, 1986; Dugan, 1990; Barbier, Acreman and Knowler, 1997; Roggeri, 1998; Silvius, Oneka and Verhagen, 2000). The Ramsar Convention has made significant progress in highlighting their importance for global biodiversity, and, in recent years, research has drawn attention to the environmental functions and socio-economic benefits that wetlands can provide; what the MA (2005b) terms the “ecosystem services” of wetlands.

Discussions of the services provided by wetlands are numerous (Adamus and Stockwell, 1983; Maltby, 1986; Dugan, 1990; Barbier, 1993; Roggeri, 1998; MA, 2005b), and considerable research has been carried out on the specific roles wetlands play and how these interact with the local environment. However, despite the wealth of literature, classifications of these services (often called functions and benefits) have rarely been consistent. Hence, the recent MA (2005b) terminology, and its widespread acceptance, is helpful. This uses the term ecosystem services for all wetland functions and benefits, and subdivides these into:

- provisioning (goods produced or provided by ecosystems, e.g. food, fuel and fibre);
- regulating (benefits from the processes of ecosystem regulation, e.g. water partitioning, and climate regulation);
- cultural (non-material benefits from ecosystems, e.g. spiritual, recreational and aesthetic);
- “support” (factors necessary for producing ecosystem services, e.g. hydrological cycle, soil formation, and nutrient cycling).

These are summarized in Table 2 and discussed further below.

The first three categories of services are directly useful or beneficial to humans or human well-being as they provide the primary means for production, natural resources management, and spiritual well-being. The fourth one is distinct in constituting services,

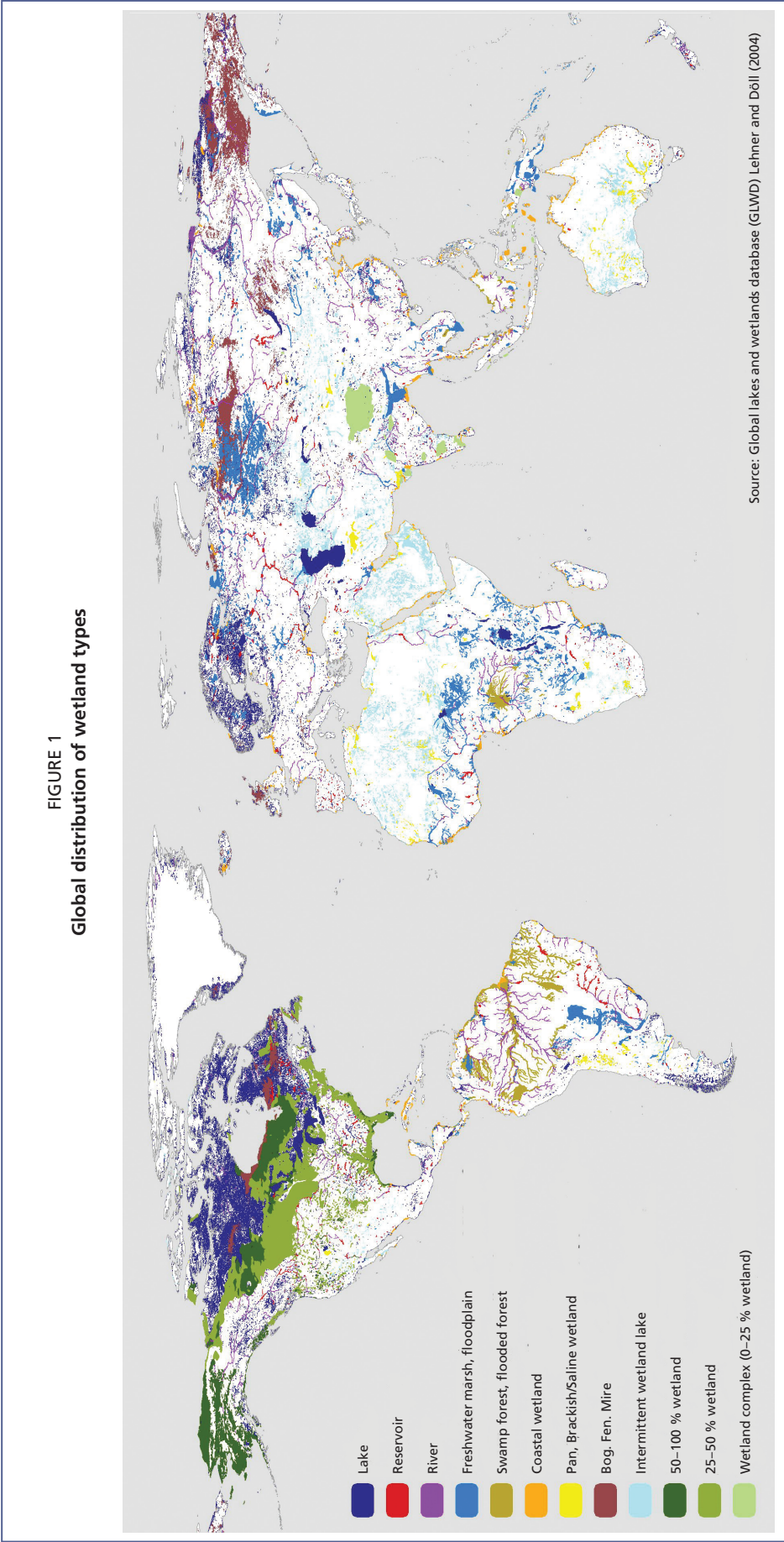


TABLE 2
Ecosystem services provided by, or derived from, wetlands

Services	Comments and examples
Provisioning	
Food	Production of fish, wild game, fruits and grains
Freshwater (a)	Storage and retention of water for domestic, industrial and agricultural use
Fibre and fuel	Production of logs, fuelwood, peat and fodder
Biochemical	Extraction of medicines and other materials from biota
Genetic materials	Genes for resistance to plant pathogens, ornamental species, etc.
Regulating	
Climate regulation	Source of and sink for greenhouse gases; influence local and regional temperature, Precipitation, and other climate processes
Water regulation (hydrological flows)	Groundwater recharge/discharge
Water purification and waste treatment	Retention, recovery and removal of excess nutrients and other pollutants
Erosion regulation	Retention of soils and sediments
Natural hazard regulation	Flood control and storm protection
Pollination	Habitat for pollinators
Cultural	
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	Opportunities for recreational activities
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	Opportunities for formal and informal education and training
Supporting	
Soil formation	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling, processing and acquisition of nutrients

(a) While freshwater was treated as a provisioning services within the MA, it is also regarded as a regulating service by various sectors.

Source: MA (2005b).

or natural processes, that are required to maintain the ecosystem and/or have a distinct function in natural resources cycles. This ecosystem concept has received widespread recognition and has been formally adopted by Ramsar as a principal framework for wise use of wetlands.

Not all wetlands support the full range of ecosystem services, and specific services may be associated with specific types of wetland (Table 3). However, the key lesson from this conceptualization is the linkages between different sorts of services and the way in which the support and regulating services are essential for ensuring the continuation of provisioning services.

Provisioning services

The provisioning services provided by wetlands tend to be associated with the direct exploitation of wetland products for economic gain or subsistence.

Crop production

Farming activities are major economic pursuits in and around many wetlands, where crops such as rice, maize, and various vegetables and fruit are cultivated (Dries, 1989; Soerjani, 1992; Omari, 1993). Seasonally inundated floodplains are often particularly important farming resources because they frequently have very fertile soils, with high clay content (which facilitates water retention in the dry season). Various methods have been developed to maximize the use of these areas throughout the seasons, both during the flood period and especially after it has receded (Adams, 1993; Meinzen-Dick and Bakker, 1999).

TABLE 3
Relative magnitude of ecosystem services derived from different inland wetland ecosystems

Services	Perm. & temp. rivers & streams	Perm. lakes & reservoirs	Seasonal lakes, marshes & swamps, including floodplains	Forested wetlands, marshes, & swamps including floodplains	Alpine & tundra wetlands	Springs & oases	Geothermal wetlands	Underground wetlands, including caves and groundwater systems
Inland wetlands								
Provisioning								
Food	high	high	high	high	low	low		
Freshwater	high	high	medium	low	low	low		high
Fibre & fuel	medium	medium	low	high	medium	low	low	
Biochemical products	low	low	not known	not known	not known	not known	not known	not known
Genetic materials	low	low	not known	low	not known	not known	not known	not known
Regulating								
Climate regulation	low	high	low	high	low	low	low	low
Hydrological regimes	high	high	medium	medium	low	low		low
Pollution control & detoxification	high	medium	low	medium	low	low		medium
Erosion protection	medium	low	low	medium	not known	low		low
Natural hazards	medium	high	high	medium	medium	low		low
Cultural								
Spiritual	high	high	medium	medium	low	medium	low	low
Recreational	high	high	medium	low	low	low	low	low
Aesthetic	medium	medium	low	medium	low	low	low	low
Educational	high	high	medium	medium	low	low	low	low
Supporting								
Biodiversity	high	high	medium	medium	low	low	low	low
Soil formation	high	low	medium	high	low	not known	not known	
Nutrient cycling	high	high	high	high	low	low	not known	low

Note: Blank cells indicate that the service is not considered applicable to the wetland type.
Source: MA (2005b).

Fishing

Fish production is a basic element in the economy of many wetlands. There is often a localized economic and nutritional dependence on this resource as fish provide a crucial source of protein. In addition, in recent decades, fish farming (aquaculture) has been developed in coastal brackish lagoons in several parts of the tropics (DeMerona, 1992; Bwathondi and Mwamsojo, 1993; Primavera, 1995; Ocampo-Thomason, 2006).

Livestock grazing

Seasonal wetlands can provide a valuable resource for livestock grazing as a result of the high biomass associated with these areas. Sometimes, these are grazed directly, but in other cases they are used for hay production. In many of Africa's savannahs where the climate is semi-arid and rainfall is seasonal, wetland grazing is widespread (Scoones, 1991), with wetland landforms, such as the dambos of Zimbabwe, the fadama of Nigeria and the floodplains of Niger and Zambia, being important seasonal grazing resources (Roberts, 1988; Turner, 1994).

Water supply and hydropower

Most wetlands can provide a potable supply of water for the surrounding population (either directly or from springs). This is a critical function in many semi-arid or seasonally dry areas (Scoones, 1991). Depending on their ecohydrological characteristics, wetlands may be able to purify water supplies as a result of the effects of microbial action. The ability of a wetland to regulate and store water can also be beneficial in the production of hydroelectric power by moderating and thereby improving the flow of supply of water for power production, and there are many human-made wetlands created for this purpose. However, in the tropics, wetlands are often seen to compete for water owing to high evaporation rates.

Production of fibre, fuel, and medicinal and dietary supplements

Natural wetland plants can be used for a variety of purposes from construction to medicine. Soerjani (1992) points out that 70 percent of the 266 species of weeds associated with wetland rice cultivation in Indonesia can be utilized in a range of activities including medicine, cattle fodder, household uses and for human consumption. On Lake Tana in Ethiopia, locally harvested papyrus has been used in the construction of fishing boats for hundreds of years (Muthuri, 1993).

Agrobiodiversity as a provisioning service

Biodiversity² is discussed below under cultural services. However, from an agricultural perspective, agrobiodiversity created by human management on and around farmlands, may have crucial provisioning services to provide to farming systems. Specifically, services such as pollination, harbouring natural predators of agricultural pests (integrated pest management [IPM]), and hatching and breeding for fish are found in wetlands. Indeed, these niches may be created through some agricultural use of wetlands. However, conversely, some pests may also be harboured and supported in this way. In terms of land use and the ecosystem, the important element here is that enough diversity is maintained to provide adequate niches or agrobiodiversity refuges, i.e. provide “agricultural off-season” refuges for species that thrive within crop systems (or seasonal fishing grounds). From the ecological perspective, agrobiodiversity refuges can be considered supporting services to the ecosystem. Thus, in an ecosystems management approach, the conscious management of agrobiodiversity refuges can be expected to be an important element.

Regulating services

Depending on their specific ecohydrological and geomorphological characteristics, wetlands are able to provide a diversity of services that play a key role in the regulation and stability of the physical environment.

Climate regulation – biosphere and microclimate stabilization

The conditions of high humidity and evapotranspiration found in many wetlands may affect local and regional climates significantly (Roggeri, 1998). In addition, the process of microbial decomposition is encouraged in wetland ecosystems. This can lead to storage of carbon or emissions of gaseous by-products (including methane), which may have implications for global atmospheric stability (Odum, 1979). While the destruction

² Biodiversity contributes to all of the ecosystem services depending on the perspective from which it is viewed and the service which is focused on. Products of biodiversity include many of the provisioning services provided by ecosystems (such as food and genetic resources). In this case, specific economic benefits are obtained from the contribution to integrated pest management (IPM). In cultural services, biodiversity is valued for its intrinsic and aesthetic sake. In regulating services, biodiversity in the form of plants helps regulate flows. In the case of supporting services, biodiversity is part of the functioning of the natural wetland ecosystem.

of wetlands results in the release of carbon into the atmosphere, the extent to which wetlands actively mitigate carbon dioxide (CO₂) emissions through photosynthesis remains unclear and the subject of ongoing research.

Water regulation – flood control and river regulation

Wetlands are able to mitigate floods by storing potential floodwaters, reducing floodwater peaks, and ensuring that the floodwaters from tributaries do not all reach the main river at the same time (Maltby, 1986). During the dry season, subsurface flow from wetlands may replenish stream flow. However, there is increased evidence that wetlands vary considerably in their capacity for water storage and for dry-season flow maintenance and that these capacities are dynamic during the seasons and with rainfall conditions (Bullock and Acreman, 2003).

Water regulation – water table recharge and discharge

When the velocity of water entering a wetland is reduced and its subsequent residence time in the wetland increases, there may be some percolation of the water downwards into the aquifer, and, consequently, water table recharge occurs (Mihayo, 1993). As a result of their lowland position in relation to surrounding land, many wetlands also act as sinks for water discharged from aquifers (Roggeri, 1998). However, the relationship between groundwater and wetlands is extremely complex and dependent on many factors, such as regional groundwater flows, geology, hydraulic conductivity, and the slope and relief of the catchment (Carter and Novitski, 1988).

Water purification – maintaining water quality

The practice of discharging wastewater into natural wetlands has been used as a means of waste disposal for hundreds of years (McEldowney, Hardman and Waite, 1993). Research on the ability of wetlands to purify water has shown that anaerobic conditions, which exist within wetlands, enhance the retention of many compounds and facilitate processes such as denitrification, ammonification and the formation of insoluble phosphorous–metal complexes (Bastian and Benforado, 1988). Wetland vegetation, such as *Eichhornia crassipes*, is able to store large quantities of nutrients and heavy metals (Gopal, 1987). Paddy rice fields also seem able to act as a sink for synthetic agrochemical pollutants.

Erosion regulation – sediment trapping

As the velocity of water decreases on entering a wetland, suspended sediment settles. Destruction of wetlands can seriously affect this process and lead to downstream sedimentation. However, the buildup of sediment in a wetland also causes its waterholding capacity to deteriorate and can change its vegetation, soil characteristics and agricultural productivity.

Not all the above regulating services are provided to the same degree in each wetland. In many cases, it is difficult to identify precisely the extent of the service and the value that can be put on it (Bullock and Acreman, 2003). It is suggested that the following qualifications need to be considered, as part of a general recognition of the site-specific nature of these regulating services, although the degree to which these qualifications apply is also debated:

- Water table recharge and discharge: Infrequent and very difficult to quantify; natural wetlands are most likely to occur in natural depressions in the landscape with low permeable soils and/or high water tables.
- Flood control and river regulation: Very site-specific, and exploitable mostly with respect to urban centres.
- Sediment trapping: Common in floodplains and deltas; in other wetlands, it is too complex to measure positive impacts.

- Water purification and maintenance of water quality: Most likely and most valuable – in terms of being manageable and economically exploitable, although it can be variable.
- Biosphere and microclimate stabilization: Limited, except for mist rain forests; too complex and difficult to be exploitable.

Cultural services

Cultural services include aesthetic, educational, spiritual, biodiversity and recreational values. They contribute to human well-being via the direct economic benefits of their exploitation (e.g. tourism), and their psychosocial value.

Spiritual and inspirational

There are many examples of cultures around the world where wetlands or water have a spiritual significance. For example, for the Bantu-speaking peoples of Southern Africa, water sources and riparian zones have sacred status through their association with water spirits (Bernard, 2003). For the Maori in New Zealand, water has its own life-force (*mauri*), for which people are obligated to have a duty of care (Williams, 2006).

Aesthetic value

In many parts of the world, there is a growing recognition of the importance of wetlands as major wildlife habitats, which offer significant potential for tourism. In Zimbabwe and Zambia in particular, wetland tourism is being developed as a component of a wider rural development programme in that local communities are given the responsibility of managing wetlands for their aesthetic and other benefits (such as game and sport fish). In return, they receive economic and social benefits from tourism (Chabwela, 1992; Sanyanga, 1994; Barbier, Acreman and Knowler, 1997; Duim and Henkens, 2007).

Biodiversity

Wetlands are host to a rich species biodiversity because they offer a range of ecological niches for wildlife both spatially and temporally (Maltby, 1986; Denny, 1994). In seasonally inundated wetlands, different species have adapted to conditions during the dry season and the wet season. In permanent wetlands, species may have evolved in ecological isolation and may represent an endemic and rare population (Turner, 1988). Dugan (1993) presents a variety of specialized plant adaptations to wetland environments. These include *Sphagnum* spp., which is tolerant of the extreme acidic conditions found in some marshes, and a range of aquatic and emergent plants including *Cyperus papyrus*, *Pistia stratiotes* (water lettuce) and *Eichhornia crassipes* (water hyacinth). In addition, many areas of wetland support high concentrations of endemic fauna. For example, the Bangweulu basin in Zambia provides a habitat for 30 000 black lechwe antelope (*Kobus lece smithemani*) and it constitutes one of Africa's most important areas for sitatunga (*Tragelaphus spekei*). Wetlands provide vital habitats for migratory waterbirds – a factor that served as the impetus for the Ramsar Convention.

Supporting services

These services refer to the key processes or factors necessary for maintaining the ecosystem services provided by wetlands. They include the major environmental cycles involved with hydrology, nutrient flows and soil formation. The key point is that these services are the essential underpinning of the wetland ecosystem services. If disrupted, they will affect the services that wetlands can provide. Specifically for agriculture, if these support services are disrupted, then the provisioning services through wetland agriculture will be adversely affected with reduced yields and sustainability will be undermined. Extreme examples are salinization and loss of water through gully formation.

This discussion confirms the wide range of ecosystem services obtained from wetlands. It shows the value that can be obtained locally, at the basin level and globally, and the potential for the generation and sustaining of livelihood benefits / provisioning services, directly and indirectly. It also confirms the point made above about the way in which these services are interlinked and all involved in supporting human well-being.

However, despite the importance of wetlands, recent research has argued that the ecohydrological relationships and socio-economic process in many wetlands remain poorly understood (Bullock and Acreman, 2003; Woodhouse, Bernstein and Hume, 2000) (Table 3). Therefore, it is important to exercise caution when generalizing about the services performed by wetlands, and also the socio-economic benefits that emanate from them. A key criticism of global wetlands policy to date has been the popularization of universal wetland values as a means of justifying and promoting wetland preservation (Bullock and Acreman, 2003). In reality, there is a need for a combination of approaches with a more site-by-site approach, with sensitivity to the biophysical and socio-economic diversity. Greater understanding of specific ecosystem services is needed if they are going to be promised in return for wetland protection and payments.

Application and relevance of the ecosystem service concept to the GAWI initiative

The concept of “ecosystem services” is particularly pertinent to the GAWI initiative in that most AWIs can be characterized by their use of, or effect on, provisioning, regulating, cultural and supporting services. Therefore, a key task of AWI analysis is to identify the linkages and interactions between the various ecosystem services, and to determine those whose services are mutually supportive, or incompatible. An understanding of these relationships is central to the development of sustainable wetland–agriculture systems.

As outlined below, the MA (2005b) regards the balanced use of diverse wetland ecosystem services as synonymous with sustainable utilization. This draws on a well-established body of literature that regards diversity among ecosystems as central to ecological resilience, i.e. the capacity to withstand shocks and pressures (Adger, 2000). Any AWI that relies heavily on the overdevelopment of a single provisioning service may facilitate degradation in the resource base, this being seen in the reduced capacity to perform one or more services. While maintaining a diversity of ecosystem services is important for wetland sustainability, a key challenge for the GAWI project is to identify how this balance is to be obtained and made compatible with agricultural activities, and with the increasing global demand for food.

WETLAND CHANGE DYNAMICS

Wetland formation and loss under natural conditions

Wetlands are areas whose formation is influenced by ecological, hydrological and geomorphological processes. As these underlying processes are extremely dynamic, so too are the wetlands. As transitional zones between dryland and waterbodies, wetlands are continuously evolving in response to local ecohydrological processes.

Many wetlands experience gradual change and form slowly through the accumulation of water and sediments, and the partial decomposition of plant material. Others are ephemeral in nature, occurring only in response to seasonal rainfall. Some wetlands represent one stage in the succession from a standing waterbody to a terrestrial environment, which can occur over decades or millennia (depending on wetland size and sedimentation processes). Wetland formation and succession is a natural process – by no means is all wetland change caused by anthropogenic influences. Hence, in studying AWIs, this dimension needs to be kept in mind.

Global change in wetlands, patterns and rates

It is widely accepted that wetlands are degrading at an unprecedented rate, vastly beyond that of natural loss, yet there are few reliable accounts of the current situation. The MA (2005b) reports that more than 50 percent of specific types of wetlands in parts of North America, Europe, Australia and New Zealand were converted for agriculture during the twentieth century. However, for elsewhere, many estimates are speculative. Infrastructure and urban expansion have also led to the loss of some wetland areas. A recent global assessment of 227 major river basins showed that 37 percent were affected by fragmentation and altered flows, potentially indicative of wetland loss (MA, 2005b). However, loss of coastal wetlands is better established. The MA (2005b) reports that 35 percent of the world's mangrove forests (for which data exist) have disappeared within the last two decades owing to aquaculture development (mostly for shrimp and prawn production).

However, there are also some gains in wetland areas as a result of water management, especially through the extension of rice cultivation beyond existing wetlands, and to a lesser degree through reservoir formation, seepage from dams and irrigation systems, and the rehabilitation of former wetlands (this mainly for recreation, cultural or biodiversity conservation or flood management, primarily in high-income countries). However, in many of these cases, especially with rice production, the full range of ecosystem services is not developed. The growing interest in artificially constructed wetlands for wastewater treatment has also led to gains in wetland area in most parts of the world (Gopal, 1999; Kivaisi, 2001).

Key driving forces – their diversity globally and by wetland type

The underlying causes of global wetland degradation and loss are complex and diverse, and ultimately vary from one location to another, and between wetland types. Although it is dangerous to generalize, some lessons and trends can be drawn from empirical research around the world. In many developing countries for example, the partial or full conversion of wetlands for subsistence agriculture may represent a direct response to population pressure, which in turn is linked to poverty. Globally, wetland conversion for agriculture is likely to be economically motivated and linked more intrinsically to regional or global markets. The trend towards wetland rehabilitation in the developed world has also been driven by the recognition of the value of wetlands for recreation, conservation and flood protection.

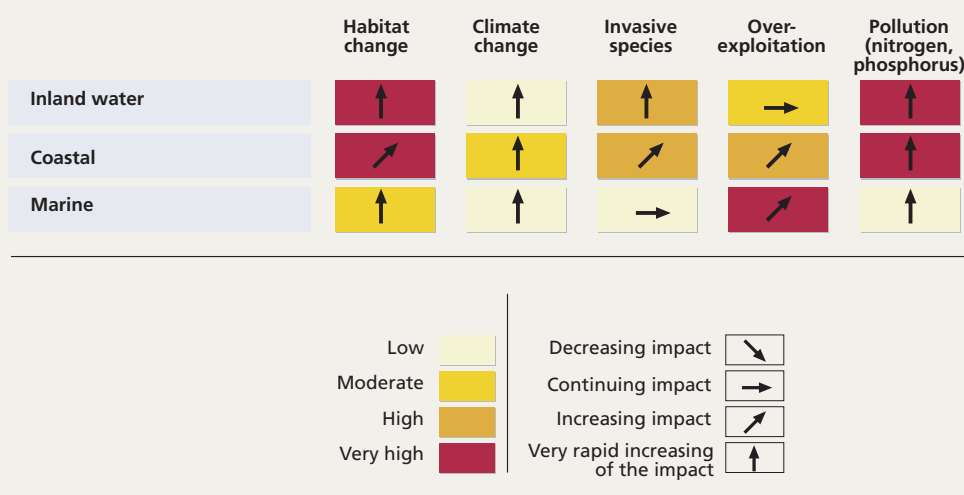
In an analysis of the key driving forces behind wetland loss and destruction, the MA (2005b) draws a distinction between inland and coastal wetland systems, and differentiates between indirect and direct drivers of change. It suggests that the primary indirect drivers (termed “drivers” in this study) of wetland loss in inland wetlands have been population growth and increasing economic development. These have influenced the direct drivers (termed “pressures” in this study), which are more conspicuous and include: infrastructure development; land conversion (to agriculture); water withdrawal; pollution; overexploitation of plants, land and fish; and the introduction of alien species. For coastal wetlands, such as saltwater marshes, mangroves and coral reefs, population growth and economic development are again cited as the key indirect drivers of change. Conversion to other land uses, the diversion of freshwater flows, nitrogen loading, overharvesting, and siltation have constituted the major direct drivers of wetland destruction. Figure 2 gives some indication of the relationship between direct driving forces or pressures on different wetland types in the context of impacts on biodiversity.

AGRICULTURE AND WETLAND INTERACTIONS

In examining the relationship between wetlands and agriculture, it is useful to distinguish between *in situ* interactions (where there is direct agricultural intervention

FIGURE 2
Main direct drivers of change (pressures) in wetland systems

The cell colour indicates the impact of each driver on biodiversity in each type of ecosystem over the past 50–100 years. High impact means that over the last century the particular driver has significantly altered biodiversity in that ecosystem; low impact indicates that it has had little influence on biodiversity in the ecosystem. The arrows indicate the trend in the driver. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively stronger increasing trends in impact. Thus, for example, if an ecosystem had experienced a moderate impact of a particular driver in the past century (such as the impact of overexploitation in inland water systems), a horizontal arrow indicates that this moderate impact is likely to continue. This Figure is based on expert opinion consistent with and based on the analysis of drivers of change in the various chapters of the assessment report of the MA Condition and Trends Working Group. The Figure presents global impacts and trends that may be different from those in specific regions.



Source: MA (2005b).

within wetlands) and external interactions (where the effects of external [upstream, downstream or peripheral] agricultural activities affect the wetland and its ecosystem services). These relationships are presented in Figure 3, which shows the linkages through a basin, from the headwaters areas, via wetlands at any stage in the basin, to coastal wetlands. In addition, there can be several inland wetlands in a river basin, or coastal wetlands adjoining one another. Hence, individual wetlands should not be seen in isolation, as they are usually linked to others within the river basin system. The nature of the interactions highlighted can be of various types: environmental – where drainage occurs; socio-economic – where livelihoods are affected; and political – where conflicts are stimulated.

In situ interactions

In situ interactions, represented by 1.1 to 1.4 in Figure 3, involve on-site wetland agricultural activities. They can be characterized by the complete (1.1) or partial (1.2) transformation of wetlands to agricultural use, which usually alters the regulating services of wetlands. Agricultural transformation includes a range of practices that create pressures on the wetland ecosystem, such as drainage, the application of fertilizers and pesticides, and livestock grazing. Examples are the seasonal cropping of floodplains in West Africa, the cultivation of upland peat bogs in the Andes, and the drainage of floodplain marshes in Europe for arable land use or livestock grazing. There is a clear transformation of wetland ecohydrology in these cases as a result of these interactions.

In situ interactions can also include agricultural exploitation that does not transform the wetland environment or have any impact on available ecosystem services (1.3). This

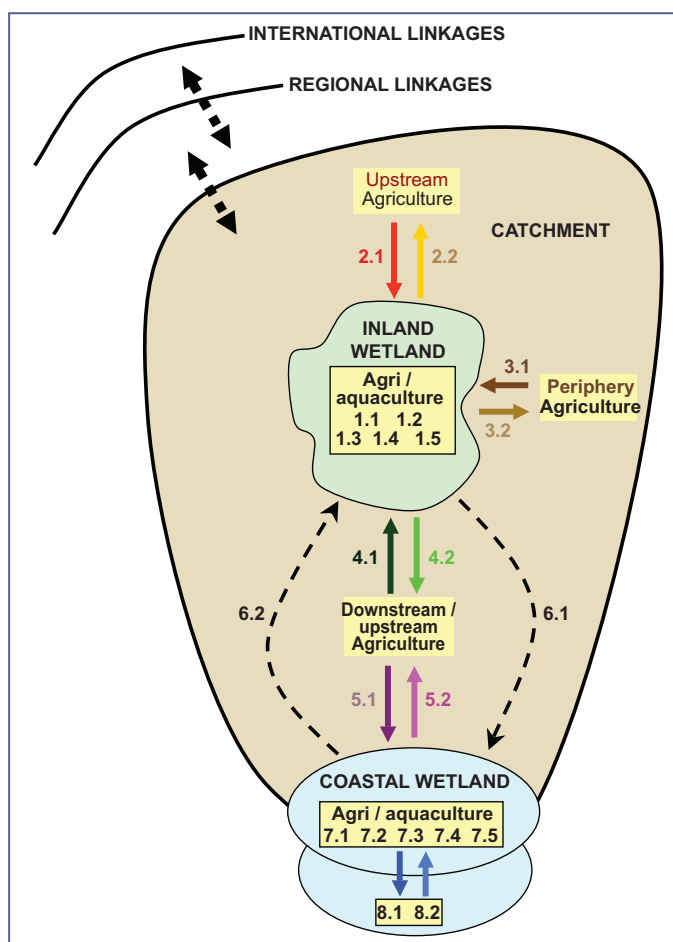
FIGURE 3
Conceptual model of agriculture–wetland interactions

Key:

1. Wetland agriculture (*in situ*) interactions
 - 1.1 Complete transformation of wetland ecosystem to agricultural use
 - 1.2 Partial transformation of wetland ecosystem to agricultural use
 - 1.3 Agricultural use of wetlands without transformation of ecosystem (e.g. limited/sustainable ecoagriculture).
 - 1.4 Enhancement of wetlands / creation of additional wetlands (often used for agriculture)
 - 1.5 Reversion to natural wetland
2. Upstream agricultural activity (external) interactions (from distant catchment)
 - 2.1 Upstream agricultural activity influencing wetland ecosystem and wetland agriculture downstream
 - 2.2 Wetland ecosystem influencing upstream agricultural activity
3. Periphery agricultural activity (external) interactions (from local catchment)
 - 3.1 Periphery agricultural activity influencing wetland ecosystem (e.g. irrigation water, fringe drainage)
 - 3.2 Wetland ecosystem influencing periphery agricultural activity (e.g. flooding)
4. Downstream agricultural activity (external) interactions
 - 4.1 Downstream agricultural activity (including wetland agric) influencing wetland upstream (or wetland agriculture upstream)
 - 4.2 Wetland ecosystem influencing downstream agricultural activity (e.g. flooding, constant supply of water, water purification)
5. Coastal-upstream agricultural activity (external) interactions
 - 5.1 Influence of immediately upstream (wetlands and non-wetland agriculture) on coastal wetland
 - 5.2 Influence of coastal wetland on upstream non-wetland agricultural activity
6. Coastal wetland – inland wetland (external) interactions
 - 6.1 Influence of inland wetland (natural or altered by agriculture) on coastal wetland
 - 6.2 Direct influence of coastal wetland (natural or altered by agriculture) on inland wetland
7. Coastal wetland agriculture (*in situ*) interactions
 - 7.1 Complete transformation of wetland ecosystem to agricultural use
 - 7.2 Partial transformation of wetland ecosystem to agricultural use
 - 7.3 Agricultural use of wetlands without transformation of ecosystem (e.g. limited/sustainable ecoagriculture).
 - 7.4 Enhancement of wetlands / creation of additional wetlands
 - 7.5 Reversion to natural wetland
8. Coastal wetland agriculture / aquaculture – other coastal wetlands (external) interactions
 - 8.1 Influence of adjacent / upstream coastal wetlands
 - 8.2 Coastal wetland aquaculture / agriculture influencing adjacent coastal wetland functioning

Regional linkages = Groundwater resources, microclimates, shared wildlife resources (including birds), population, ethnic groups, culture, agricultural and conservation policies, etc.

International linkages = same, but next scale up.



is most commonly seen in fishing where this involves “harvesting” in a sustainable manner. Other non-agricultural services of this sort include the gathering of reeds and plant materials. These sustainable harvesting activities are the typical “wise uses” of wetlands as defined by the Ramsar Secretariat. In addition, some wetlands have been manipulated to create “artificially” constructed wetland environments for agricultural and aquaculture purposes (such as rice paddy fields and fish ponds) and water storage for irrigation. In such cases, there may be the enhancement of wetlands or the creation of additional ones (1.4). Another scenario is one where wetland agriculture occurs at a level that does not disturb the wetland ecohydrology or ecosystem services (1.3). It may be characterized by ecoagricultural practices, where, for example, crops that are well adapted to the wetland environment are cultivated in an environmentally sensitive manner. An example is the multicropping and agroforestry practices in the *Terminalia* wetland forests in Micronesia (Drew *et al.*, 2005). Similarly, the management of water-meadows in Europe does little to disturb wetland ecohydrological conditions. A third case is on the upper Zambezi floodplain, where the scale of the annual flood and groundwater flows into the floodplain is so great and the areas of cultivation so limited at present that there is little or no alteration in the ecosystem services.

The above discussion has focused on inland situations, but it could also refer to coastal wetlands with similar interactions owing to aquaculture or, to a lesser degree, crop production. Figure 3 also shows such *in situ* interactions within coastal wetlands – lagoons or mangrove swamps (7.1–7.4).

Because of the ecohydrological requirements of crops, it is typically inland wetlands that are more susceptible to direct agricultural interactions. Swamps, marshes, floodplains and bogs, in particular, are an important source of water and fertile soil in semi-arid areas. Hence, they constitute attractive agricultural resources. In more temperate areas where the soil moisture in wetlands is perceived to be more of a problem rather than a resource, such wetlands are more likely to undergo intensive drainage. Coastal lagoons in the tropics have also been particularly attractive in the last three decades because of various types of aquaculture and fish pond development.

External interactions (basin interactions)

External interactions between agricultural/aquaculture activity and wetlands are represented by interactions 2–6 in Figure 3. They are typically interactions between the wetland ecosystem and agricultural/aquaculture activities that are external to the wetland itself (upstream, downstream or on the periphery of wetlands).

Upstream agriculture–wetland interactions

Wetlands are most frequently influenced by upstream agricultural activity (2.1, 5.1 and 6.1). A typical example is where upstream agriculture results in the diversion of water, which affects the quality and flow of water entering a wetland ecosystem. This may be associated with dam development or irrigation. Poor agricultural practices in the upland areas may also lead to soil erosion and sedimentation or the runoff of agricultural waste, both of which can affect wetlands. The subsequent pressures may lead to the degradation of that wetland and a reduction in its ability to perform certain ecosystem services. If that wetland is itself directly transformed by agriculture within it (see above), this agriculture may also be affected. An example of this relationship is the case of an upstream dam and irrigation development influencing people’s wetland-dependent livelihoods downstream in the inner delta of the Niger River (Zwarts *et al.*, 2005).

Alternatively, there is the possibility of wetlands (either in a natural state or themselves directly transformed by agriculture) influencing agricultural activity upstream (2.2, 5.2 and 6.2). An example is where wetlands contribute to the overall reduction in velocity of river flow, and their capacity to store water and retain sediment causes upstream waterlogging that may affect agricultural activity. This may also lead to the extension

of the wetland if this flooding is prolonged, as is the case in the Sorou Valley in Mali (Woodhouse, Bernstein and Hulme, 2000). Further, as in the case of the Usangu plains in the United Republic of Tanzania, conservation of downstream wetlands may lead to increased agricultural pressures on the limited resource base upstream, as provisioning services, such as grazing, can no longer be used in the downstream wetland.

Periphery agriculture–wetland interactions

The interactions of wetlands with peripheral agriculture (3.1 and 3.2) are arguably similar. Wetlands in their natural state, or those directly transformed by agriculture, can affect agriculture in adjoining, neighbouring and peripheral areas through the regulation of the water table and accommodation of runoff. Similarly, peripheral agriculture can induce change in the natural wetland ecosystem, or influence wetland agriculture itself, in the same way as upstream agriculture. A similar series of scenarios could exist for coastal wetlands (8.1 and 8.2).

Downstream agriculture–wetland interactions

Wetlands can also play an important role in downstream agricultural activities (4.1). A key function of some wetlands is their ability to store water and regulate river flows. This has clear implications for the productivity of downstream agriculture. The direct use of a wetland for agriculture results in the alteration of its water regulation function, and can also have implications for downstream agriculture. Downstream agricultural activity (4.2), such as water extraction for irrigation, may alter the hydraulic gradient and result in the more rapid release of water from wetlands upstream, lowering the level of the water table. Similarly, downstream agriculture reliant on the extraction of water from upstream wetlands (either through gravity or mechanical means) will also tend to induce change.

These types of interactions also occur with respect to coastal wetlands (5.1 and 5.2). For example, agriculture in upstream areas may influence the functioning of coastal wetland environments such as estuaries and mangrove forests (5.1) through sediment deposition and hydrological changes, while the reverse interaction also occurs owing to features such as saline influxes when freshwater flows are very low due to irrigation extraction.

Some interactions from inland wetlands onto coastal wetlands may also be identified (6.1), with the reverse (6.2) being more hypothetical.

These AWIs typically occur in chains that go beyond a single wetland and its immediate catchment to include the whole river basin. For example, upstream agriculture reducing the flow of water to a wetland may indirectly affect further downstream agricultural activities. All wetlands are susceptible to this catchment-wide nature of external AWIs. These can become international in nature in some cases where human or animal populations, as well as water, move long distances.

Nature of agriculture–wetland interactions

While most of the above discussion has focused on the environmental nature of these interactions between agriculture and wetlands, all the linkages discussed above (in Figure 3) can also have a socio-economic and political dimension. For example, in considering the interaction between a wetland ecosystem and upstream agricultural activity that reduces stream flow and produces polluted runoff, both the impacts and the areas where responses are required are likely to be socio-economic and political, as well as environmental (physical, chemical and biological):

- Environmental impacts and responses: transformation of wetland ecosystem or wetland agriculture (pollution, desiccation, reduction in biodiversity, or hydrological change); overall change in regulating ecosystem services available.

- Socio-economic impacts and responses: reduction or increase in wetland provisioning services for local people; reduction or increase in some aspects of livelihood security; wider impacts on local markets.
- Political impacts and responses: creation of conflict between different interest groups (see below); local mobilization to influence upstream agricultural practices and policy; upstream agricultural policy may change (via a feedback loop).

This has considerable significance in terms of the subsequent analysis of AWIs, pointing to the need to take a wider view than is often the case with site-specific studies of environmentalists.

Relevance for the GAWI project

Recognition of the different interactions that occur between agriculture and wetlands confirms the emphasis that the GAWI project has to place on functional linkages, be they of an ecological, economic, social or political nature. Moreover, in the study of AWIs, two major types of interactions need to be explored: (i) those within wetlands; and (ii) those between wetlands and other parts of the functioning system, usually the river basin.

MA AND CA PERSPECTIVES ON WETLANDS AND AGRICULTURE Millennium Ecosystem Assessment (MA)

The MA recognizes that, with respect to inland wetlands, agricultural development has historically been the principle cause of wetland degradation worldwide. It reports (MA, 2005b) that, by 1985, between 56 and 65 percent of inland water systems had been drained for intensive agriculture in Europe and North America (27 percent in Asia and 6 percent in South America). Other agriculture-related developments are also reported to have had their impacts, including the building of irrigation dams (which have disrupted river flows and flooded or drained wetland areas), the diversion of water from wetland areas for irrigated agriculture, and the destruction of mangroves for shrimp culture. Moreover, poor agricultural practices, rather than agriculture per se, such as polluted agricultural runoff and erosion that leads to sedimentation, have led to the damage or loss of wetlands through biodiversity loss and the rapid succession to dryland environments.

However, the MA notes that, while most agricultural activities in and around wetland ecosystems fundamentally alter their structure and functioning (affecting the ecosystem services that wetlands can provide), agriculture in wetlands (in the widest sense as used here) has made a positive contribution to society. In many countries, the socio-economic benefits associated with wetland agriculture are often significant in terms of agricultural output, livelihoods, poverty reduction and trade. In other words, the reduction in regulating, cultural and support services is “compensated” for by increased provisioning services.

In considering various scenarios for the future of wetlands, the MA (2005b) predicts an increase in wetland degradation and wetland conversion to agricultural land in the next 50 years, with these trends being exacerbated by the likelihood of climate change. Specifically, population growth and the need for food production will place increasing demands on the provisioning and regulating services of wetlands, while the actual capacity of wetlands to provide these services will decrease. In particular, the MA notes that the overdevelopment of provisioning services can damage regulating and support services, which in turn can feed back and undermine provisioning services.

The MA proposes that, in order to address this situation both today and in the future, it is necessary to try to move from the presently skewed or imbalanced use of ecosystem services that occurs in many AWI situations and achieve a more balanced use of the services. This will require appropriate valuing of these services. In particular, the MA suggests the need to pursue a more equitable balance in the use of wetland

ecosystem services, thereby reducing the pressure on wetlands from provisioning services alone and enhancing the regulating and support services so as to achieve more ecologically balanced and functioning wetland and river basin systems.

The view is presented that, while agriculture inevitably has some impact on wetland ecosystems and their regulating services, agriculture does not necessarily lead to complete wetland degradation and loss, with a range of regulating services retained (albeit reduced or altered). Conversely, it notes that a level of support and regulating services is critical for the maintenance of provisioning services. In addition, it shows that there can also be positive impacts from agricultural development in terms of biodiversity, such as that supported by irrigation tanks in Sri Lanka or by irrigation scheme wastewater lakes in California, the United States of America, which support migratory birds (Meinzen-Dick and Bakker, 1999).

With this perspective, the MA suggests the need to explore the issue of trade-offs between different wetland ecosystem services in wetland management policy. However, it also recognizes that in the wider context of the Millennium Development Goals (MDGs), climate change mitigation strategies, and the commitments under the Ramsar Convention, there may be a need to address the issue of trade-offs between different ecosystem services (e.g. a reduction in agricultural use in exchange for maintaining water provision) in order to fulfil the specific needs of various wetland stakeholders. This implies a new skewed use of ecosystem services (over time and in space) to meet MDG goals with negative impacts on wetlands and their ecosystem services. At the same time, the MA also advocates the use of “ecosystem approaches” to wetlands management and planning that focus on managing environmental resources and human needs across landscapes; in other words, balancing trade-offs at a level beyond the wetland alone.

Comprehensive Assessment of Water Management in Agriculture (CA)

The recent Comprehensive Assessment of Water Management in Agriculture, published in 2007 (CA, 2007), drew attention to the emergence of competition for water resources between agriculture and natural ecosystems. In the context of a growing population with increasing food demands (doubling in the next 50 years) and the uncertainties of climate change, the assessment argues the need for more efficient and equitable water management in agriculture, in support of the MDG, especially given the fact that 850 million people remain undernourished at present. The question framing the CA was “How can water for food be developed and managed to: help end poverty and hunger; ensure environmentally sustainable water–agriculture practices; and find the balance between food and environmental security?”

The fact that the CA is informed by the MA is clear from the environmental points in this framing question and from the focus in one of its eight Policy Actions, which includes obtaining more ecosystem services from agriculture.

However, the CA takes a more detailed look at the situation. Rather than talking in generalities about the balancing of ecosystem services, it focuses on the provisioning services and makes specific recommendations in this area. These include:

- pursuing water-efficient strategies in agriculture as an important means of ensuring the supply to other stakeholders via the services of water-dependent ecosystems and the maintenance of environmental flows;
- seeking multiple-use and multifunctional agricultural systems;
- managing agriculture for diversity in the landscape;
- paying the poor for environmental services provided;
- addressing policies outside agriculture that have major impacts.

The importance of the CA to wetland management is evident in Policy Action 3, which discusses the management of agriculture to enhance ecosystem services, and recognizes that food production in many parts of the world has a negative or degrading

impact on biodiversity and ecosystem services. This has implications for human well-being in terms of livelihood sustainability. In response, the CA suggests:

- promoting services beyond the production of food, fibre and animal products in agro-ecosystems;
- making adaptations to agro-ecosystems to cope with the uncertainties of environmental change;
- incorporating, in land and water management, an understanding of the importance of biodiversity in supporting ecosystem services;
- recognizing the importance of diversity in land and water management, and ecosystem services, in promoting resilience and sustainability;
- raising awareness of the role and value of ecosystem services;
- improving inventories and assessments of ecosystem services, and their environmental thresholds with respect to service provision and agriculture.

As in the MA, the CA advocates the adoption of integrated approaches to managing land, water and ecosystems; ones that recognize and incorporate diversity within the landscape. Wetlands constitute an important landscape unit with the potential for facilitating multiple stakeholder benefits, and environmental and livelihood security. However, in order to achieve these, more attention needs to be given to how ecosystem services can contribute to agriculture, and to how agriculture should be sensitive to and support ecosystem functioning.

Conclusions for the GAWI initiative

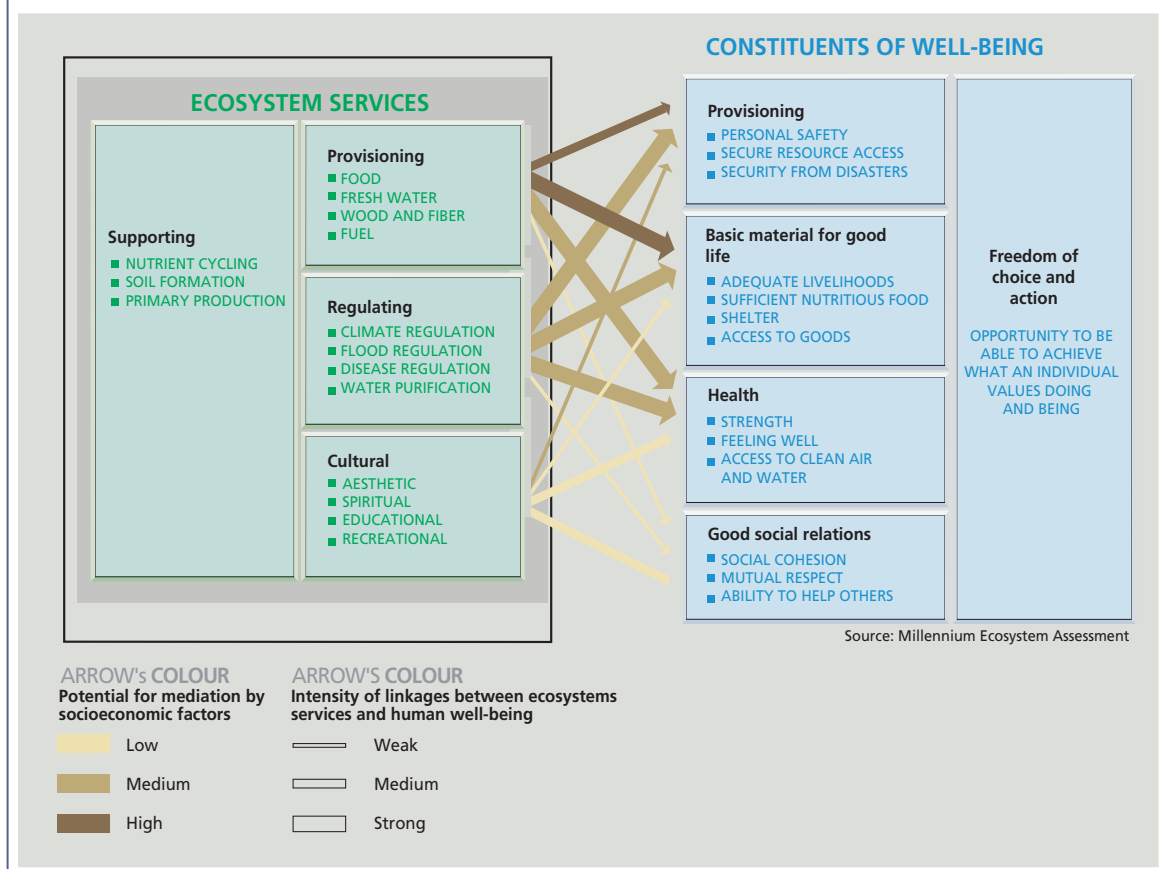
Overall, this discussion shows that increasing economic and population pressures have been the major driving forces in the predominantly human-induced transformation of wetlands. The drive to increase economic output and food production, in particular, has led to production systems in wetlands that depend on excessive emphasis of the provisioning services at the expense of the regulating services (in the MA view), and excessive water use (in terms of the CA). This has led to wetland degradation and to situations where water resources in a river basin are overallocated (closed basins – CA terminology) and where environment flows are inadequate for wetlands. The MA stresses that a rebalancing of the ecosystem services is needed in order to sustain the productivity of these areas. However, this balance could be increasingly difficult to achieve because of some of the other priorities of governments, such as the poverty reduction goals of the MDGs. The CA focuses on the provisioning services and the need to make these more ecologically sensitive, with attention to agro-ecological opportunities, multiple-cropping systems, and achieving diversity within agricultural landscapes.

Together, the MA and CA provide vital guidance for the GAWI work, drawing attention to different concepts and scales of analysis, including the ecosystem services, the functioning of river basins as a whole, multiple uses in agro-ecosystems, and the landscape scale of management. Overall, it can be concluded that the focus for the GAWI project must be on applying an ecosystems approach to agriculture, and a productive services approach to ecosystems in order to achieve a more environmentally friendly agriculture, and a productively-oriented natural environment, rather than a pure agricultural landscape.

LIVELIHOODS, POVERTY REDUCTION AND WETLAND STAKEHOLDERS

As the MA and CA point out, the pressures on wetlands are growing, and new ways of thinking are needed in order to address the issues involved in AWIs. The need for such innovations is especially important given the role of wetlands in the developing world and their contributions to livelihoods through subsistence and domestic market production and through their contribution to exports. In understanding this situation, it is necessary to identify the pressures that are being put on wetlands, their origins, and the actors involved in managing these areas.

FIGURE 4
Ecosystem services and human well-being



Source: MA (2005a).

Livelihoods and poverty reduction

Wetlands are important in the development process as they can contribute in several ways to the MDGs – through food security, water and sanitation and the ecologically sustainable use of natural resources (Figure 4). The MA reformulates the MDGs into a well-being concept and identifies four areas where ecosystem services can contribute: security, material well-being, health, and social relations. Despite growing pressures on wetlands for agriculture, it is necessary to try to maintain these multiple benefits and to ensure their availability across the socio-economic spectrum.

However, access to these ecosystem services is not equitable, and wetland agricultural development often leads to winners and losers, with conflicts and marginalization resulting. For example, large-scale commercial agriculture has often appropriated open-access wetlands for estate production, with the positive provisioning outputs being offset by negative effects not just on regulating ecosystem services but on previous users of the area (Bondestam, 1974). Smaller-scale use of wetlands also raises many debates about the socio-economic implications, with pre-existing low-intensity users of wetlands losing out to those who seek to develop these sites for intensive farming. For some wetland farmers, use of these areas is a survival strategy or a lifeline (Silvius, Oneka and Verhagen, 2000) with wetlands seen as marginal areas. For others, wetlands offer an opportunity for enhancing an accumulation strategy, and these are far from peripheral and difficult areas to use given the resources they have. The different perspectives of the various groups seeking livelihood and other benefits need to be given due consideration in understanding AWIs.

Local-level stakeholders

At the community level, there are diverse interest groups, reflecting the involvement of different people in wetlands in different ways, as well as their varying socio-economic and political influences. Differentiation in society is increased through interactions with wetlands; with the poor, in some areas, using them for survival with limited success, while the rich mobilize resources successfully to use these areas in response to market opportunities (Woodhouse, Bernstein and Hulme, 2000). In other cases, local government is interested in appropriating wetlands for its own uses, sometime to address population pressure and land shortages (Rwanda), or to provide opportunities for investors and estate agriculture (Ethiopia) (Bondestam, 1974).

National-level stakeholders

At the national level, one regularly finds entrenched sectoral views of wetlands from the different lines, ministries and agencies. Sometimes, there is competition between government agencies as they pursue their specific interests and responsibilities for water, agriculture, biodiversity, hydropower, etc. National economic development goals often tended to dominate and win out in the competition for national resources and political support, so that food security and export earning were pursued through national water policies that failed to take a holistic view of wetland ecosystem services. While there is still evidence of this in several countries, with political pressures leading to an emphasis on short-term goals and policies (Dries, 1991), there is also growing recognition of the need for greater sensitivity to environmental considerations and the need to strike a balance, or reach a trade-off, between different ecosystem services. The precise methods for achieving this remain subject to much discussion and have few examples of successful practice.

International community and wetlands

At the level of the international community, there is a range of stakeholders interested in wetlands, from those that focus on agricultural production to those that focus on conservation. Some of these international organizations focus on the provisioning services from wetlands because of their interest in benefits for local communities, national food security, and poverty reduction. Depending on their sensitivity to the other ecosystem services of wetlands and their recognition of the importance of wetland regulating services in order to maintain provisioning services, these organizations may focus on sustainable use rather than purely on agricultural production.

In recent years, there has been increased recognition among most of the international organizations concerned in some way with wetlands about the value of wetland ecosystem services and the need to achieve some consensus with other perspectives in order to take forward their specific interests. This is seen especially on the conservation side, where the need for inclusion of human development needs (especially addressing poverty) has grown. It is also seen in the areas of development where the need to maintain water flows for environmental purposes (including the maintenance of wetland ecosystem services) and the functioning of hydrological systems are increasingly recognized.

Relevance to the GAWI initiative

The GAWI initiative has to consider its task with reference to the current development priorities outlined in the MDGs, especially the eradication of extreme poverty and hunger (MDG 1) and ensuring environmental sustainability (MDG 7). Wetlands are potential contributors to development goals in many ways and, hence, there is a need to enhance their functioning as multiple-use resources, providing a range of ecosystem services that meet these goals and improve livelihoods. To achieve this, there is a need

to understand and engage with the actors involved in order to address the dynamics of AWIs and the different environmental and socio-economic consequences.

CONCLUSIONS

This chapter confirms the complexity of the AWI situation. There is diversity in terms of the wetlands and the ecosystem services they provide. There is a wide range of different ways in which agriculture and wetlands can interact, both spatially and in terms of their characteristics – ecological, socio-economic and political. Finally, there is a range of actors involved in AWIs, operating at different scales and with different interests. This complex situation suggests that any analysis will require a clear framework and a rigorous approach. Chapter 2 addresses this issue.

Chapter 2

Methods and sources

In order to explore the diverse experience of AWIs, the GAWI partnership decided to search for cases of such interactions across the world and to apply a standard analytical tool to them. In order to obtain cases, all GAWI partners volunteered to submit studies, drawing from their own experience or from materials obtained through partner organizations. In terms of the standardized analysis, it was recognized that cause–effect chains were common in the AWI experience but that this was a rather simplified conceptualization of the situation. Consequently, the DPSIR model was chosen for use in analysing these cases (below) as it was felt to be more comprehensive than the cause–effect model. It was also felt that the DPSIR model would provide a framework with comparability with the work of the MA, which had used the DPSIR concepts but in a slightly different form.

ACQUIRING THE CASE STUDIES

Sources

The GAWI partners provided about one-third of the cases that were obtained for analysis, the majority of these coming from WA (with an African focus), Wageningen University (with a European and Neotropics focus), WI and FAO (with an Asian focus), and IWMI (with an Asian and Oceania focus). In addition, a request for case studies was posted on the Ramsar listserve, and a small number of responses were obtained from this.

In order to try to ensure more comprehensive coverage, an extensive search of academic literature was undertaken using the on-line Scopus journal database (Scopus is the largest available abstract and citation database of peer-reviewed literature). Initially, a search of the terms “wetlands” together with “agriculture” in the title, abstract and keywords of the online content was undertaken, and this yielded 1 093 references between 1985 and 2007. Subsequently, the search was widened to include other keywords, such as marsh, swamp, irrigation and drainage (Table 4).

Given the large number of articles identified, a key challenge was to identify those most suitable for use in the identification of GAWI case studies. Suitability was determined on the basis of the following process:

- A quick examination of the title of each article ascertained whether it reflected AWIs, and whether the text was likely to contain information relevant to the DPSIR framework. (It was noted that the vast majority of

TABLE 4

Search terms and results of academic database interrogation

Search terms	Number of articles listed
Wetland + agriculture	1 093
Wetland + drainage	1 545
Swamp + agriculture	150
Marsh + agriculture	259
Wetland + irrigation	554
No. articles downloaded for preliminary analysis	85
No. used in GAWI case studies	43

Lead authors: Adrian Wood and Alan Dixon (WA)

articles were not particularly useful as they focused in great depth on only one or two particular elements of AWIs, e.g. plant performance in constructed wetlands, or chemical properties of agricultural runoff. These were considered unlikely to yield information relating to the full range of elements in the DPSIR framework, resulting in incomplete case studies. Hence, they were discarded.)

- For articles with titles that appeared suitable, an initial reading of the abstract was undertaken to ascertain whether the article was likely to yield sufficient relevant information suitable for inclusion in the DPSIR framework.
- Where the above two criteria were met, the article was downloaded, analysed, and a DPSIR checklist compiled simultaneously (below and Annex 2). Where, after analysis of an article, there was found to be insufficient or irrelevant material to include as a GAWI case study, a general Web search was undertaken to identify any additional information. In many cases, this approach did not yield further information and, hence, the article was discarded.
- In those articles considered suitable, the reference list was checked for additional relevant information, and, in many instances, these additional articles were downloaded, analysed, and the data added to the DPSIR case study checklist (below). General Web searches were also undertaken to triangulate information and consolidate the case studies. This often involved the identification of relevant grey literature contained on government Web sites or those of non-governmental organizations (NGOs).

Additional cases were obtained from participants at the expert meeting held in Wageningen in October 2007 to review a draft of the framework document and a series of issue papers relating to how to take the GAWI work forward. These cases were usually followed up through Web sites and e-mails with contact persons.

Despite the problems in identifying cases and obtaining literature on them, after a considerable period of work, more than 100 cases were identified from the various sources. Of these, 90 were processed using the DPSIR model (Annex 3).

Methodological limitations

The coverage of AWIs obtained in this way was far from complete or unbiased. In the first instance, the GAWI partners provided material from their areas of expertise, which reflected both the locations of their work and also their particular professional skills. This aspect of professional influence was also seen in the literature search. It was clear that certain types of AWIs (water quality being a particular example) attracted funding for studies and so were reported in the literature more than others. Moreover, within the cases used, there was incomplete coverage of the AWI elements. In one case, soil characteristics were studied, while this was not done in another case. In several cases, socio-economic differentiation was given limited attention compared with water tables and flooding regimes. As a result, care should be taken when comparing the cases as the absence of information on one aspect of AWI may be more a result of the professional skills and interests of the author rather than the actual situation. The use of the online search method may have also led to an emphasis on direct *in situ* AWI cases, and to the neglect of indirect basin-level cases.

In addition, the use of the DPSIR model (below) also affected the selection of case studies. For example, more general articles describing sustainable or traditional AWIs were not covered well by the model because pressures, impacts and state changes were not elaborated upon in the material. Hence, rather than presenting a case study that lacked information on many components of the model, such cases were usually discarded, even though in reality there may have been important findings for sustainable AWIs. Some of these cases did remain where there was reasonably full information, and these are discussed in Chapter 9.

In a small number of cases, some potentially relevant articles considered were not available to download (these being published prior to the mid-1990s). However, it should be stressed that the bulk of the database search covered the period from 1985 to 2007.

Reflecting on the cases obtained, it is relevant to note how little “joined-up” work on AWIs in particular locations, or sites, was found in the cases studied. For example, many articles discussed wetland management in depth without addressing the drivers and pressures that are fuelling emerging issues. Others papers focused entirely on biophysical state changes without any appreciation of the wider socio-economic context. This is a key area for future research and one that the GAWI initiative should address.

ANALYSING AGRICULTURE–WETLAND INTERACTIONS

The DPSIR framework

The DPSIR framework has been used by a range of agencies for the analysis of different situations. It builds on input–output models developed by economists in the Organisation for Economic Co-operation and Development (OECD) and Eurostat, and has been used by environmental economists, not so much as an analytical tool, but more as an auditing framework, e.g. by Turner *et al.* (2000). Their use of the model was specifically with reference to the Fen wetlands in the United Kingdom, while their particular focus on auditing meant that the definitions of the elements in the model were rather specific.

Operationalizing some elements of the model, especially with respect to pressures and state changes, proved challenging at times. However, an agreed terminology was achieved, similar to that in the paper by Turner *et al.* The definitions of the elements in the model are outlined below.

Elements of the DPSIR framework

For the purpose of the GAWI work, the following definitions were used. Specific examples are provided here for clarity. In all cases, these are specifically focused on AWIs. The MA equivalents are given in parentheses after the title for each category.

Drivers (indirect drivers)

These are any natural (biophysical) or human-induced (socio-economic) factors that lead directly or indirectly to a change in the wetland ecosystem, or in socio-economic processes that influence wetlands and AWIs. Simply put, drivers are the underlying causes that lead to pressures on wetlands or agriculture–wetland-related processes.

Examples are: population dynamics, market development, natural environmental processes, government policies, and community behaviour.

Some drivers operate by influencing ecosystem processes. For example, market opportunities may lead to the establishing of a sugar-cane estate and so changing land use in a wetland, while population growth may cause agricultural expansion into a wetland. Some drivers operate more diffusely, by altering other drivers. They may be seen as “deeper causes”, such as broad policies or their failings, international economic circumstances, and the cultural value systems in a society, which create other specific influences on people’s behaviour and situations.

Pressures (direct drivers)

Pressures are the consequent results of the drivers on the wetland environment or wetland-related agriculture and any associated socio-economic developments. Pressures are how the drivers manifest themselves on the wetlands and wetland-related societies/activities through processes related to the transformation of wetlands

or the disturbances of their ecological state. In other words, they represent strategies to satisfy the drivers. They are seen here as processes, or activities, that are operating on a generalized scale.

Examples are: agricultural colonization in wetlands, vegetation clearance, agricultural intensification, nature conservation, and water resources management and use.

State changes (changes in ecosystem services)

State changes in the (wetland) ecosystem can be described in terms of biophysical processes that determine the ecological character of the ecosystem and/or the natural resources base. They include changes in the quantity and quality of the various environment elements in the wetland (soil, water, plants, animals, etc.) and their consequent ability to support the demands placed on them (for example, biodiversity, environmental functioning and their ability to support human and non-human life, and supply resources) – in other words, the state of the ecosystem and especially its regulating and support services.

Examples are: water resources, water quality and pollution, soil characteristics (chemical and biological), and biodiversity.

Impacts (human well-being and poverty reduction)

These are the socio-economic results that come from changes in the state of the wetland environment. In other words, they are the way in which the socio-economic characteristics and condition of a wetland society are affected, especially the provisioning services.

Examples are: livelihood gains from market-oriented production, food and nutritional changes in subsistence situations, socio-economic differentiation and conflicts, and recreational development.

Responses (strategies and interventions)

These are actions in response to drivers, pressures, state changes and impacts. These may be technical and institutional or involve policies and planning. They can be implemented by a range of actors.

Some examples of responses are:

- technical or socio-economic actions that try to address specific impacts;
- institutional development by communities that respond to state changes by improving wetland site management coordination;
- planning by basin-level organizations that respond to pressures within a river basin with initiatives for water and land-use management;
- national-level policies and economic development measures that try to address the needs in the society and especially achieve sustainable and ecologically sound economic development;
- international-level responses, including government-to-government types of cooperation, actions of international NGOs (INGOs), and international agreements to which national governments adhere.

Exploration of responses has been limited in most uses of the DPSIR model to date. As a result, considerable attention was given to the question of how best to analyse this material. This led to three characteristics of the responses being seen as important:

- actor,
- measure,
- drivers addressed.

Actor focus

Responses can be found at different levels:

- household – usually concerning day-to-day management;

- community – typically involving local institutions and local policy, as well as coordinated action at a wetland site and maybe the catchment;
- NGOs – often linked to community initiatives, but also including wider perspectives;
- state – involving policies, policy implementation and legislation, major engineering measures and formal research.

Type of response/measure

A second dimension of the responses can explore their nature:

- technical – in terms of specific management practices being addressed, whether these relate to water, crops, natural vegetation, soil or land;
- institutional – in terms of the development of capacity at the community to state level or arrangements for undertaking wetland and catchment management;
- policies from community-level by-laws up to national-level policies;
- planning interventions by the community or the state.

DPSIR focus

A third dimension for thinking about responses is to explore how they address different elements of the DPSIR model and what measures or actions are relevant for these different elements. For example, it is possible to see responses that try to address drivers as needing to have a much wider remit (policy responses perhaps) compared with ones that address state changes that may be specific technical measures.

Applying the DPSIR framework to case studies

An example is developed in Box 1 in summarized form in order to clarify the interpretation of the elements in the framework outlined above. It is elaborated in Chapter 4, where the value of the DPSIR analysis is explored in detail.

ANALYSING THE CASES

Checklists

The understanding of the DPSIR model outlined above was turned into a checklist format (Annex 2) in order to provide a way of summarizing the case studies obtained. While the checklist was primarily a means of identifying the various DPSIR elements in each AWI, it was also a means for identifying areas of common experience between cases, which may inform guidance.

In addition to the DPSIR information recorded for each site on the checklist, six pieces of additional information were recorded to help characterize the situation being studied. These were:

- type of wetland (using all 42 Ramsar categories as in Table 1);
- economic development status of the country (using World Bank data);
- degree of subsistence / market orientation of the agriculture;
- degree of water control – full, partial or none;
- Ramsar region;
- type of AWIs (as in Figure 3).

The construction of the checklists from the diverse case material was undertaken by ten people, although the vast majority were compiled by a three-person team. This compiling of the checklists from literature and other sources involved a filtering-out of information and, hence, the compilers could “stamp their mark” on the work at this stage, or influence the information selected for the next stage in the work. To guard against this, guidance was provided on the checklists about the meaning of the different terms in the DPSIR model, while each checklist was checked by one person responsible for the work overall.

BOX 1

Permanent swamps, Illubabor, Ethiopia**Drivers:**

- a) population growth and land shortages – often linked to upland degradation;
- b) food insecurity – owing to pests and crop storage problems;
- c) land shortages for cultivation and grazing owing to coffee planting on uplands;
- d) land reform in 1975 (equal access to all land types including wetlands) – giving more people access to wetlands and encouraging use;
- e) government policy and task force to improve national food security by drainage agriculture;
- f) in-migration owing to land degradation in north leading to resettlement and land allocations;
- g) local market for food in coffee towns.

Pressures:

- a)–g) drainage and cultivation in wetlands;
- b) double-cropping of some wetlands (intensification);
- a) and c) sediment deposition from uplands associated with upland degradation;
- d) uncontrolled and heavy grazing by cattle in wetlands.

State:

- a)–g) lowered water tables and increased soil acidity;
- b) soil nutrient decline and soil structure changes with prolonged low water table;
- c) decline in soil quality at fringes of wetland owing to upland sediment deposition;
- c) and d) soil compaction;
- a)–f) destruction of the wetland vegetation;
- a)–f) biodiversity in wetlands increased owing to more diverse, especially non-wetland, conditions.

Impacts:

- b) food security improved, but not for all households, some through cultivation and some through piece work – on wetland farms;
- d) some upper-middle-income farmers are gaining at the expense of others in the community who traditionally use wetlands for local uses, e.g. women for water collection, poor men for reed harvesting;
- a)–g) springs drying up and women having to walk further to obtain domestic water supplies;
- d) tensions between different user groups in a few cases;
- c) forage resources enhanced where wetlands partially drained;
- e) recognition of value of wetlands in government and more widely in communities;
- g) urban food supply improved.

Responses:

- at driver level:
 - e) NGO action to reduce demands of wetland task force through training on the dynamics of wetlands and the impacts of double-cropping and intensive wetland use;
- at pressure level:
 - a)–d) development of community-based institutions to manage wetlands;
 - a)–d) development of local guidelines for the selection of wetlands for agriculture;
- at the state level:
 - a)–d) use of community-developed techniques, such as ditch blocking, to assist in maintaining water table level;
 - a)–d) farmer experimentation on land management and multiple land use;
 - a)–d) rules to protect springs.

Database, coding and analysis

In order to analyse the cases, a database was created and a coding regime developed to prepare the cases for entry. This coding was based initially on the words and terminology used in the checklists that were drawn directly from the source documents. It was developed in various iterations as the number of case studies built up. This involved both adding more detail as the experience diversified and consolidating that diversity into groups to facilitate analysis. The final categories used for coding the DPSIR experience are shown in Annex 3. In order to maintain rigour and reduce the variability in this process, it was undertaken by one person.

Once the coding had been completed and the checklists entered into the database, a series of interrogations of the database were undertaken. These focused initially on the patterns of DPSIR variables by the major groupings of the cases (wetland type, Ramsar region, market orientation and water management). Some of these groupings were simplified to facilitate analysis.

REFLECTIONS

Using the DPSIR model was helpful. It provided rigour in the analysis of a range of cases with different levels of documentation and detail, and forced this diverse body of information into a form that allowed comparison. This is particularly important given the variations in the data outlined in this chapter and the diversity of experience referred to in Chapter 1. The main area where the model did not work particularly well was when it was applied to cases of apparent sustainability and stability in AWIs, as these do not appear to have current drivers and pressures leading to current state changes. Overall, a balance had to be struck between using the DPSIR model, the checklist and the coding rigorously to ensure comparability, and allowing a degree of flexibility to include the range of cases identified with their varying data availability.

Chapter 3

Assessment of agriculture–wetland interactions across the case database

This chapter reports the overall results of the DPSIR analysis conducted on the 90 cases of AWIs collected for the database, as described in Chapter 2. The aim of this analysis is to identify the broad patterns and characteristics in AWIs as currently reported. Specifically, this focuses on the general trends, occurrences and impacts of AWIs, as well as the responses currently deployed to manage these interactions towards achieving the sustainable and diverse use of wetland ecosystem services. This assessment is undertaken considering the interests of the Ramsar constituency in terms of wetland types and Ramsar regions, but also in terms of economic development regions and agricultural systems.³ Overall, this analysis seeks to guide and inform the need and scope for guidelines on sustainable AWIs.

A balance has been sought in this analysis between the quantitative details and generalized trends where generic features can be identified. There are inherent limitations in such a global analysis as the assessments inevitably show trends and identify issues in general terms, using broad classes and groupings of interactions and impacts. The result is that the rich context and agro-ecosystem specificities are lost. This is an important issue to keep in mind as the responses, and the guidance for responses, need to be contextually sensitive and agro-ecosystem-specific.

One consequence of this is that the application of the DPSIR framework, as seen through the global analysis presented in this chapter, does not provide a sufficiently strong justification of the value of this approach. The real strength of the DPSIR lies in its context-specific application, which enables a comprehensive mapping out of the complex mesh of AWIs and their causal interrelations, thereby identifying multiple options, levels and types of responses (that are specific to the context) to redress the state of the ecosystem services. Such a context-specific application of the DPSIR framework is the focus of Section II of this report, where five specific cases are analysed.

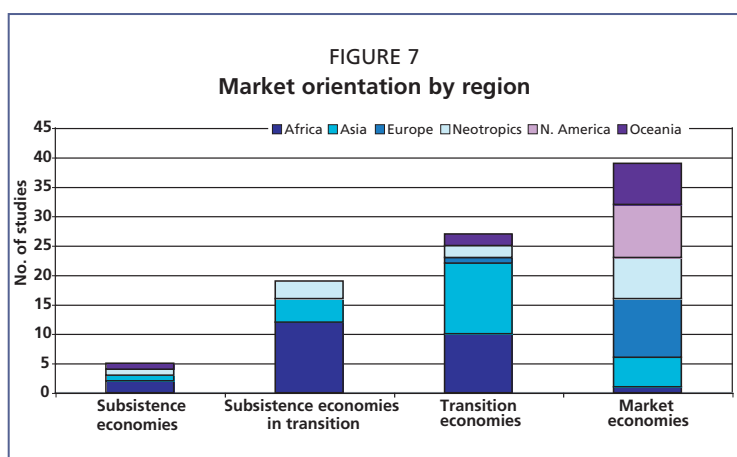
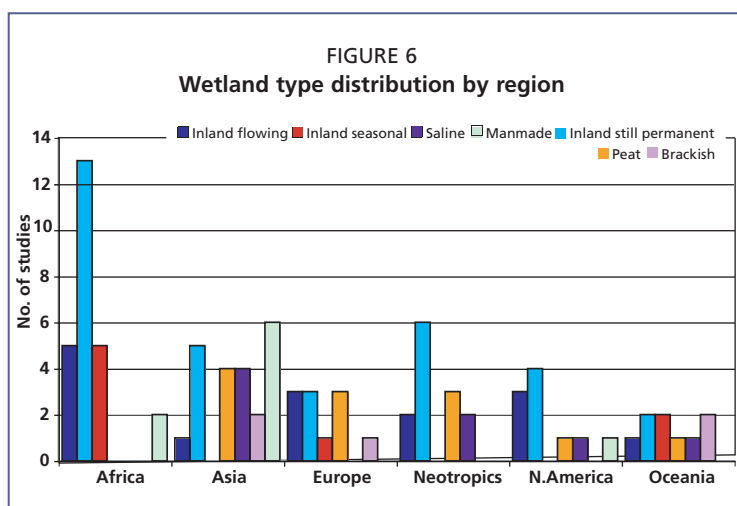
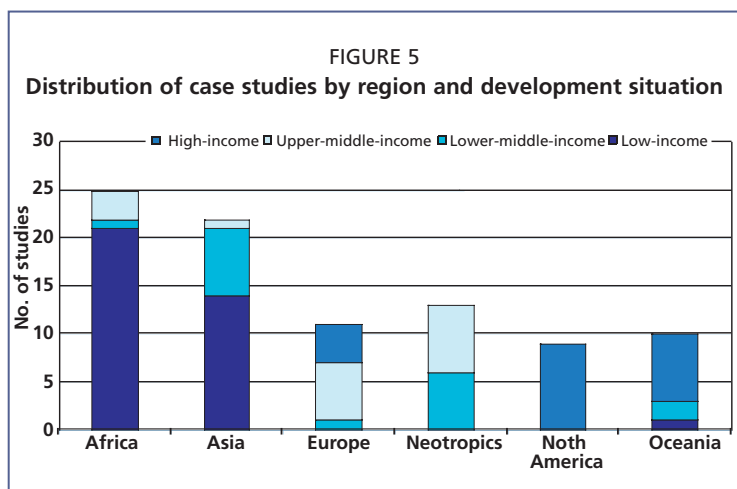
Notwithstanding these inherent limitations, and being sensitive to their implications, the global analysis and general assessment of the cases is made using the DPSIR framework with a view to:

- exploring the relevance and significance of AWIs and their impacts on ecosystem services across the wide range of wetland types and regions;
- providing support, context (accessible through the database) and underpinning to the hypotheses, conclusions and recommendations of the MA and CA;

Lead author: Gerardo E. van Halsema (WUR)
Contributing authors: Hans Langeveld (WUR), Adrian Wood (WA) and
Ben Rutgers (WUR)

³ Considerable efforts were made to make the database as comprehensive as possible by reviewing literature, grey literature and approaching Ramsar country focal points. However, given the wide range of Ramsar wetland typologies (42) and regions (6), it was impossible to cover all possible typologies within the time and financial limitations of this initiative.

- identifying gaps and limitations that still need to be addressed;
- exploring the value of commonalities in experience for sharing knowledge and devising adequate response strategies.



THE CASE DATABASE

From various sources, 90 cases were obtained for analysis of their DPSIR elements (Chapter 2 and Annex 4). Figure 5 summarizes the global distribution of these cases, together with their distribution by level of economic development.⁴ It shows that almost half of the cases are drawn from low-income countries and slightly more than one-fifth from high-income countries.

Of perhaps greater importance for this study are the wetland and agricultural characteristics of the sites studied. These are presented in Figure 6 and Table 5. These show that the major types of wetlands captured in this study belonged to the categories: inland still permanent wetlands, inland flowing wetlands (including rivers), and peat wetlands. In relation to the Ramsar typology, the most frequent captured wetland types are: permanent freshwater marshes/pools (Type 22), permanent rivers/streams/creaks (Type 14) and permanent freshwater lakes (Type 16) (see Table 5).

Regionally, permanent rivers/streams/creaks (14) and permanent freshwater marshes/pools are quite widely distributed, while a number of types tend to be mainly found in Asia, e.g. saline and brackish (7–10) as well as irrigated land (35). In the analysis by wetland type, and also in Table 5, only the primary wetland type of each case is considered – in several cases, more than one type of wetland was found within the area considered.

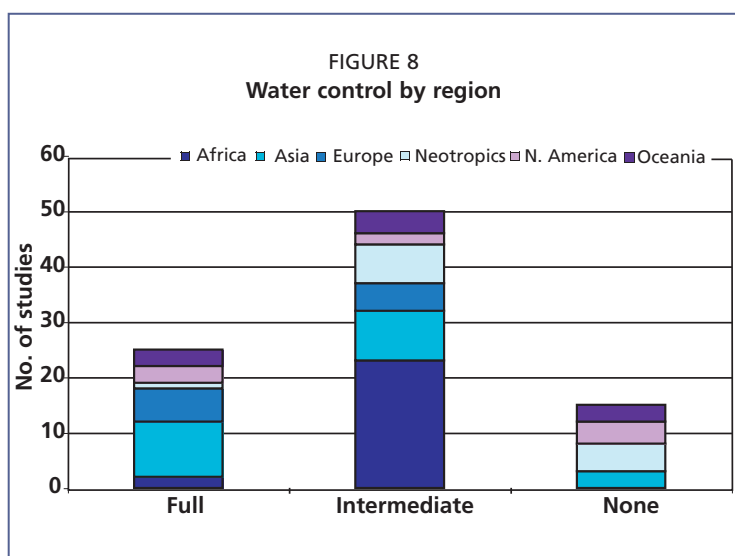
⁴ Economic development level is taken from World Bank documentation. Neotropics refers to South and Central America, including Mexico, in this analysis.

TABLE 5
Global distribution of case studies by Ramsar wetland type

Code	Wetland type	No.	Wetland group
Marine/coastal wetlands			
1	Permanent shallow marine waters		
2	Marine subtidal aquatic beds		
3	Coral reefs		
4	Rocky marine shores		
5	Sand, shingle or pebble shores		
6	Estuarine waters		
7	Intertidal mud, sand or salt flats	1	Saline
8	Intertidal marshes	1	Saline
9	Intertidal forested wetlands (mangroves)	6	Saline
10	Coastal brackish/saline lagoons	5	Brackish
11	Coastal freshwater lagoons		
12	Karst and other subterranean hydrological systems		
Inland wetlands			
13	Permanent inland deltas	2	Inland flowing
14	Permanent rivers/streams/creeks	12	Inland flowing
15	Seasonal/intermittent/irregular rivers/streams/creeks	5	Inland seas
16	Permanent freshwater lakes	12	Inland still permanent
17	Seasonal/intermittent freshwater lakes		
18	Permanent saline/brackish/alkaline lakes		
19	Seasonal/intermittent saline/brackish/alkaline lakes and flats		
20	Permanent saline/brackish/alkaline marshes/pools		
21	Seasonal/intermittent saline/brackish/alkaline marshes/pools		
22	Permanent freshwater marshes/pools	21	Inland still permanent
23	Seasonal/intermittent freshwater marshes/pools on inorganic soils	3	Inland seasonal
24	Non-forested peatlands	5	Peat
25	Alpine wetlands	4	Peat
26	Tundra wetlands		
27	Shrub-dominated wetlands		
28	Freshwater, tree-dominated wetlands	1	Inland flowing
29	Forested peatlands	3	Peat
30	Freshwater springs;		
31	Geothermal wetlands		
32	Karst and other subterranean hydrological systems		
Human-made wetlands			
33	Aquaculture (e.g. fish/shrimp) ponds		
34	Ponds		
35	Irrigated land (including wetland created by irrigation)	8	Human-made
36	Seasonally flooded agricultural land		
37	Salt exploitation sites		
38	Water storage areas	1	Human-made
39	Excavations		
40	Wastewater treatment areas		
41	Canals and drainage channels, ditches		
42	Karst and other subterranean hydrological systems		

In the analysis by agricultural category, the majority of cases are in market-oriented agriculture with full water control, or the transition to market orientation with intermediate levels of water control⁵ (Figures 7 and 8).

⁵ Water control refers to whether there is full control with full irrigation, none where there is rainfed cultivation and no flood control, and intermediate where there are elements of both.



In terms of the wetland interactions outlined in Chapter 1 (Figure 3), the cases show a predominance of within-wetland transformations (interactions 1.1 and 1.2). Almost half of the cases have interactions with their catchments, mostly through downstream impacts and from catchments upon wetlands (interaction 2.1).

The analysis of the DPSIR elements across the case database was conducted on two levels that provide a distinct, but complementary, set of information and conclusions.

In the first instance, the DPSIR elements were analysed at the group level, using groupings of individual but related drivers, pressures, etc. Figures 9, 11, 14 and 17 present the frequency distribution of, say, all reported drivers over the distinguished driver groups. In general, an individual case reports more than one driver, pressure, state change or impact – hence, the 90 cases of the database had 23 different, or individual, drivers, which were categorized into eight groups (Table 6 and Annex 3). (In total, there were 296 reported drivers across the 90 cases.) Cases may also report more than one driver, pressure, etc. within one group. The “average” frequency distribution of drivers (or other DPSI elements) over the groups is first provided for the entire database (see foot of Figures 9, 11, 14 and 17), and subsequently for region, market orientation, water control and wetland type (above in Figures 9, 11, 14 and 17). To facilitate comparison, the latter four are presented as deviations from the overall average distribution. Thus, the group-level analysis provides insight into what the dominant (most frequent occurring) groups of drivers/pressures/etc. are and shows whether this frequency distribution is influenced by region, wetland type, level of water control or market orientation.

The second type of analysis, which complements the group-level analysis, involves consideration of the individual drivers, pressures, state changes and impacts (Annex 3). As each case can only list an individual driver/pressure/etc. once, the frequency analysis is conducted to show the proportion of the 90 cases reporting the individual driver/pressure/etc. in question – across the entire database, region, or wetland type. Hence, while the group-level analysis provides an indication of how important a group of drivers/pressures/etc. is in the light of the overall reported drivers/pressures/etc., the individual analysis provides an indication of how widespread the individual driver/pressure/etc. occurs across the sample of cases under consideration.

These variables can be cross-tabulated as required to inform different types of analysis. However, this high level of variables also imposes significant statistical limitations to the analysis of the database entries because the overall sample of 90 cases

TABLE 6
Major characteristics of the case database

	Drivers	Pressures	States	Impacts	Wetlands	Regions	Economy	Water control
Groups	8	5	6	9	7	6	4	3
Individual	23	23	39	38	21*			
No.	296	312	384	313	90	90	90	90

* Relates to Ramsar typologies.

is too limited to reach a large enough set of entries for more than ten variables. With this in mind the analyses are purposefully kept at a broad level and focussed on clear trends to lessen the chances of misinterpretation.

DRIVERS

As discussed in Chapter 2, drivers are natural (biophysical) or human-induced (socio-economic) factors that lead directly or indirectly to a change in the wetland ecosystem, or in socio-economic processes that influence wetlands and AWIs. In short, drivers are the underlying causes that lead to pressures on wetlands or agriculture–wetland-related processes.

Driver groups

The case study analysis reveals that population and natural resources dynamics (population, food and land dynamics – Annex 3) are the most frequently reported driver group, accounting for 36 percent of all reported drivers (no. = 296) (Figure 9). This is followed by markets (28 percent) and government policies (excluding land-use policies) (16 percent). Together, these three groups account for 80 percent of all reported drivers. Conspicuously absent among the reported drivers are ones in the realm of climate change/variability. This may be explained by the age of the case study material (2–15 years) and/or a tendency to account for natural and climate factors as “natural” contextual settings, rather than factors that may drive agricultural and ecological changes.

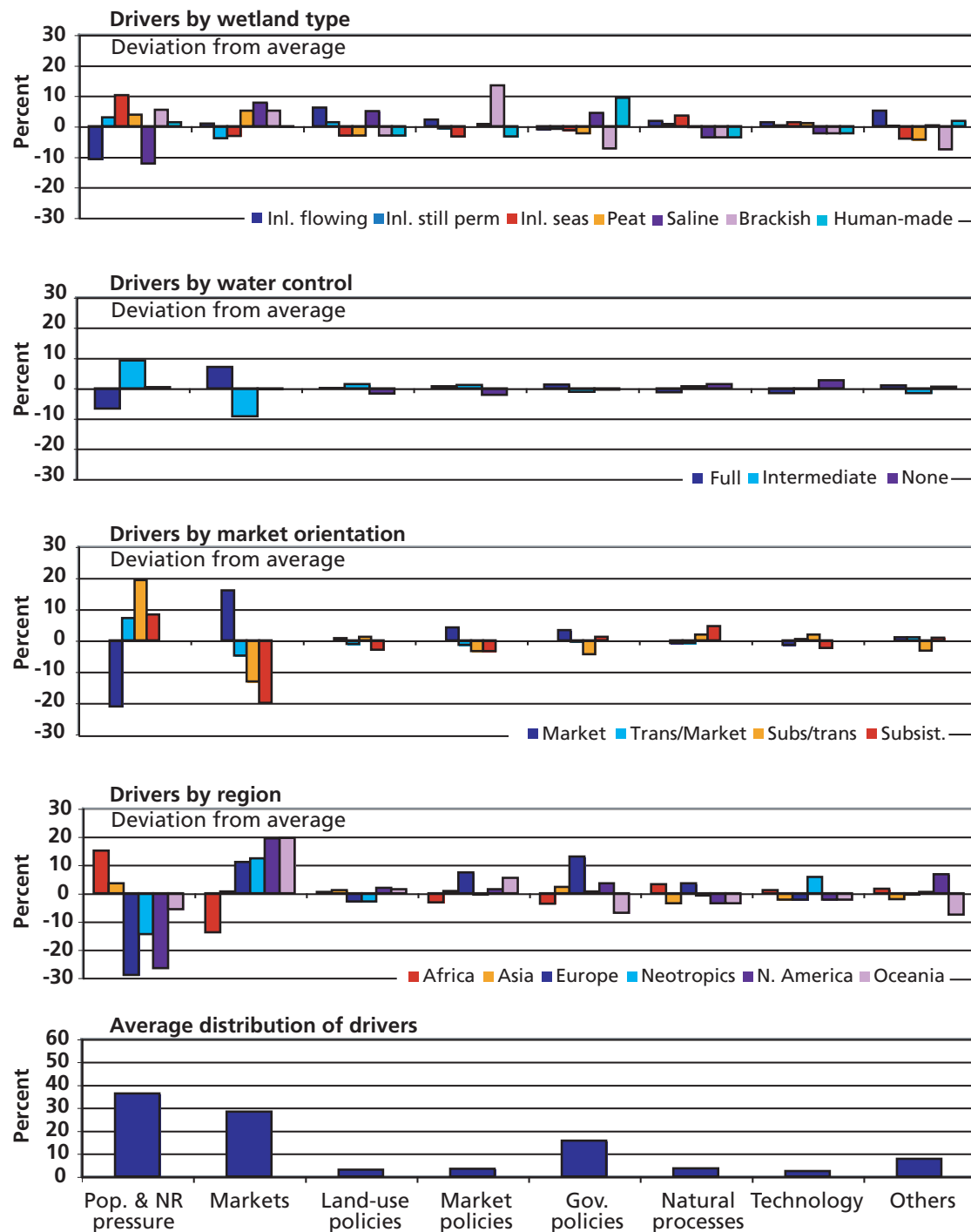
Population and natural resources dynamics

Drivers arising from increasing population pressures, food shortages and land dynamics are more pronounced in Africa, and markedly less so within the OECD and Neotropics (Figure 9). In fact, the predominance of African and Asian cases in the database (see Figure 5) distorts the overall average distribution of reported drivers towards this category because the population, food and land drivers are more pronounced in subsistence and subsistence economies under transition. When viewed against the level of water control, these drivers from population and natural resources dynamics are more pronounced in conditions of intermediate levels of water control and slightly less so under full levels of water control. This reflects the importance of wetlands in subsistence economies, where they tend to be at least partially (or intermediately) developed for water and agricultural use, but yet not fully developed. In terms of wetland type, this driver group is slightly more pronounced for inland seasonal wetlands, which are increasingly becoming a new agricultural frontier in countries with distinct dry seasons, or “hungry seasons” in livelihood terms (Chapter 4).

Markets

Market drivers fuelling agricultural intensification and expansion show the reverse tendency to population, food and land dynamics drivers. They are more pronounced in the OECD countries, especially North America and Oceania, and less pronounced in Africa. Market drivers are more dominant in market-oriented economies and progressively less so towards subsistence economies. When viewed against the level of water control, market drivers are more pronounced in situations of full water control and less so for intermediate levels of control. This reflects the relationship between investments in water control infrastructure and market-oriented agricultural production. When viewed against wetland type, market drivers are slightly more predominant for peatlands (e.g. demand for oil-palm, see Chapter 6) and for saline and brackish wetlands (e.g. demands for fish and aquaculture, see Chapter 7). The higher than average influence of market policies in brackish wetlands is also entirely related to fisheries and aquaculture policies.

FIGURE 9
Distribution of reported drivers by driver group



Government policies

While government policies may be less frequently listed as drivers than those originating from population, natural resources and markets, this does not necessarily mean they are less significant in shaping particular response strategies or shaping present AWIs and the resulting state of ecosystems. On the contrary, government policies are frequently enacted, or acted upon, as a means to regulate the use of natural resources and/or the

environmental impacts of agriculture. Illustrative examples of these are provided by Chilika Lagoon – e.g. the driving force of the Montreux Record in shaping the response strategy (Chapter 7) – and the Netherlands floodplain policy (Chapter 5).

Drivers stemming from government policies are predominant in the European region. This explains the relatively lower dominance of market drivers in Europe when compared with North America and Oceania. This importance of government policies is because of European Union (EU) legislation, which is geared towards establishing a strong regulatory environment, not only in terms of agricultural production and trade, but also in the realms of environmental protection, and this shapes AWIs (Chapter 5).

Individual drivers

Analysis of the individual drivers listed enables the analysis of the frequency distribution of drivers over the case samples (such as region, wetland type), thus providing an insight in how widespread a specific driver is occurring across the cases. In contrast, the analysis of driver groups as presented above provides an indication of how much of the listed drivers belong to a specified group of drivers. In general, the individual drivers analysis confirms the results of the driver groups as discussed above. However, in some instances, refinements to the analysis are provided, which are briefly discussed below.

Population, food and natural resources dynamics

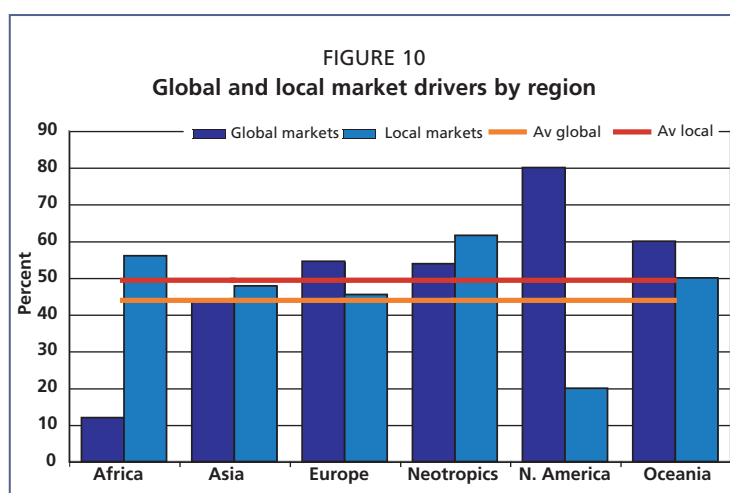
Population growth is still listed as the single most important driver in Asia and Africa, where it is found in three-quarters of the cases from these regions. For the Neotropics, population growth is still seen as a driving force in half of all the cases (Annex 5, Table A5.1). Only for the Africa region is a more diverse set of drivers from this group listed as relevant, with immigration, land and food shortages and increased food demand seen to influence AWIs in one-third of the cases.

Global vs local markets

For market drivers, a distinction has been made between global (international) and local (within country) markets. Although the market drivers group was substantially less frequent in the Africa region when compared with other regions or with the driver group stemming from population, food and natural resources dynamics (Figure 9), market forces do play a significant role in Africa as well. Local markets are listed as driving forces in slightly more than half of all African cases – which is similar to the local market influences for Asia, Europe, Oceania and the Neotropics (Figure 10 and Annex 5, Table A5.1). It is in particular on the influence of global markets that the African cases score significantly lower than the other regions. However, this is strongly case and context dependent, as African AWIs may be influenced strongly by global market forces when export-oriented agriculture (i.e. flowers, vegetables and coffee) has developed in the region. The other marked exception is the North America region, which appears to be centred on global market-oriented agriculture.

Government policies

At the driver group level (Figure 9), the relevance of drivers stemming from government



policies is lower than market and population drivers. However, when considering individual drivers, on average half of all cases report drivers stemming from government policies (Annex 5, Table A5.1). Europe deviates from this in that nearly three-quarters of its cases report government policies as drivers; whereas Oceania and Neotropics list substantially less government policies as drivers, this being in only one-fifth and one-third of their cases, respectively.

Other drivers

Masked by the very low listings of drivers of climate change/variability when considered over the overall distribution of driver groups (Figure 9) is the substantial higher reporting of climate variability as an individual driver in the Africa region, where it is listed as a driver in one-third of cases. This supports the general notion that agriculture in general, and crop cultivation in particular, are particularly susceptible to the vagaries of rainfall variability, especially in Africa. Here, poor rainfall, and thus poor yields, can further drive the intensive use of wetlands (resources) for food production/gathering and/or the expansion of the agricultural frontier.

Urbanization is also frequently reported as a driver in Africa, where it has been listed by more than one-third of the cases – substantially more than in the other regions. This is mostly a reflection of the increasing urban markets for food.

Another refinement and anomaly that becomes apparent at the individual driver level is related to tourism. In North America, tourism/recreation is listed in nearly one-third of the cases as a driver shaping AWIs, while it is practically absent in all other regions. To what extent this reflects a bias in the cases obtained for North America or is a growing trend where demands from the tourism and recreation sector increasingly shape restoration measures for wetlands is impossible to say. On the other hand, although frequently propagated as a promising potential client to serve through “payment for environmental services” (PES) schemes, actively implemented tourism-driven and recreation-driven good response cases (as opposed to planned ones or ideas) proved hard to come by for other regions.

PRESSURES

The pressures that result from the drivers discussed above encompass mostly processes related to the transformation of wetlands or the disturbances of their ecological state. In other words, they represent strategies arising from the predominant drivers of population, food and natural resources dynamics and market demands, as well as other drivers.

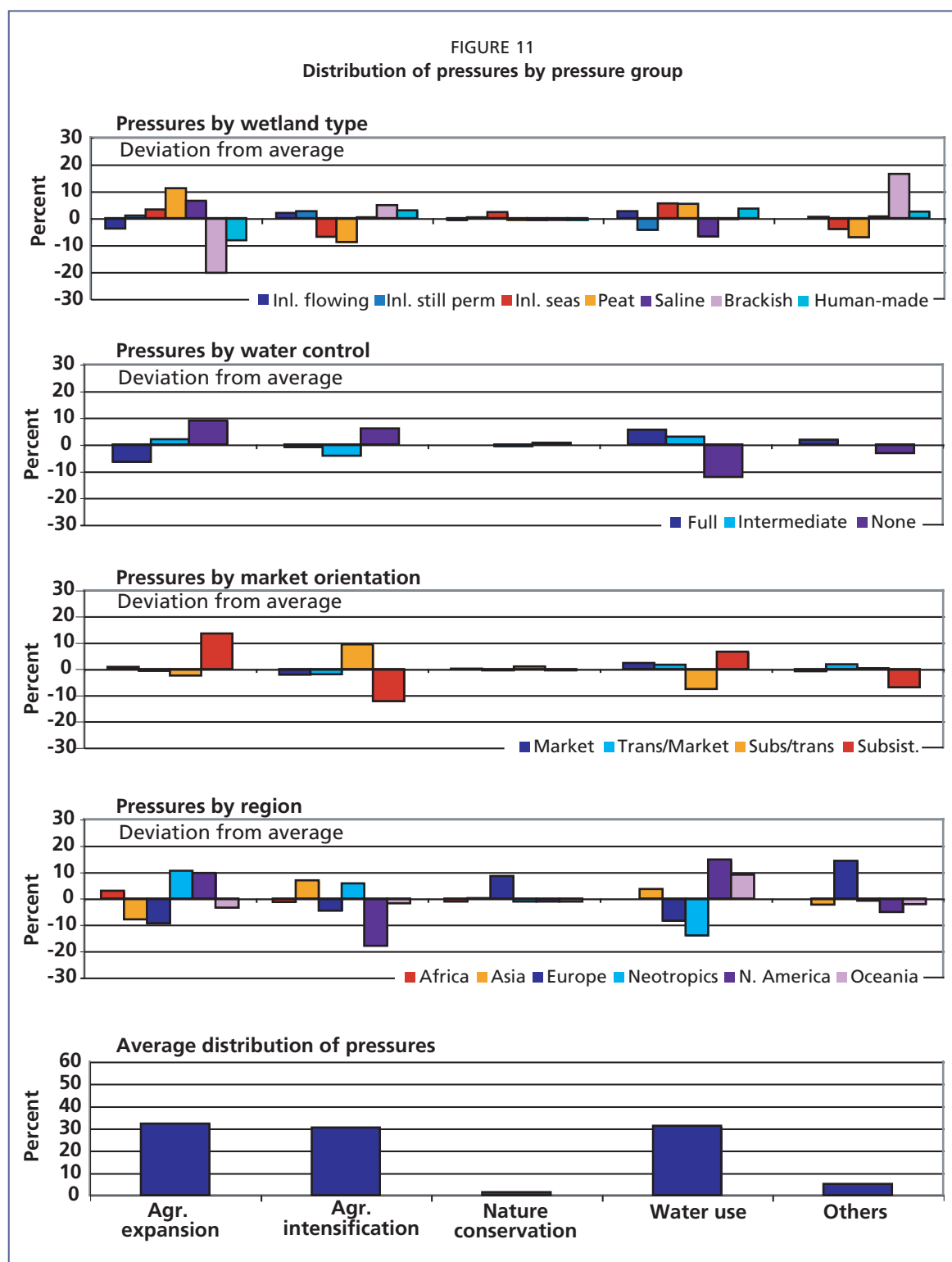
Pressure groups

The pressures are distributed approximately evenly over the three major groupings of agricultural expansion, agricultural intensification and water use – where on average each group accounts for roughly one-third of the listed pressures (Figure 11). When set against the different categories of region, market orientation, water control and wetland type, the deviations from the average distribution of pressures by these groups are only modest, and they obscure the more detailed differences and particularities that are captured in the individual pressures (discussed below) and the case studies (see Section II). Hence, the bulk of the discussion in this section is by individual pressures, not pressure groups.

Individual pressures

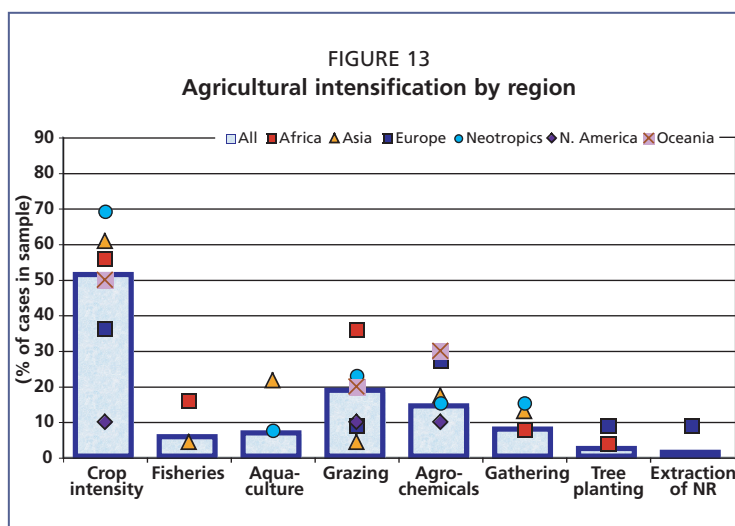
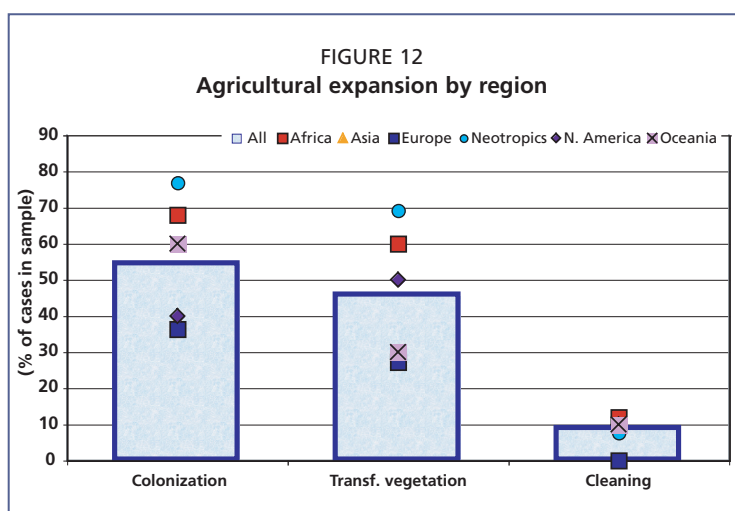
Agricultural expansion

When viewing the individual pressures within the agricultural expansion group, a more distinct picture emerges, revealing how expansion pressures are still prominent in some



regions (Figure 12). The expansion of the agricultural frontier is represented by three interrelated pressures: colonization (land settlement); transformation of vegetation;

⁶ Another source of potential variability in the interpretation and listing of pressures of agricultural expansion is related to the time frame over which the analysis is conducted, e.g. with a historical perspective, all agriculture has its origins in expansion. It is recommended to restrict the analysis to active expansion for which a response strategy may still be relevant and appropriate.



and clearing of natural vegetation (as reported in the checklists). In practice, it may be difficult to distinguish between these three, and the data entry may thus be susceptible to a degree of variable interpretation.⁶ Nevertheless, in line with what is expected, Figure 12 shows a clear distinction between regions of still active agricultural expansion and those of agricultural consolidation. Africa and the Neotropics stand out as regions where agricultural expansion through colonization and transformation of vegetation is ongoing in two-thirds to three-quarters of cases in these regions. In contrast, Europe and Asia represent a more consolidated agriculture frontier with expansion pressures listed in only one-third of the cases (Annex 5, Table A5.3).

Agricultural expansion is markedly more pronounced in subsistence economies, which is in line with expectations.

When analysed by level of water control, agricultural expansion is more pronounced under conditions of no water control and less so under

conditions of full water control (Figure 11). This is what one would expect, as water control enables agricultural intensification.⁷ The trend for water use, with higher listings for full water control to fewer listings for no water control, conforms to expectations.

When analysed by wetland type, agricultural expansion in the form of colonization and/or transformation of natural vegetation is reported to occur in two-thirds of the peat and saline wetlands cases (Annex 5, Table A5.4). This is primarily caused by conversion to oil-palm estates (Chapter 6) and aquaculture (Chapter 7), respectively.

Agricultural intensification

When analysed by region (Figure 13), Asia shows the most pronounced individual pressures of agricultural intensification – intensified crop production (two-thirds of its cases) and intensified aquaculture (one-fifth of its cases, all coastal) (Annex 5, Table A5.3). In Africa, the intensification pressures are seen in intensified crop production (two-thirds of cases), intensified grazing (one-third of cases), and

⁷ This seems to be contradicted when comparing agricultural intensification by water control. However, this is misleading as agricultural intensification is higher than expansion for the sample of cases that list full water control. Furthermore, the pressure distribution for full water control is influenced by the listings for water use, which are markedly less for no water control and hence favour the distribution of the latter towards agricultural expansion and intensification.

intensified fisheries (one-fifth of cases). Intensification in one type of agriculture can lead to trade-offs in other realms, and hence lead to further pressures for expansion and/or intensification of affected agricultural subsectors (i.e. through negative feedback loops). The slightly lower pressure from agricultural intensification in Europe is offset by its higher listing in terms of pressures of nature conservation / agricultural extensification (Figure 11). This reflects the current situation of a predominantly consolidated agriculture sector that is increasingly subject to demands and regulations to provide more room for, and improve its relations with, nature (Chapter 5). European pressures of intensification are limited to intensified cropping (half of cases) and intensified agrochemical use (nearly one-third of cases). The low listing of agricultural intensification for North America cannot be taken as a general indicator. This is because it is informed by the cases in the database that primarily deal with extensive agricultural practices that are being implemented as part of the cross-compliance agreements for creation and management of prairie pothole wetlands and the development of seasonal duck habitats in wetlands with agricultural use. The lower than average pressures of intensification listed for subsistence economies is entirely in line with its higher-than-average pressures of agricultural expansion (Figure 11). Subsistence economies in transition towards market orientation report a higher-than-average pressure of intensification. These intensification pressures are highly dispersed over intensified cropping, grazing, fisheries and gathering, which reflect the diversified agricultural systems operating in these economies.

Water use

Pressures stemming from increased water use are more pronounced than the average in the cases from North America and Oceania (Figure 11). This is primarily a reflection of the relative water scarcity in these regions. Conversely, these pressures are less pronounced in the Neotropics region, which overall is still classified as a relatively water-abundant region (CA, 2007). The below-average reported pressures of water use for Europe need to be treated with caution. On the one hand, this figure is influenced by the absence of cases in the database from the Mediterranean region, which does face water scarcity issues and pressures. On the other hand, Europe lists higher-than-average other pressures, which in this case stem from pollution that affects water quality (Annex 5, Table A5.3).

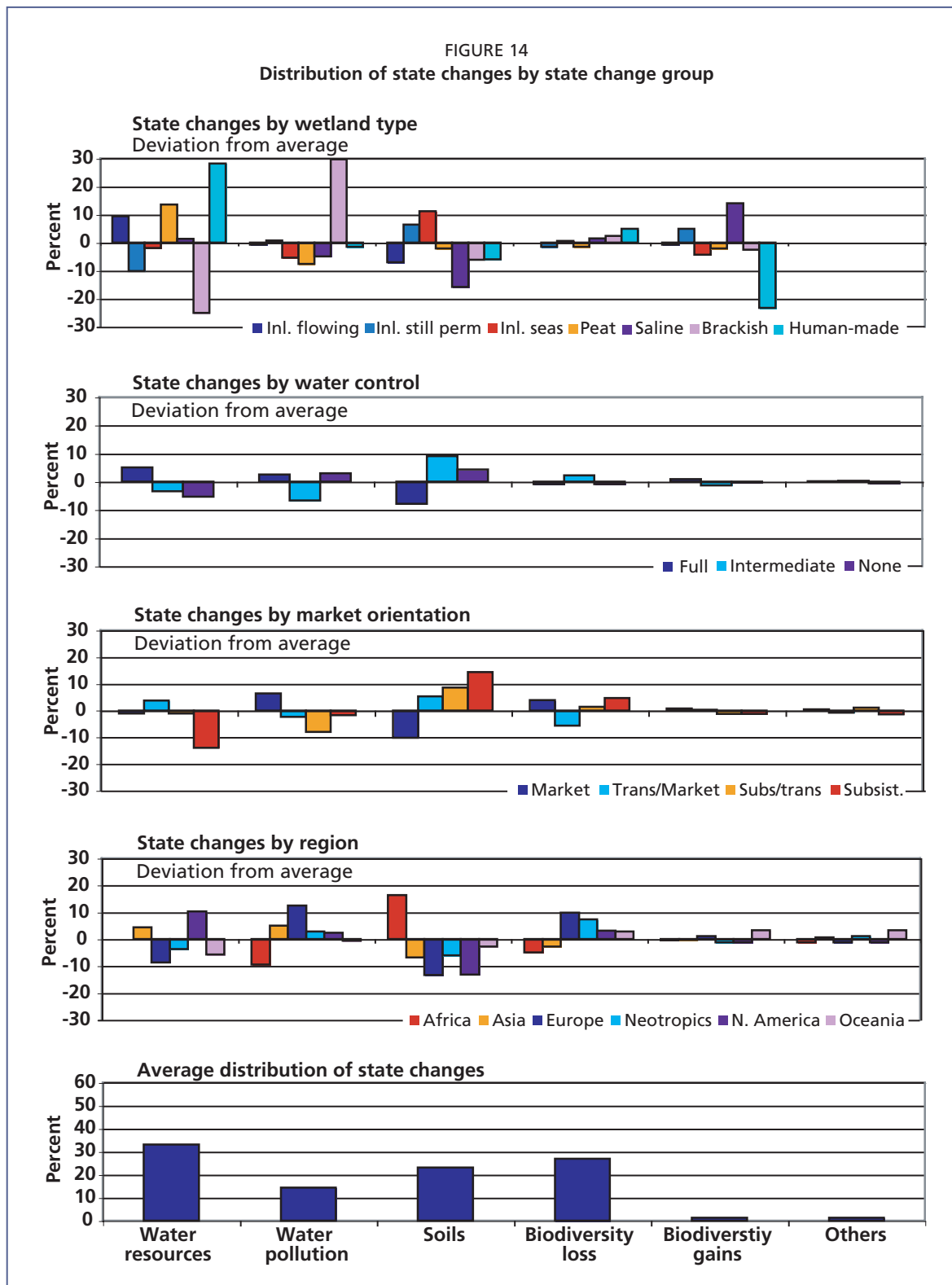
When viewed against wetland type, pressures of water use are slightly higher for inland seasonal and peat wetlands. In the case of peatlands, this is because of the dominance of drainage pressures, as reported in 87 percent of its cases. Brackish wetlands report higher-than-average other pressures, which relate to the management and control of the freshwater and saltwater interface.

STATE CHANGES

State changes in the (wetland) ecosystem can be described in terms of biophysical processes that determine the ecological character of the ecosystem and/or the natural resources base. Understanding these processes is expected to yield concrete guidance as to the possible response strategies to adopt and apply in order to address processes that currently undermine the balance between ecosystem services and determine the current state of (negative) change. In addition, the state changes can be linked and used for a diagnosis of the ecosystem services outlined by the MA. This is done at the end of this chapter.

State change groups

Within the multitude of state changes, four groupings of biophysical processes are on average the most frequently listed in the cases of the database (Figure 14). Of all state changes listed in the database, one-third refer to changes in the state of the water



resources. Of all reported state changes, one-quarter are changes pertaining to the loss of biodiversity – which one would associate as a common trade-off for increases in agriculture/provisioning services. Changes in soil conditions account for just less than one-quarter of all reported changes (and are particularly an African phenomena), and water quality for nearly one-sixth of changes.

Individual state changes

State changes defined in biophysical processes are diverse and multiple (Annex 5, Table A5.5). They impinge upon a complex of processes and subsystems that are both dependent on: (i) the typical configuration of the ecosystem; and (ii) the agricultural manipulation of these processes and subsystems. This is reflected in this database in that: (i) the entries and listings for individual state changes are more numerous than those for drivers and pressures (39 against 23); and (ii) the distribution of state changes by wetland type is more diverse and dispersed, providing a confirmation of the ecosystem dependency on state changes.

Water resources base

When analysed by region, state changes in the water resources and wetland hydrology generally correspond to the reported pressures on water use in the previous section. The only exception is for Oceania, which reports a slightly lower-than-average listing of state changes in water resources with a slightly higher than average listing of pressures stemming from water use. Though seemingly contradictory, it should be kept in mind that merely the frequency distribution of reported pressures and state changes are discussed here. As such, no conclusions can be drawn as to the severity (or level) of the limited state changes that are listed – which in this case is lower floods, flows and smaller flood areas, as reported by one-third of the Oceania cases.

The state changes in water resources are slightly more frequent in situations of full water control and less frequent in cases with no water control (Figure 14). When viewed against wetland type, the listed state changes in water resources are highly diverse. Inland flowing and human-made wetlands show higher than average listings, probably because they are more susceptible to a wide range of the 16 individually distinguished state changes on the water resources base. Peatlands show slightly higher state changes, as two-thirds of the peat cases report lower water tables and associated state changes (Annex 5, Table A5.6). Inland still permanent wetlands feature slightly lower-than-average listings of these state changes as they tend to be concentrated on the major state changes, such as lower floods, lower water tables and increased variability in hydrological regime. For brackish wetlands substantially less than the average number of state changes in water resources are listed, as the major issues are concentrated around water quality, and in particular the management of the “fresh-brackish-salt” water interface (below). This is reflected in the substantially higher listing of state changes relating to water quality for brackish wetlands.

Water quality/pollution

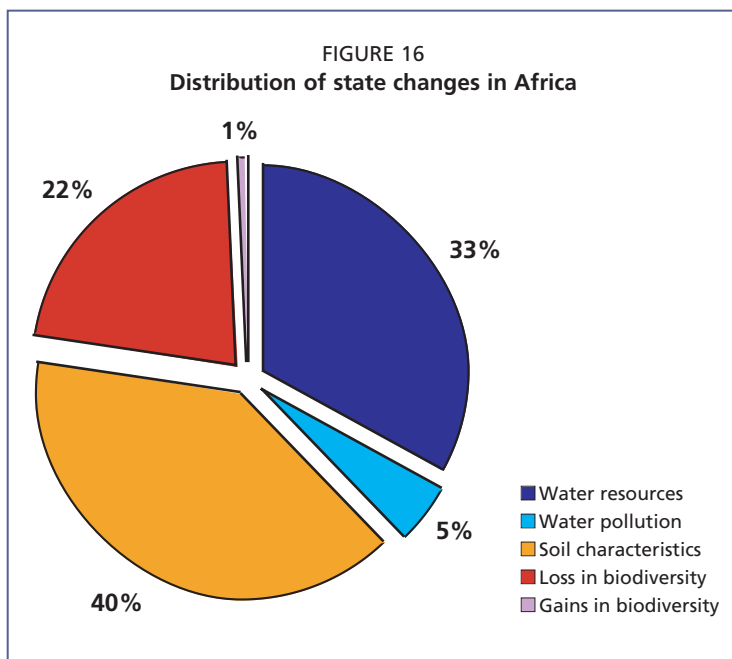
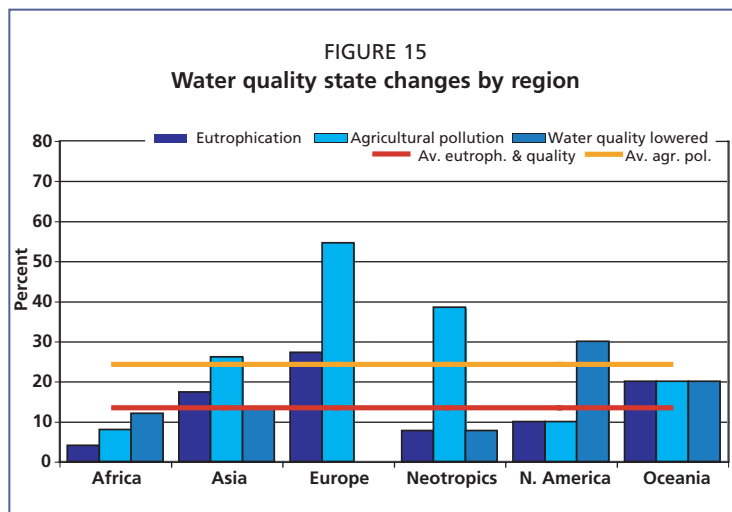
Overall, state changes in water quality or pollution are reported with a low frequency (Figure 14)⁸. Nevertheless, at group level, Europe stands out with a more pronounced water quality problem, as does brackish wetlands that face issues with the maintenance of the “fresh-brackish-salt” water interface.

In view of the diverse aspects of water quality/pollution, there is a need to discuss this at the individual state-change level in order to capture these phenomena. Figure 15 presents the occurrence of three⁹ individual state changes on water quality/pollution by region, as well as their average occurrence¹⁰ in the overall database sample of

⁸ However, the analysis of these state changes at the group level provides somewhat of a distorted picture. The frequency listing of group state changes is skewed towards favouring other state changes as the group of water quality comprises a limited number of five individual state changes, compared with 16 for water resources (Annex 3).

⁹ For the sake of graphical clarity, the additional state changes related to increased freshwater level and increased salinity have been omitted. These occur primarily in brackish wetlands and/or occur with a low frequency in the case database.

¹⁰ The overall averages for eutrophication and lowered water quality are the same at 13 percent.



90 cases (Annex 5, Table A5.5). It becomes evident that deteriorating water quality originating from agricultural pollution is most severe (most frequent) in Europe (reported by more than half of cases), the Neotropics (more than one-third of cases) and Asia (one-quarter of cases). In the case of the Neotropics and Asia, this corresponds to the slightly higher-than-average listed pressures in the form of agricultural intensification. In contrast, in Europe, this reflects a common trade-off of the present intensive agricultural systems. The more specific state of eutrophication is most frequently listed in Europe (one-quarter of cases) and Asia (one-sixth of cases). In the latter region, these are all related to coastal wetlands. On the other hand, the African cases list very few state changes in water quality/pollution, which is in line with what would be expected of the generally low (or lower) input agriculture systems. The general state change of lowered water quality is the most pronounced for North America (one-third of cases). As in the case for Oceania, this general state change provides little insight as to the origins (agriculture or other) or effects of the water pollution (chemical or biochemical). However, it does indicate the presence of an issue.

Soils

Individual state changes in soil conditions include both those defined in terms of “hydrophysical” properties (6 individual processes) and in terms of chemical properties (5 individual processes) (Annex 5, Table A5.5). These are associated with common problems such as sedimentation and loss of soil fertility that directly affect water retention capacity and agricultural productivity in wetlands. In addition, chemical properties, such as toxicity, salinity and acidity, may also impinge directly upon the ecological character of the ecosystem. When analysed by region, it becomes apparent that state changes in soil characteristics are a particularly African phenomenon. With 40 percent of all reported state changes in Africa ($n = 124$) pertaining to the soil characteristics group, this is the most dominant category of state changes for this region (Figure 16).

The individual state changes related to soil conditions are more informative (Annex 5, Table A5.4). Overall, the most frequently reported state change is that of increased

sediment deposition in wetlands, as reported in half of the cases from Oceania, one-third of those from Africa, and one-quarter of those from Asia and the Neotropics. The other frequently reported soil changes, which are specifically reported in Africa, are: loss in soil fertility (one-third), reduced infiltration, erosion and physical deterioration (one-quarter each). For Europe, state changes in soils are limited to soil subsidence, which is reported in more than one-third of the cases. This is due to the fact that the cases from Europe are predominantly peatlands. For the African cases, the yield and (water) resources losses associated with these soil state changes may form important negative feedback loops to the drivers and pressures that encourage rural communities to expand their agricultural frontiers, especially through the exploitation of prime land and water resources of wetlands, thus increasing their further contraction and conversion.

Overall, the reporting on chemical state changes of soils is rather minimal (except for salinity in Oceania). Rather than being a reflection of the low occurrence of such problems, this is likely to be influenced by the difficulty of assessing chemical state changes (both in quantitative and qualitative terms). Hence, chemical state changes are more likely to be underreported in case studies. On the other hand, hydrophysical state changes are visible and more likely to at least be reported upon in qualitative terms.

Loss in biodiversity

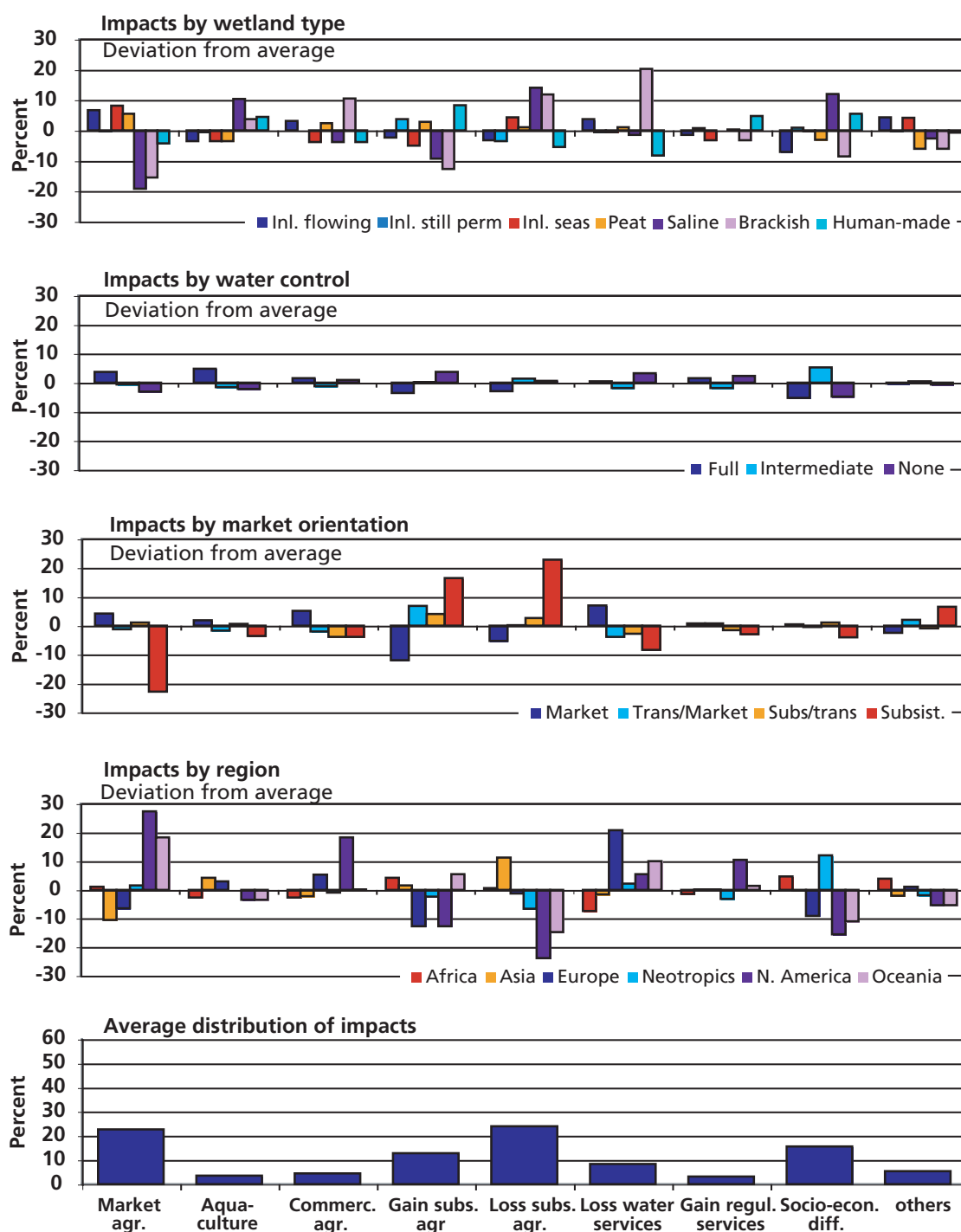
Loss in biodiversity comprises five individual state changes. This is the second-most frequent reported state change after changes in the water resources base. The most frequent individual state change (Annex 5, Table A5.5) is that of decreased vegetation, biodiversity and groundcover, which is reported by between two-thirds and nine-tenths of the regional sample cases. This reflects the general and common trade-off that is associated with the expansion and intensification of agriculture in wetlands that inevitably leads to some transformation of natural vegetation and groundcover. What the general analysis of the database cases fails to provide is a qualitative insight into the extent of the reported loss in biodiversity (primarily owing to contraction of the wetland ecosystem) and how this is undermining the ecological character and resilience of the ecosystem (i.e. a measure of degradation). Some measure of qualification could have been provided through the additional individual state changes of loss in biodiversity, were it not that fewer fish, less wildlife and increases in invasive species are, in general, minimally reported upon – except for invasive species in the case of Oceania (one-third of cases). Thus, this general reporting of the common trade-off between agriculture and nature shows no meaningful variation when set against region, market orientation, level of water control or wetland type (Figure 14). Thus, in its common reporting and classification in the database, this state change is a mere general truism. There is a need to develop a method to quantify and qualify this state change in a meaningful fashion.

IMPACTS

Impacts are the socio-economic results of changes in the state of the wetland environment. They show the way in which socio-economic characteristics and conditions of the wetland society are affected, especially the provisioning services that can be obtained from the wetlands.

The impacts of AWIs on the socio-economic situation of wetland-dependent communities and other communities (from local urban centres to the national and international community) are highly diverse and multiple. Therefore, impacts have been distinguished in a variety of specific individual impacts (38 in total, Annex 5, Table A5.7) that cover the specific and diverse farming and economic systems that can be affected by the state of ecosystem services. This approach was adopted to capture explicitly the potential multiple trade-offs between socio-economic / livelihood gains and losses of AWIs (e.g. increased irrigated agriculture vs loss in fisheries). This allows

FIGURE 17
Distribution of impacts by impact group



attention to be given to how changes in the exploitation of specific ecosystem services lead to changes in the economic benefits that different stakeholders reap from the ecosystem services. The rebalancing of ecosystem services into a sustainable equilibrium thereby inevitably becomes burdened with the intractable issue of redistribution of access to resources and derived wealth.

Impacts groups

Gains and losses in provisioning services

Pressures, such as agricultural expansion and intensification (Figure 11), can induce significant transformations in the agrowetland landscape, and lead to specific shifts within the provisioning services being derived from the ecosystem, as well as between provisioning and other ecosystem services. As a consequence, one would expect these shifts to be replicated (if not amplified) in the impacts they have in terms of the socio-economic benefits derived from these ecosystem services.

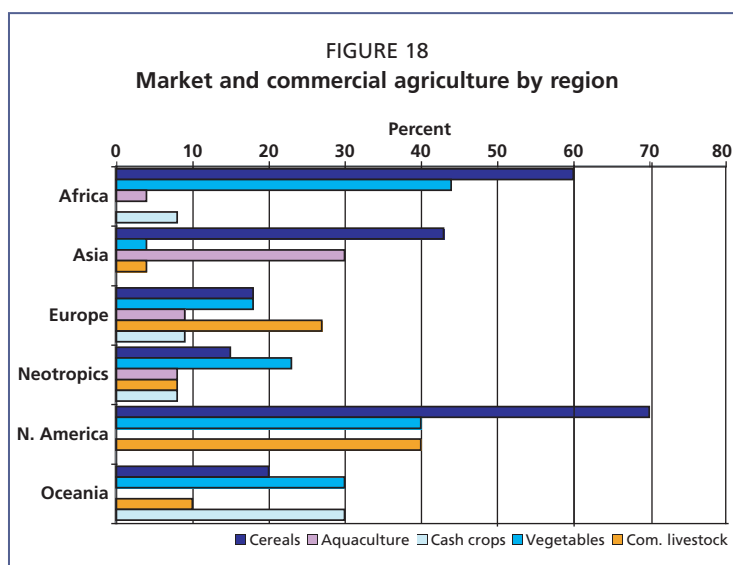
When viewed at the group level (Figure 17), these relative shifts are reflected in a high frequency of reported gains in agricultural production and benefits – 45 percent of reported impacts relate to gains in agricultural production, with market-oriented agriculture (nearly one-quarter of impacts) and subsistence agriculture (one-seventh of impacts) as the dominant groups. On the other hand, these gains are offset by a substantive reported (productivity) loss in subsistence agriculture (mostly owing to changes to market-oriented production, as well as loss of gathering type activities), with one-quarter of reported impacts pertaining to this group.

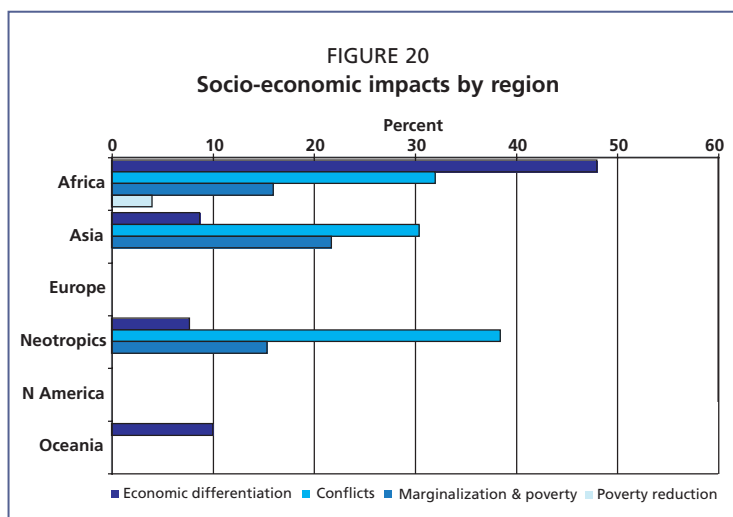
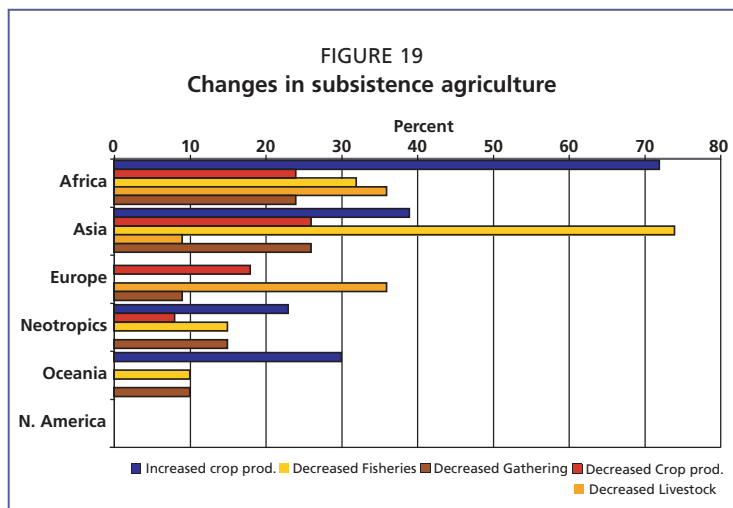
When analysed by region, impacts show a slight variation around the average distribution, except for a higher dominance of market-oriented agriculture for North America and Oceania. Loss in subsistence agriculture is more frequently reported in Asia than in the other regions, which is mainly because of the high frequency of reported loss in fisheries and gathering (below). When analysed by market orientation, there is an expected trend with regard to the dominance of increased subsistence agriculture in wetlands in subsistence-oriented rural economies. Analysed by wetland type, the variation in impact distribution is as expected – e.g. market-oriented agriculture is more frequent in inland flowing, inland seasonal and peat wetlands, and aquaculture is more pronounced in coastal and human-made wetlands. The loss in subsistence agriculture, reported frequently in coastal brackish and saline wetlands, is primarily because of the high frequency with which loss in captured fisheries and gathering have occurred in these wetland types.

Individual impacts

In order to capture the specific trade-offs that may occur between agricultural (i.e. provisioning) systems – especially the livelihoods that depend on these – and regulating services, it is necessary to study the (provisioning services) impacts at the individual level.

Figure 18 shows the impact by region of the most prominent individual impacts for market-oriented and commercial agriculture, as well as aquaculture. Gains in cereal production (e.g. food commodities) are the most frequently reported impacts and the most pronounced in North America and Africa (almost two-thirds of cases) and Asia (two-fifths of cases). Next in importance is gains in vegetable production, which is a particularly pronounced impact in market-oriented agriculture for Africa and North America (two-fifths of cases)





and Oceania and the Neotropics (one-third and one-quarter of cases, respectively). Gains in aquaculture is a decidedly Asian phenomenon and reported in one-third of cases in this region. Europe and the Neotropics (and Oceania to a lesser extent) show less pronounced impacts from market-oriented agriculture, mainly because of a more diverse range of reported impacts, including sugar and livestock (Annex 5, Table A5.7).

As gains in market-oriented or commercial agriculture represent shifts and transformations in resources utilization, any gains need to be viewed against potential trade-offs or offsets elsewhere. Within the provisioning services such trade-offs are evident within the reported impacts in terms of gains and losses in subsistence agriculture (Figure 19). Gains in subsistence agriculture are limited to reported increases in subsistence crop production – in particular in Africa (from two-thirds to three-quarters of cases) and Asia (two-fifths of cases). Such gains are generally the direct result of the agricultural expansion that has taken place.

On the other hand, the reported losses or decreases in subsistence agriculture are substantive in terms of the frequency with which they are reported. The most prominent of these is the reported loss in fisheries, which seems structural for Asia (three-quarters of cases) and significant for Africa (one-third of cases). However, these declines in fisheries may be a result of transitions to market-oriented/commercial agriculture and/or expansion of subsistence agriculture. Moreover, as in the case of livestock in Africa, decreases in derived socio-economic benefits from fisheries often tend to signify a deprivation of an entire livelihood. Decrease in livestock, in particular owing to loss of grazing lands, is prominent in Africa (more than one-third of cases). Decreased subsistence crop production (e.g. rainfed) is common in both Africa and Asia (one-quarter of cases), as is the reported decrease in gathering (one-quarter of cases in each of the two regions). For Africa, the decrease in subsistence crop production is linked to the reported state changes in soil characteristics (especially erosion and loss of fertility). The reported losses in subsistence agriculture in Europe are misleading – decrease in livestock and crop production are primarily indicators of switching from intensive agriculture to low-intensity agriculture as a means of agro-ecological landscape management. Thus, they are as much a nature conservation response and impact as that they are an agricultural impact (see Chapter 5).

Socio-economic differentiation

Different gains and losses in market-oriented/commercial and subsistence agriculture affect the economic benefits and livelihoods that different people can derive from these provisioning services. This is reflected in the reported impacts on socio-economic differentiation. Shifts and trade-offs within the provisioning services, i.e. from subsistence to market-oriented, or from fisheries to crop production, thus often represent overall trade-offs in economic benefits and livelihoods (e.g. increase of aquaculture at the expense of capture fisheries), rather than transformations of the livelihoods themselves (e.g. capture fisher people transformed to aquaculture people). Within the impact group of socio-economic differentiation, these impacts were analysed using four reported aspects: economic differentiation; increase in conflicts; marginalization and poverty; and poverty reduction (Figure 20).

Economic differentiation among agrowetland-dependent societies is a dominant impact in Africa, being reported in nearly half of the cases in this region. This is often a consequence of early (or selected) adopters being able to shift to irrigated and/or market-oriented crop production in wetlands, thereby accumulating relative wealth and access to the limited land and water resources available. At the same time, other groups within the community lose access to these scarce resources. A second frequently reported, and associated, impact is a rise in competition for, and conflicts in access to, prime resources, such as land and especially water. In Africa, Asia and the Neotropics, a rise in competition and conflicts for limited resources has been reported in one-third of the cases in these regions. In most cases, these conflicts stem from intensification and expansion shifts in agricultural production that make increased claims on available water resources. The growing competition and conflicts in resources management that are encountered should be seen as a direct trade-off of realized gains in provisioning services.

The occurrence of increased marginalization and poverty is difficult to assess as a general impact when not explicitly monitored in case studies – especially as it forms a qualitative and quantitative subset of the more general (and qualitative) impact of economic differentiation. Therefore, the reported cases of increased marginalization and poverty in the database (e.g. one-fifth of the cases from Africa and Neotropics and one-quarter of the Asia cases) tend to be restricted to situations in which entire livelihoods are clearly and greatly affected (e.g. fisher folk, livestock keepers and gatherers). Positive impacts in terms of a reduction in overall poverty have rarely been reported, and are limited to 4 percent of African cases.

Absent from Figure 20 are reported impacts of socio-economic differentiation in the European, North American and Oceania regions. This may be a reflection of well-established and well-regulated resource-allocation regimes in these regions that restrict shifts between, and moderate impacts across, different users and sectors. In addition, any trade-offs and “losers” may be easily absorbed and “lost” in the wider (industrial and service-based) economy. However, this explanation should not suggest a level playing field for impact assessment across the regions. Shifts in the derivation and use of ecosystem services – whether within provisioning services or across provisioning to regulating services – will inevitably lead also to shifts and transfers of economic benefits between sectors and individual stakeholders. This occurs even in well-established, broad-based economies such as those in Europe and North America. The current database analysis is prone to limitations that fail to capture these socio-economic impacts for these, and other, regions. For example, the effects of AWIs on the regulating and cultural services tend to be reported only in terms of their state changes, e.g. water resources, soils and biodiversity (Figure 14). The socio-economic impacts that these state changes may lead to are at present underassessed, as these require specific and often laborious valuation studies that are not yet routinely carried out. Moreover, shifts in economic benefit are more meaningfully articulated in

OECD economies when formulated as relative shifts between sectors (i.e. agriculture, fish, nature, water purification, flood protection, etc.), rather than in terms of specific groups of stakeholders within these sectors.

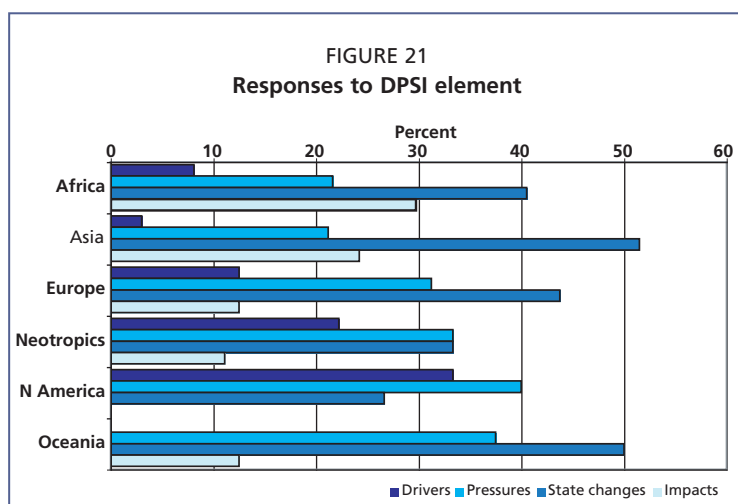
In the database, socio-economic impacts of regulating and cultural services remain underreported and underassessed in terms of gains and losses. Of those impacts reported, the vast majority relate to the obvious, but of limited-impact, category of recreation and tourism (Annex 5, Table A5.7). As an attractive, and high-potential, economic sector this has been one of the first economic sectors to be targeted for the uptake of cultural services. This is reflected in the database, where losses and gains in recreational services are reported by one-fifth to one-third of the cases for Europe, North America and Oceania. However, economically valuable services, such as water purification and flood protection, still remain underreported and underassessed in the case studies, even for OECD countries. Exceptions are those limited cases that are specifically dealing with restoration and exploitation or regulating services (e.g. the Netherlands floodplain case, and the Katskill water purification scheme). Europe lists a negative cultural impact for 45 percent of its cases, which relates to the decline of traditional low-input agricultural practices that are increasingly valued as agro-ecological landscape management options.

RESPONSES

In this section, the response strategies deployed in the cases in the database are analysed in terms of three characteristics: DPSI level addressed; actors; and nature of the response. The grouping and individual categories used elsewhere in this chapter were not applicable. This yields interesting and informative results, but these are prone to limitations as far as the assessment of the DPSIR approach is concerned. By and large, the DPSIR approach has not been applied (as far as is known) in the cases discussed here, but has been retroactively applied in this study on the cases for the purpose of this framework document. As a consequence, the responses deployed in the cases have not been informed by the DPSIR approach but by other various, often not explicit, methods and approaches. Thus, the responses discussed here are likely to be steered by the particular scope, focus and assumptions of these methods.

DPSIR level of responses

Of the responses identified in the database, the majority are directed towards state changes (Figure 21), with responses directed towards the interactions between agriculture–water–ecosystems at wetland sites. For the cases from Asia and Oceania,



state changes account for about half of all responses; for Africa and Asia about two-fifths, and for the Neotropics and North America one-third to one-quarter. Pressures are the second-most frequently addressed category of responses – less so for the cases from Africa and Asia, where pressures account for one-fifth of responses compared with about one-third for all other regions. Drivers are the least addressed but still account for a significant proportion of the responses of the cases from North America

(one-third) and the Neotropics (one-fifth). Impacts are more frequently addressed in Africa and Asia (one-third and one-fifth of responses), where they are targeted at ameliorating or mitigating livelihood effects on the poor.

The focus of responses towards state changes and pressures shows a clear preference to act concretely at the local level where agriculture–water–ecosystem interactions take place within and around the wetlands. In contrast, it might be suggested that a broader approach to responses should be considered addressing all levels in the DPSI analysis more equally. However, this interpretation should be viewed with caution as it does not necessarily follow from a DPSIR approach that multiple responses should be equally spread over the drivers, pressures, state changes and impacts in order to be effective in restoring the sustainable balance of ecosystem services.

Actors responding

Of the responses described in the database, the vast majority are deployed by governments (two-fifths of all responses). (No distinction has been made as to whether these relate to national, provincial or local governments.) The regional disparity of government responses is pronounced (Figure 22). In Europe and Oceania, more than half of listed responses stem from government – which in the case of Europe is as might be expected with the emphasis on EU-based regulations and facilities. For Oceania, the explanation for the high proliferation of government responses also relates to government responsibilities with respect to environmental considerations in Australia and New Zealand. The cases from the Neotropics and North America show a markedly less pronounced dependence on government actions, with one-seventh and one-quarter of responses stemming from governments, respectively. Community responses are the second-most common, and are most prolific in the Oceania and the Neotropics, and to a lesser extent in North America. This is followed closely by NGO responses, which are most prominent in the Neotropics and North America, where they account for about one-quarter of responses. They are notably limited in the Africa and Asia cases, where they account for a one-tenth of responses. From North America, two cases provide a further interesting phenomenon, where responses are deployed by not-for-profit organizations that have been deliberately created to implement responses.

Type of responses

As to the type of responses listed in the database, there is a wide diversity of responses, with 12 types being distinguished (Table 7). However, there is, a discernable preference for responses using technical measures, planning and initiating new policy and legislation – with some regional disparity. Technical measures are predominant in North America, accounting for slightly fewer than half of all responses. Planning is slightly more common among European cases, where also policy and legislative responses are most common – both accounting for about one-quarter of European responses.

The dominance of technical responses is in part a result of the importance of responses directed towards state changes and pressures. However, it raises questions when these technical responses are deployed predominantly by governments, rather

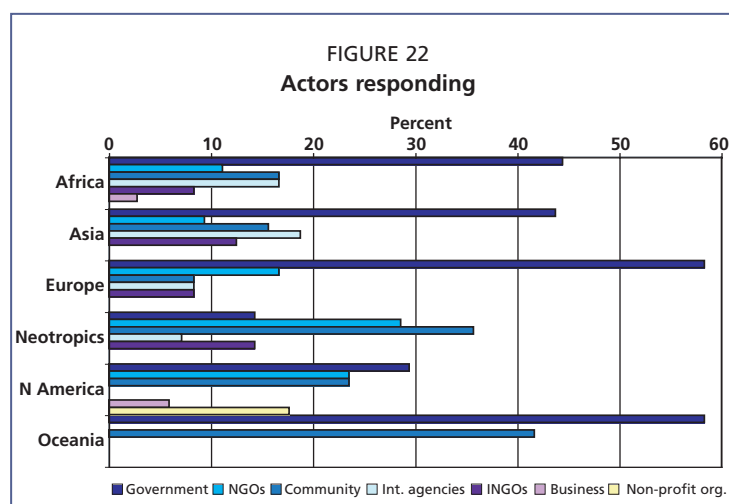


TABLE 7
Type of response as percentage of total responses

Response	All	Africa	Asia	Europe (%)	Neotropics	N. America	Oceania
Policy & legislation	12	12	9	26	8	10	6
Economic diversification	1	2	0	4	0	0	0
PES	1	0	2	0	0	0	0
Legislation enforcement	1	0	2	0	0	0	0
Technical measures	28	27	28	22	23	45	25
Institutional dev. – govt.	5	4	2	0	8	10	13
Planning	19	17	17	26	15	20	19
Monitoring	8	2	15	0	8	5	19
Institutional dev. – comm.	8	13	9	0	8	0	6
Ecotourism development	5	0	7	9	8	10	0
Conservation	8	8	7	13	8	0	13
More dev. & no responses	6	15	2	0	15	0	0
Total	100	100	100	100	100	100	100

than by local-level actors and communities. The failure to distinguish in this DPSIR analysis between the different levels of national, provincial and local governments hinders this analysis as in light of the decentralisation of governance one would expect technical responses to be deployed mostly by the lower levels of government. Nonetheless, the predominance of government involvement in technical responses, even if at the local level, does not fit well with the current policy trends and efforts to disengage governments from executive tasks and concentrate instead on regulatory tasks and facilitating responses. In contrast, the predominance of technical responses in North American cases corroborates well with the predominance of NGOs and communities as the responding actors, which together account for nearly half the responses. The same applies for the Neotropics.

The slight preference for planning responses – as well as monitoring for the cases from Oceania and Asia – fits the predominance of government responses. Planning and monitoring are basic elements of their regulatory tasks, and frequently a prelude to regulation measures and legislation. However, in terms of effectively responding to AWIs and “managing” their state changes, planning and monitoring may also reflect the ongoing search for adequate responses and attempts to grapple with the ensuing state changes rather than being an indicator of coping with the interactions and changes.

DISCUSSION

By and large, the analysis of the cases in the database supports the general trends and conclusions of the MA and CA. It confirms the increasing competition for natural resources stemming from, in particular, increasing demands for provisioning services (e.g. food and agricultural products) that lead to substantial shifts and imbalances in the ecosystem services that wetland systems can sustain and provide. From the database analysis, it is apparent that these shifts are driven primarily by population and natural resources dynamics and market demands for agricultural (food) products. The CA provides a further thorough assessment and projection of how these drivers are set to increase in the next four decades, ultimately leading to a doubling of global food demand (CA, 2007). Whereas for Africa and Asia, population growth and natural resources dynamics (e.g. the ratio population to resources) are still listed as the major drivers, the CA concludes that the highest rise in global food demand in the coming decades will stem from emerging economies changing to richer diets. This demand will primarily be channelled through global and local food markets, which have already been identified in this study as the second-most prominent driver (also in Asia and Africa). In the near future, markets are therefore expected to quickly become the dominant drivers in AWIs.

The premise of both the MA and CA recommendations (as well as future guidelines for the GAWI initiative) is that the effects of these drivers on ecosystem services will need to be attenuated and guided by policy measures. This analysis of the database indicates that there may be scope for such action, as policies are listed as drivers in half or more of the cases – except for Oceania and the Neotropics (where policies are seen much less as driving forces). However, this analysis has failed to differentiate between positive (i.e. towards balance) and negative (i.e. towards further skewing) policy drivers, which could have provided a better sense of which policy measures are more effective, e.g. deploying “positive” policies or abolishing “negative” ones.

However, the significant increases in global and national food commodity prices that have taken place in 2007–08 are a cause for concern. Markets are strong drivers for agricultural expansion and intensification, as supported by this analysis. They have the capacity to transform agrowetland systems and the states of ecosystems in terms of water resources and biodiversity. Thus, they represent a strong driver towards further skewing of the ecosystem services towards exploitation of provisioning services. Policy-makers are inclined to respond rapidly and submit to these, as attested by current food policy debates. The particular concern here is that rapid (market-driven) transformations of agrowetland systems to further expansion and intensification may lead, as in the past, to degradation of ecosystems and their non-provisioning services that may be irreversible or difficult to reverse/restore in future times. On the positive side, the recent price increases in food commodities are expected to lead to substantial increases in investments for the agriculture sector after years of decline (CA, 2007). This may open up opportunities for the development of “good agricultural practices” (GAPs) that have fewer negative impacts on AWIs and the state of ecosystem services. A similar consideration may also come from the rising price of oil and, hence, fertilizer.

As mentioned above, the possible effects of climate change on the often already strained interactions of drivers–pressures–states that feed the exploitation of provisioning services are significantly underreported. For the cases stemming from Africa, the effects are most prominently reported in conditions of none or limited water control (i.e. rainfed agriculture), where decreasing yields owing to the vagaries of rainfall and soil dynamics are prone to further increase the pressures for agricultural expansion and/or intensification in and around wetlands. The CA, and initiatives such as the “green revolution for Africa”, are geared towards this issue by propagating and focusing on improving rainfed agriculture. Securing access to land and water resources to permit investments in these agricultural systems are some of the principal hurdles to overcome, and it remains likely that wetland sites will remain attractive for agriculture as they can ensure adequate water resources.

In the cases of inland seasonal wetlands in Africa (above), the driver combination of population and natural resources dynamics with climate variability often has a distinct temporal character that manifests itself in the “hungry” or dry season. Thus, the subsequent pressures, state changes and impacts primarily shape AWIs during this dry season. In these situations, it is questionable whether technical responses that seek to increase provisioning services from these wetlands during the dry season without further distorting the ecosystem services balance is an approach that can ensure sustainable use and achieve a balance in ecosystem service use. Rather, responses addressing the seasonal impacts through provision of safety nets and diversification of livelihoods would seem much more effective in alleviating and absorbing the pressures on the system and diverting pressures away from wetlands.

In their analysis and recommendations, the MA and CA make a strong case for the need to carefully explore the trade-offs between the different ecosystem services and promote the diversified and multiple use of these services as the way to achieve sustainable use of ecosystems in the future. The DPSIR approach is suitable for exploring these trade-offs and for making them explicit in terms of both socio-

economic impacts as well as state changes that are affecting the ecosystem and the relative balance of its diverse services. However, this analysis shows that the problems of AWIs and ecosystem sustainability are more intricate and intractable in terms of socio-economic impacts, as trade-offs also occur within the provisioning services themselves. This point has also been acknowledged by the CA, but primarily with respect to the particular trade-off between crop production and fisheries. These then become trade-offs between stakeholders in the competition for limited resources and/or specific provisioning services. They frequently feed negative feedback loops when “losers” of livelihoods or losses in subsistence agriculture lead to new pressures for further expansion/intensification of particular provisioning services. Rebalancing the ecosystem services by fostering diversified and multiple uses of these services thereby inevitably becomes burdened with the intractable issue of redistribution of access to resources and derived wealth. The DPSIR framework provides a strong approach for revealing these trade-offs and negative feedback loops, specific to the socio-economic and agro-ecological context to which it is applied. Moreover, it highlights the need to think at which level it is best to cope with trade-offs (i.e. the driver, pressure, state or impact level) when devising a multiple-response strategy. This does not provide any easy answers, but it does underscore the point that socio-economic trade-offs in derived benefits will need more than technical response measures alone.

A weakness of the current dataset of case studies is that, on average, little is done and achieved in terms of valuing non-provisioning services, and how these can be exploited at the state level to result in positive socio-economic impacts and positive impulses to drivers/pressures that advance the rebalancing of ecosystem services. This weakness stems partly from the age of the dataset, which to a large extent pre-dates the work and publications of the MA and CA. The value of cultural and regulating services is still approached in classical terms of intrinsic values of ecosystems/nature or, in general, easily inflated values of total economic value (TEV) that incorporate opportunity costs and externalities that are difficult to assess. However, presenting these as economic reasons for the conservation of nature and the rebalancing of ecosystem services does not lead to the required changes in configurations of drivers, pressures, state changes and impacts. This is illustrated by the few cases (e.g. Netherlands floodplain policy, the Katskill scheme, and the Deschutes River conservancy) where positive drivers and pressures have been configured by establishing concrete economic drivers and pressures in the form of averted economic investments and/or economic incentives derived from regulating and cultural services that are meaningful and beneficial for the stakeholders and sectors involved. Moreover, as the current debate on the global food price increases shows, the TEVs of global or national food security quickly tend to outweigh those of other services in times of perceived crises. The call of both the MA and CA to better value the diverse services that ecosystems offer and to make them economically tangible through diversified management and use is fully supported by this database analysis, which shows a lack of diversification in the use of these services. However, there is also a real need and urgency to concretize these values and means/methods of fruition for the stakeholders and the ecosystem in their socio-economic and agricultural context. The DPSIR approach is eminently suited to facilitating this process as it maps out the complex of drivers, pressures, state changes and socio-economic impacts (both interecosystem and intraecosystem services) to which the values of services and the ways to make them economically valuable need to be applied in order to effect changes towards rebalancing of the ecosystem services (Section II).

Related to the above is the issue of assessing and valuing the biodiversity of ecosystems. As previously mentioned, the cases in the database provide only a general assessment of biodiversity loss, which is not sufficient to guide adequate response strategies. That the loss of biodiversity tends to be a general trade-off as a result of increases in agriculture (through expansion or intensification) is more of a general

truism rather than an insight, especially when considered over longer time spans. Although better qualifications can be made of different degrees of biodiversity loss and their role and function in sustaining supporting, cultural and regulating ecosystem services, such specialized and complex assessments are not captured in this dataset. However, there is a clear need for more precise assessments and diagnosis of the role of biodiversity in sustaining ecosystem services and in defining the ecological character of the ecosystems. In particular, as the drivers and pressures for provisioning services are set to continue to increase, rather than decrease, there is a need to qualify the role of biodiversity in sustaining the ecological character and functioning of ecosystem services, and in specifically identifying the thresholds. This is so that inevitable trade-offs in interactions at the landscape/catchment level between provisioning services and other services can be assessed and dealt with adequately. However, this goes beyond the scope of the present report.

Cases that are explicitly geared towards restoring and revamping regulating services, often in tandem with the revival of cultural services, are relatively few and tend to be limited to the OECD regions. They are based on concretely perceived and valued shortfalls in specific regulating services that tend to be considered and valued for their impacts and trade-offs across sectors rather than stakeholders. This requires specific valuation methods when these services are to be explicitly assessed, rather than intuitively qualified. However, the former are not yet widely applied. Some informative new cases have been found, but no clear impact of these approaches has yet been found in terms of the database analysis.

This database analysis using the DPSIR method suggests that coping with trade-offs in the socio-economic impacts (both intraecosystem and interecosystem services) will require concerted multiple-response strategies specifically geared towards diversifying the exploitation and distribution of derived economic benefits from regulating and cultural services. This will require the deployment of multiple-response strategies at the driver, pressure, state and impact levels that are currently not structurally applied. Too much effort continues to be geared towards technical responses at the state–pressure interface (i.e. agriculture and natural resources management) that are more likely to mitigate negative impacts rather than rebalance the state of ecosystem service. The use of the DPSIR framework on a case-by-case basis (see Section II) will help to broaden the scope and targets for multiple-response strategies, as well as facilitate the assessment of possible negative feedback loops. It will also help in exploring how to appreciate the value of ecosystem regulating services in relation to socio-economic impacts and provisioning services, and so ensure that their economic value is recognized.

Section II

Case studies

This section elaborates on the summary analysis of Chapter 3 through the detailed exploration of five different types of AWIs. It shows the value of the DPSIR and ecosystem concepts for undertaking the necessary analysis to identify appropriate responses. It is not possible to be comprehensive in this section in terms of the AWIs covered. Rather, specific interaction situations that occur repeatedly have been identified. From these, particular example cases have been chosen where a high level of information was available. While the analysis in each chapter focuses on one specific case, material from similar cases in the case database is included (in boxes) to reinforce particular points.

Chapter 4

Small swamp wetlands in southwest Ethiopia

The case study reviewed in detail in this chapter as an example of the DPSIR analysis concerns the shallow permanent swamps in the semi-forested part of Illubabor Zone in the western highlands of Ethiopia. These are drained for dry-season cultivation of maize, but extended drainage is practised in some cases to permit double-cropping. Cultivation of these wetlands has a long history with reports dating back to the mid-nineteenth century, and pollen analysis suggesting a much longer history of use (McCann, 1995; Wood, Rushworth and Corr, 2005). Similar cases are presented in Box 2.

DRIVERS

The drivers in the Illubabor situation are seasonal food deficits (owing to poor crop storage and erratic harvests caused by rainfall variations) and a shortage of cleared land for upland cereal cultivation (owing to coffee expansion and population growth, the latter being partly a result of in-migration and resettlement). Upland agricultural land shortages have also occurred as a result of land degradation. These drivers have led to the search for supplementary food production and income-generating opportunities by the poor as a survival strategy, especially by using wetlands to produce crops in the dry part of the year and so overcome the “hungry” season. However, among the better-off households, cultivation of wetlands is more in response to market opportunities, which may reflect rural food shortages, but also urban demands from the growing “coffee towns”. For these farmers, this is likely to be part of an income or enterprise portfolio diversification strategy.

Government food security policies also act as drivers through local pressures that encourage, or require, communities to expand wetlands cultivation. This is to reduce food imports into this zone, which has an overall food deficit owing to the focus on cash crop production, namely coffee. Moreover, modernization in the form of

BOX 2

Similar cases from other countries

The Illubabor case has similarities in terms of the DPSIR analysis with a number of others in the database, such as: the permanent inland valley swamps (IVSs) of Sierra Leone, with flood recession rice cultivation; the Nakivumbo wetland on the edge of Kampala, where sweet potatoes, bananas and vegetables are the most important crops; and the Craigieburn wetland in South Africa, which is primarily used for subsistence farming. Other similar cases in the database are: the seasonally flooded stream valleys, or fadamas, of northern Nigeria, where vegetables are grown; the seasonal valley wetlands / stream floodplains of Simlemba, in central Malawi, where maize and vegetables are the main crops; and two cases of seasonal wetlands in drier areas – the bas-fonds of Burkina Faso and the wadis of Kordofan in the Sudan. Small inland swamps are also used for agriculture in Papua New Guinea, in Mexico and in South Asia, with various development-related pressures (Annex 3).

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BOX 3

Common and diverse drivers of wetland agriculture in Africa

In African countries, population growth and land shortage are the most common drivers that lead to wetland cultivation (Chapter 3). This has led to wetlands, especially small ones that can be cultivated without major technological innovations, becoming probably the “new agricultural frontier” for small-scale subsistence farmers. This trend is often intensified by land degradation in rainfed upland fields and rainfall variability, which lead to declining and less reliable harvests (Malawi and Zambia). However, in some cases, local population growth is the result of government resettlement policies (South Africa and Ethiopia) and population relocation due to conflict (Sierra Leone), while population growth can be seen as the result of failed development policies.

Market forces are the other major driver of wetland cultivation in Africa. The growing urban centres are a major stimulus for vegetable cultivation and some cereals. Specific government policies have supported such cultivation, such as the subsidies on wheat-growing in northern Nigeria, and encouragement of rice production in Sierra Leone and other West African countries through government and regional policies (Inland Valley Consortium, West Africa Rice Development Association, 1997).

an increased need for cash for purchases, school fees, taxes, etc. is often reported as part of the combination of drivers operating in this area.

Other drivers in this situation (Box 3) include development policies (which have failed to reduce rural poverty) and the macro development situation (which has led to rapid population growth), while the lack of tenure security contributes to long-term land degradation. Variable weather patterns (increasingly linked to climate change, but possibly also to forest clearance and the associated loss of climatic moderation) have also played a role, leading to the increased incidence of upland harvest failure in recent decades.

Some drivers have operated only at specific periods. These have included the 1975 land reform process, which led to wetland being divided up among the community, with farmers required to cultivate these plots in order to retain access to them.

Moreover, in the early 1970s, the collapse of seasonal coffee-picking income (as a result of coffee berry disease) provided a short-term stimulus to wetland cultivation for households needing to replace their coffee-picking income by growing more food during the dry season.

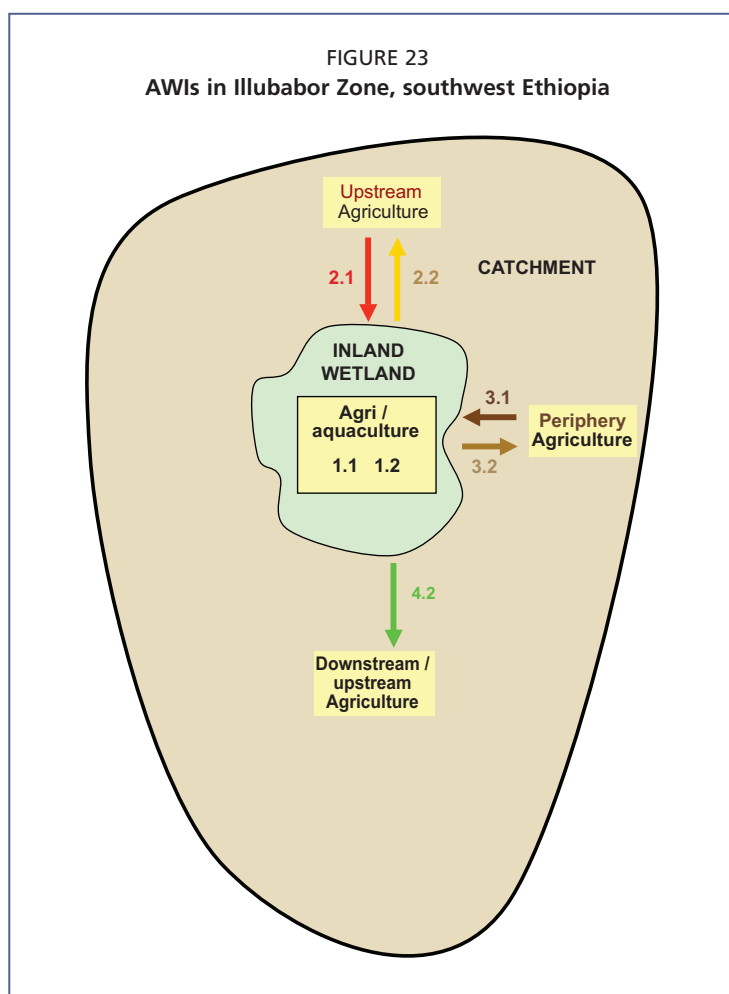
Finally, some facilitating factors have influenced the impact of these drivers on wetland agriculture. They include various wetland technology developments, including specific drainage methods developed in the first half of the twentieth century, and the introduction of short-season maize varieties in the 1980s. Another facilitating factor has been the existence, in some locations, of community institutions that have coordinated the management of the wetlands (Wood *et al.*, 2002).

PRESSURES

The pressures faced by swamp wetlands in southwest Ethiopia are primarily agricultural expansion and intensification, both linked to water management in the form of drainage. In most cases, drainage is for six months. However, in some instances, it lasts for eight to ten months to allow double-cropping, which increases the pressures on the wetland environment. This longer drainage is often associated with a “drying out” process in wetlands and degradation of the resource base. However, in some wetlands, farmers reduce the environmental pressures by practising ditch blocking after the cultivation season and try to maintain the natural flooding regime to help recover soil fertility through sediment retention. In cases of severe soil fertility loss, they will abandon cultivation for a number of years and allow the regeneration of the natural sedge vegetation in order to recover soil fertility (Dixon, 2003).

Agriculture in the wetlands also leads to the clearance of the natural vegetation. However, this is not always complete because sedge vegetation is valued as a construction material, and in some cases it is retained at the head of the wetlands to store water and at the outlet to control erosion. Such down-cutting and the formation of gullies in wetlands often occurs where there is soil compaction in the wetland owing to cattle grazing, and when the natural vegetation has been removed at the outlet. Cultivation also creates pressures through the disturbance of soil, while different pressures from grazing on the vegetation and soil can affect biodiversity. Some pressures in the wetland may also come from changes in the catchment, with poor agricultural practices in these upland areas leading to rapid runoff, which causes sediment deposition and erosion in the wetland.

The direction and location of interactions that lead to these pressures are shown in Figure 23.



STATE CHANGES

The changes in the state of the wetland environment as a result of *in situ* agricultural development are seen in the hydrology, soils and biodiversity within the wetland (Wood and Dixon, 2002). Overall, these lead to poorer regulating and support services.

The major state change is the lowered water table in the swamps in the dry season as a result of drainage to permit maize cultivation. The lowered water table and reduced dry-season storage of water in the wetlands leads to reduced dry-season flow and may alter the flood regime, with the drained wetlands needing to be recharged first in the rainy season before the flood progresses downstream.

Cultivation in the wetlands leads to an increase in soil acidity owing to drainage. There is also evidence of declining soil fertility as a result of prolonged cultivation and of reduced organic matter content, which reduces dry-season water storage when cultivation is taking place. (This is consistent with the Africa results in Chapter 3). The other major change in wetland soils is compaction, which usually results from grazing pressures. In turn, this may affect water infiltration into wetland soils and sediments, increase runoff and erosion, and possibly reduce groundwater recharge in the flood season. Wetland soils are also affected in limited areas by the deposition of coarse sediments from upland erosion, thereby altering soil quality and their suitability for cultivation.

As mentioned in connection with pressures, agriculture in wetlands, but also in uplands near wetlands, may lead to the development of erosion features, especially

gullies. This is usually caused by increased runoff from the uplands and possibly also in the wetland (owing to vegetation clearance).

Major biodiversity changes also occur in these wetlands as a result of agriculture causing the loss of habitat for wildlife (Wood and Dixon, 2002). There is often an invasion by dryland species of weeds into wetlands once these areas are cultivated, while the changed vegetation may reduce the buffering role of the wetlands in moderating peak flows. Fish have not been reported in these wetlands by farmers, nor have wildlife (with the exception of baboons and wild pigs, which are attracted to the maize fields) and some important birds, such as black crowned cranes and egrets.

When combined, these various state changes, especially in hydrology and soils, can undermine the ability of the wetlands to sustain crop production. In some cases, wetlands degrade to rough dry-season grazing within a few years of cultivation. However, in other cases, with careful management, some are reported to have been cultivated annually for more than 80 years (Dixon and Wood, 2003). The detailed state changes in the hydrology and the regulating services of the wetlands are little known. However, where wetlands are being destroyed completely, there are reported to be more extreme high and low flows as the moderating role of the wetlands is lost.

BOX 4

Conflicts resulting from wetland agriculture in Africa

Because wetlands provide multiple provisioning services, their development for agriculture alone often leads to the displacement of other users from these areas. This can result in conflicts. A common occurrence in a number of case studies is the way pastoralists, who rely on wetlands for grazing, have lost access to critical dry-season feed for their animals. This has been the case with the Fulani in northern Nigeria as the fadamas have been developed for small-scale agriculture (Turner, 1984, 1989), and the Afar in the Awash Valley in Ethiopia as large estates were developed for cotton production in the 1960s (Bondestam, 1974). In the latter case, this led to hunger and widespread livestock and human mortality.

It is often the poorer groups in society who suffer from agricultural development in wetlands. Examples include those who collect medicinal plants in the bas fonds of Burkina Faso, and fishing groups in the fadamas of northern Nigeria and the inland valleys of Sierra Leone. In northern Nigeria, pump irrigation for upland wheat cultivation by richer farmers has lowered the water table in the fadamas beyond that accessible to the rest of the community using shallow wells (Kimmage, 1991).

More widespread disturbance may occur, as in the wadis of Kordofan, where the decline in small business and trading centres and a general collapse in the economic well-being of communities is a result of agricultural decline following the overexploitation of these seasonal wetlands.

IMPACTS

The major positive socio-economic impact is an increase in the provisioning services generated from these wetlands as a result of dry-season agriculture. These benefits are mostly in the form of improved food security and/or increased cash income. The improved food security relates partly to the poor in the rural communities whose wetland farming is mostly for domestic use, but also to the better-off farmers whose production from these wetlands is for urban and rural markets, the income from which increases their accumulation of wealth. In addition, some poorer rural dwellers benefit from daily employment as labourers on the wetland plots of the richer farmers. From the government perspective, the reduced food imports into the zone, especially for feeding the urban population, are seen as positive.

In contrast, there are a number of negative socio-economic impacts related to the cultivation of the wetlands (Box 4). The most widespread of these is the disruption of other provisioning services by agricultural expansion. For example, the expansion of

cultivation disrupts other uses of wetlands, such as the supply of domestic water, seasonal grazing, and the collection of medicinal plants for domestic use, and sedges for thatching and craft use. In particular, the loss of springs (owing to the lowering of the water table) has considerable implications as it tends to increase the workload of women and so affects child care and child health, while the use of alternative, less clean and less reliable water sources affects health negatively (Wood, 2001).

Despite the equality sought by the land reform measures, the major group involved in wetland agriculture is the better-off because they are endowed with the necessary resources, such as oxen and labour, to be successful in this enterprise. The poor do not have the resources to prepare wetlands, and may not have the time to wait for such supplementary harvests as they require immediate cash income from daily labouring. As a result, wetland agriculture is associated with increased differentiation, with the rich becoming richer and the poor losing some of their wetland sources of income, e.g. plant collection (Mulugeta, 2004).

RESPONSES

In the Illubabor situation, diverse responses have been developed in different periods. The major view of the government agencies in the 1980s and 1990s was one of continued, or increased, encouragement of wetland cultivation because of its contribution to food security, with little or no attention being given to the problems associated with the pressures, state changes and negative impacts. This has begun to change at local-government level as a result of the findings of a research project and the dissemination of those findings by a local NGO. However, national policy still supports the search for food security at all costs, with fuller use of the country's natural resources being sought in order to increase food production and economic development.

Because of the long history of wetland use in this area, a number of community-based adaptive management and technical practices have been developed. Both in the past and more recently, local community institutions for the management of the wetlands have been developed. These have coordinated use to prevent excessive drainage and to limit wetland erosion (Dixon and Wood, 2007). Wetland farmers have experimented to develop their own technologies, such as ditch blocking and spring protection. These have also fed into the by-laws of the community institutions that help to limit the negative effects of wetland farming and to encourage the use of specific practices (Dixon, 2003). In addition, there is some recognition of the value of a mix of land uses within the wetlands in order to prevent the overdevelopment of provisioning services in the wetlands and excessive drainage, which lead to negative state changes and reduced regulating services. However, even in this small area, such positive experience is patchy and varies from community to community.

These local responses have been identified by a local NGO (above) that is consolidating them into a set of guidelines for local dissemination among wetland-using communities and for discussion with local government staff. This has included discussion of the need for GAPs in the catchment, including soil and water conservation measures, to increase upland yields, and so reduce demands on the wetlands, while also improving water storage in the uplands and preventing sediment deposition in the wetlands.

THE VALUE OF THE DPSIR ANALYSIS IN ILLUBABOR

This DPSIR analysis of the situation in Illubabor Zone (Figure 24) shows that the responses to date are primarily at community and NGO level. Because of this, the focus is on reducing some of the pressures (e.g. excessive drainage) and negative state changes (e.g. soil degradation and compaction) in order to maintain the provisioning benefits of the wetlands. These responses involve both technical measures (local-level water management and land use), and institutional ones (community organization).

Comparing these responses with the DPSIR analysis, it is clear that responses are also needed in other areas, especially to address some of the drivers that are currently being ignored. In particular, responses are needed at the national policy level in order to address issues such as resettlement, security of land tenure (which affects upland and wetland management), rural income diversification, and the methods for achieving the national food security goal.

In addition, there may be further considerations at local-government and NGO level that relate to the greater technical advice for wetland management. These include crop choices that create less pressure owing to reduced drainage needs, as well as improved storage of upland crops (which would reduce the hungry season for farmers). Broader rural development measures that improve incomes and economic security could also reduce pressures to cultivate wetlands.

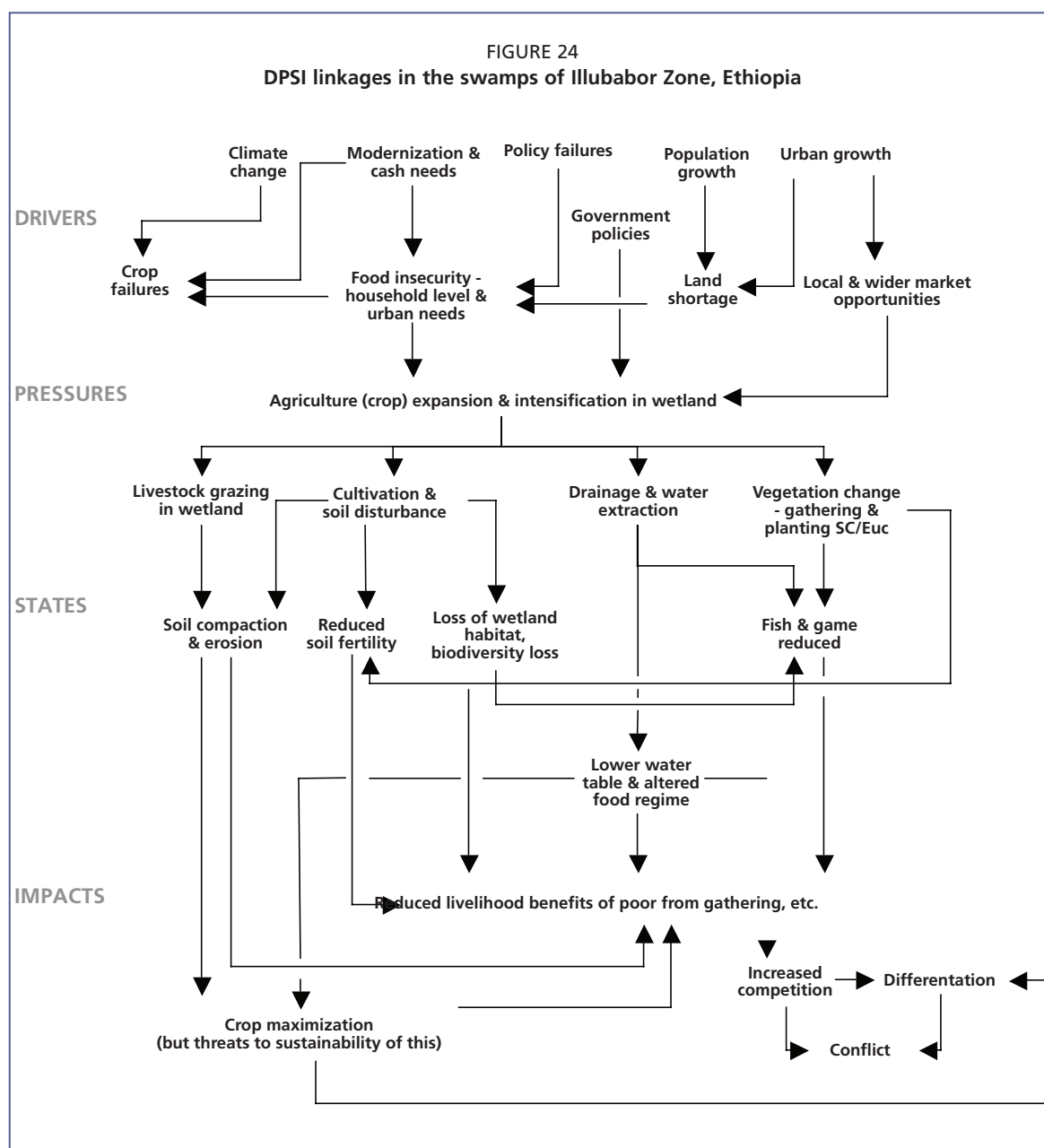
Looking beyond this specific DPSIR analysis to other experiences identified in this report, and recognizing some upcoming developments in Ethiopia, it may be possible to link wetland management to the proposed Baro-Akobo integrated catchment management pilot project (which the Nile Basin Initiative is developing for this area) and to the Baro-Akobo River Basin Commission (which the Government of Ethiopia has recently declared it will establish). These both provide the opportunity to explore the role of basinwide strategic land-use planning and hydrological management, and especially focus on sound catchment management and a more balanced view of the ecosystem services provided by the wetlands. Payment for environmental services might also be possible in order to increase recognition of the value of regulating services, especially hydrological and sediment trapping, provided by wetlands in the upper basin that could benefit hydropower and irrigation developments lower down the river system. This could see an increase in the mixed land use in wetlands, which would improve the sustainability of provisioning services at the same time as enhancing regulating services. Hence, further lobbying of the state may be required from the local NGO and other advisory groups in order to ensure that the wider benefits provided by wetlands are recognized and appropriate policies developed.

WIDER CONSIDERATIONS

A major concern from the experience analysed above (and also found in other developing country cases in the database) is the way drivers such as poverty, food insecurity and population growth, create pressures in wetlands that lead to changes in their environmental state and regulating services. In turn, these threaten the sustainability of positive provisioning service impacts (Figure 24). This involves regulating services being affected negatively, mostly by hydrological alterations and vegetation change, while provisioning services are affected primarily by changes in soil characteristics, erosion and some aspects of hydrological change. Moreover, the loss of small wetlands in the upper parts of river basins can have cumulative effects on the hydrological regime lower down the basin, with increased extreme flow events, floods and low flows, as the regulating ecosystem services are lost in those wetlands.

The DPSIR analysis helps identify the process leading to these negative developments. It also identifies specific areas where attention is needed in order to achieve a better balance of provisioning and regulating services, one that will maintain the ability of the wetlands to provide livelihood support and ecosystem services.

In some cases, these interventions may be *in situ*, within the wetland, and involve considering changes in crop choice and limitations on the transformation of the wetlands in order to ensure successful and sustainable cultivation. This could mean replacing maize with rice in some cases so that agriculture “rides with nature” rather than requiring its transformation – an ecoagriculture approach (although food preferences may be an issue in dietary changes). Further steps in this direction might involve the use of natural vegetation fallows, with *Cyperus latifolius* in permanent



wetlands. A third *in situ* consideration could be to change the agricultural practices in order to reduce negative impacts through the use of conservation farming methods, including mulching, and possibly rainwater harvesting. Overall, these changes would reduce the pressures on regulating and support services from wetland agriculture, bringing the level of state changes below that required for sustainability and resilience while still meeting the provisioning/livelihood needs. In many of these cases, there would be trade-offs between provisioning and regulating services, with the former reduced in order to ensure that the latter can continue.

Where there is an overall reduction in agricultural output in order to re-establish a balance between provisioning and regulating ecosystem services, there is a need to supplement the incomes of wetland cultivators whose farming is restricted. This would have to involve exploring other provisioning services that could be developed, especially where their impact on the wetland is minimal. In this situation, fishing, craft material collection and income derived from cultural or environmental services (such as

ecotourism) should be considered as they would not require alteration of the wetland ecosystem and could benefit from enhancing or regenerating the wetland environment. Alternatively, a wider perspective should be taken, looking outside the wetland at other income-generating and diversifying opportunities. This would require consideration of appropriate policies in terms of rural development, population growth, and non-farm incomes.

Basinwide or catchment approaches that could help improve wetland functioning, especially regulating services, include improved catchment management through soil and water conservation, and GAPs. This could increase the water infiltration and storage for dry-season flows from those areas and reduce sedimentation problems in wetlands. Payment for environmental services, which have to be based on catchment-wide functioning, is another area where activities could be developed. This would help address some of the trade-off costs, such as extended fallow periods, arising from changes in wetland site management and achieve improved regulating services.

Socio-economic elements may also need to be considered with the wetland management changes discussed above, as institutional development may be necessary in order to address some of the related challenges through the development of different forms of wetland and catchment management groups. However, such institutions will need higher-level support, especially government acceptance, if they are to be effective (Dixon and Wood, 2007). Such institutional development may also be able to address some of the conflict and differentiation problems reported, as well as livelihood diversification to reduce pressures on wetlands (Adey, 2007).

CONCLUSIONS

The experience in the Illubabor wetlands in Ethiopia and in others sites facing growing pressures from population growth, poverty and food insecurity, shows that raising awareness of the linkage between maintaining regulating and support ecosystem services alongside provisioning ecosystem services is the most essential and critical challenge. Once this awareness of this interaction and its potential negative consequences has been raised, there is a need to look at technical measures for ensuring GAPs that need to be followed in both the wetland and the catchments, and also to address the institutional arrangements and incentives for their implementation. Interventions will involve not only technical and institutional activities in specific wetland sites to address pressures and state changes. More widely, at the basin level, they will entail policy measures to address drivers nationally, e.g. with effective development approaches to reduce rural poverty. Hence, a multilevel approach is needed that will address drivers, pressures, state changes and impacts through specific actions at the appropriate level.

Chapter 5

Revitalizing regulating services: the Netherlands floodplain policy

This chapter discusses the dynamics and interactions that govern AWIs in the river floodplains of the Netherlands, with specific reference to how these have been incorporated into the Netherlands floodplain policy. In addition, case material from other floodplains and river valleys in Europe is briefly discussed where relevant. The state (changes) of these agro-ecological systems in Europe, and in particular within the EU, are currently at a stage where rebalancing the ecosystem services is being sought, and increasingly explicit attention is being given to revitalizing the regulating, cultural and supporting services *vis-à-vis* the predominantly agricultural provisioning services. This is influenced strongly by the common policy and regulation context of the EU, which includes the Common Agricultural Policy (CAP), the Water Framework Directive (WFD), the Birds and Habitat Directives (BHD) (including its resulting Natura 2000 network). These are increasingly informed by the concepts and notions of environmental sustainability, ecosystems and biodiversity. Because these cases differ significantly in their economic contexts (as well as their ecological settings in some cases), it is necessary to discuss them separately in order to explore their context-specific DPSIR configurations.

FLOODPLAIN CASES FROM EUROPE

The database contains four cases dealing with river floodplains in Europe, each of which deals with issues of retaining or revamping the regulating services, in particular flood protection. Although they are all floodplains in Europe with EU policy influences and with many similar DPSIR elements, there are also some major differences. Therefore, the case of the Netherlands floodplain policy is chosen as the central case study of this chapter, while the other cases studies will serve to highlight similarities and differences where appropriate.

The cases of the Netherlands floodplain policy and the middle Sava River in Croatia (Box 5) are ecologically similar in that they have seasonal floodplains that have been historically attractive for agriculture but are increasingly valued for their flood protection functions. The cases of the Drentse Aa River (the Netherlands) and the Biebrza valley (Poland) have similar agro-ecological settings, with peat meadows in which the established ecological landscape and character is highly dependent on the continuation of active grazing and management of the meadows. Economically, the Netherlands cases represent a setting of high economic wealth wherein agriculture has been shaped by past EU policies and agricultural price regulations that have favoured highly intensive and consolidated agriculture. On the other hand, the cases of Poland and Croatia are in less affluent settings where agriculture has been shaped by the past policies of eastern European regimes and the continued use of common grazing

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BOX 5

Flood retention in the middle Sava River

The floodplains of the middle Sava River (Croatia) contrast sharply with the Netherlands context. The Sava floodplains have been characterized by less-intensive agricultural development based on extensive and seasonal grazing of livestock on the pasture commons of the floodplains (Zingstra, 2005). The low-intensity pasture use effectively maintained the agro-ecological landscape of seasonal meadows, shrubs and forests, and supported a specific floodplain flora and fauna, rich in biodiversity and with important bird habitats. With the transition of the Croatian economy to a market-based economy, this agro-ecological floodplain system was threatened. National land privatization policies jeopardized the traditional use of the Sava floodplains for grazing as the local small farm households could not afford to purchase the privatized lands. For the Sava floodplains, this was deemed undesirable as increasing national and international recognition was being given to their value in regulating services (flood protection) and supporting services (biodiversity and specific bird habitats). This prompted the Government of Croatia to designate the middle Sava River for flood retention. This has also been beneficial for the protection of biodiversity, with farmers able to continue their traditional grazing practices of the commons that are adapted to the seasonal flooding. With the upcoming accession of Croatia to the EU, this agro-ecological landscape for flood retention and biodiversity can be supported through the CAP and other EU agri-environmental programmes.

grounds¹¹, but is now subject to a new set of regulations, norms and values with their entry into the EU.

Figure 25 shows the nature of the AWIs in these wetlands.

The common EU policy context

The CAP of the EU has influenced and encouraged the expansion, intensification and extensification of agriculture. In particular, for the Netherlands cases, this has been characterized by a progressive intensification and consolidation of agriculture in an ever-diminishing number of farms of ever-higher levels of specialization and productivity. Since the period of EU-supported overproduction in the mid-1980s and the expansion of the EU into southern and eastern Europe thereafter, financial and political pressures have been mounting to reform the CAP. The thrust of this reform has been to move away from direct production incentives / price guarantees to income support, with a gradually increasing role for wider concerns of rural agro-ecological landscape

management, resulting especially in the second pillar (rural development) in the Agenda 2000 CAP reform. With the introduction of production limits and the first partial reform of the CAP from production-based to area-based subsidies, started in the early 1990s, the incentives for maximized intensive production have gradually diminished. Milk quotas, relevant for the predominant dairy farming in Netherlands river forelands, were introduced even earlier, namely in 1984. The introduction of obligatory agri-environmental programmes under the CAP in the MacSharry reform was also important. This promoted the nature and biodiversity values and services in rural landscapes. Finally, in the Netherlands situation, a government-supported programme of land acquisition for nature conservation purposes (partly cofunded from EU rural development funds) has also been influential in increasing biodiversity and nature values/services in the rural landscape.

The importance of environmental sustainability and ecological conservation and restoration has been increasingly reflected within EU policies and regulations at about the same time as agricultural policies have changed. Such concerns have culminated in directives, in particular the BHD – resulting in, inter alia, the ecological network Natura 2000 and the restoration of the environmental/ecological state of waterbodies under the WFD as well as the above-mentioned agri-environmental programmes, later supplemented

¹¹ In Poland and former Yugoslavia, about three-quarters of the farmland was never collectivized in state or cooperative farms.

by other environment-oriented rural development measures (including Natura 2000 payments). These have provided additional policy and financial incentives for nature conservation on farmland, and, to a lesser extent (but relevant in the river regions), measures to re-shape the agro-ecological landscape through active ecosystem restoration and management, thereby increasing regulating, cultural and support services.

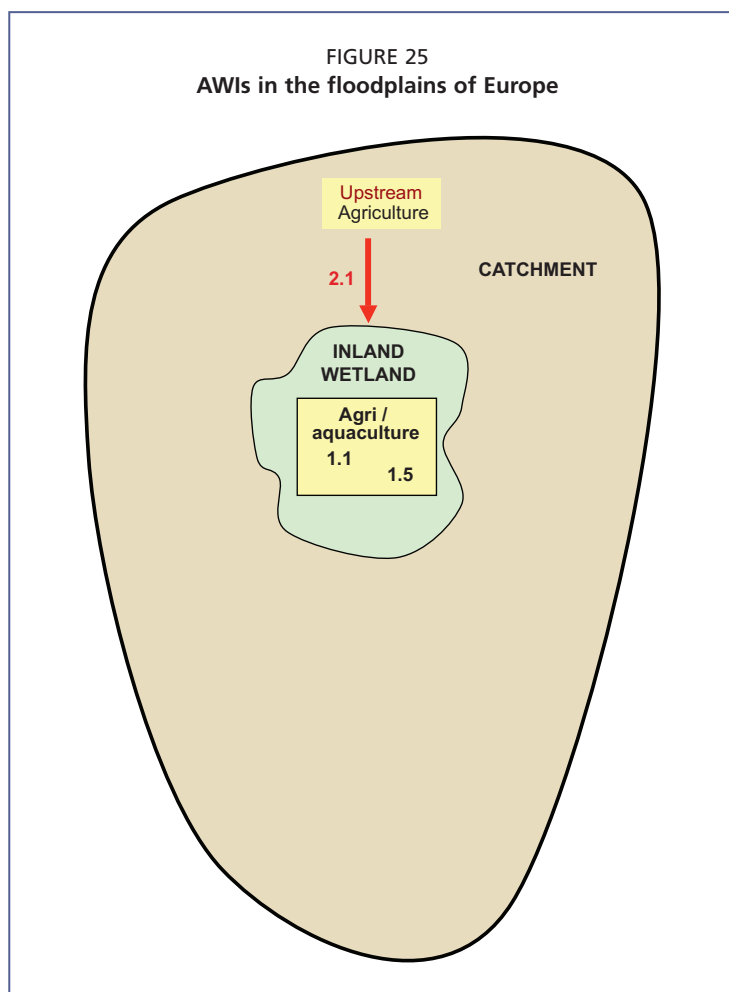
Apart from agricultural intensification, clay and sand extraction has also been a significant pressure on the floodplains in the past. These mineral extractions lead to significant state changes in the floodplain landscape, by leaving behind deep lakes or transforming mined pits to agricultural use, thus affecting the riverine flora considerably. However, there are examples of how the new “nature development” approach as supported by the EU reforms can, with some additional interventions (creating new shallow wetlands and higher places), result in valuable nature areas, although of a different nature than the original river foreland.

These shifts in the policy and regulation framework of the EU have cleared the way for increased recognition of the value of the multifunctionality of these agro-ecological landscapes, and the natural resources therein, as well as the scope of these areas for multiple uses. A functional approach to highly intensive and productive agriculture is still present and applied to a core segment of the agriculture sector and landscape that is geared towards optimizing their specific provisioning services. However, this is being increasingly supplemented by a multiple-use approach to the management of the wider agro-ecological landscape in which the regulating, supporting and cultural services are explicitly valued and supported. Within the latter, agriculture is seen and presented as a potential custodian of the natural and cultural agro-ecological landscape that can secure and maintain biodiversity and specific habitats, as well as provide recreational and cultural services.

The rebalancing of ecosystem services is induced on two fronts:

- by regulating the negative impacts of high-production agriculture, in particular for basin-level interactions (e.g. the strict nitrate budgets in livestock rearing as regulated by the Nitrates Directive);
- by providing support and financial incentives for pre-defined restrictions/conditions on *in situ* agriculture in the floodplain so as to support the regulating and supporting service of the agro-ecological landscape (e.g. biodiversity and habitat payments as provided by the agri-environmental programmes, Natura 2000 and the rural development pillar of the CAP).

FIGURE 25
AWIs in the floodplains of Europe



River floodplains and revitalization of flood retention capacity

River floodplains have long been attractive for agriculture owing to the seasonal deposition of rich clay soils. Along large tracts, dykes and dams have been built to improve the conditions for agriculture and to protect cities and towns from flooding. This has restricted the extent of the flooding during periods of high river discharge to an ever-narrowing strip along the river – especially in the case of the Netherlands floodplains.

The case of the Netherlands floodplain policy provides a valid example of rebalancing the ecosystem services around a specific and purposeful hydrological function, namely protection against flooding. This represents a marked turnaround in the floodplain land-use strategies of the Netherlands compared with previous decades. The basic principle underlying this change was the need to base land and resources use planning of the river floodplains on their regulating service for flood protection instead of their provisioning services for agriculture and urbanization. This was in the financial interest of the Government of the Netherlands as it averted investment costs. The extreme peak river flows of the spring of 1995, which led to a serious risk of flooding in the river polders in central and southern Netherlands, some of which were completely evacuated, brought to the fore the serious limitations of the river dykes. The first and immediate reaction to this crisis was that the river dyke system was in urgent need of a new complete overhaul (i.e. stronger and higher dykes), as had been implemented in previous decades. With strengthening works underway on the weakest sections and as the national plans to overhaul all dykes started to emerge, it quickly became apparent that the Government was facing major investment costs for decades to come – just as with the delta works against the sea that were nearing completion at that time.

Within the agriculture sector, the revision of the EU–CAP system initiated in 1991/92 (with the aim of limiting overproduction) started to be felt around this time. Where the EU production policies had earlier stimulated pressures for agricultural colonization, building of polders and intensification, the reduction in overproduction was being translated into drivers and pressures to reduce and consolidate the sector. For non-intensified agriculture, attention shifted more towards the multifunctionality of agriculture, with farmers becoming managers of the landscape and keepers of the rural and environmental patrimony.

The emergence of the new Netherlands floodplain policy, with the need to provide for increased flood protection by means of restoring the river floodplains and increasing the peak flow capacity within the outer (or winter) dykes, coincided with the turnaround in agricultural and environmental policies. Increasing the peak flow capacity could be achieved relatively easily and cheaply (when compared with revamping the dyke infrastructure) by actively restoring the floodplains through hydrological landscaping, and limiting and relocating agriculture and urbanization to non-flood intrusive conditions (i.e. low-flow summer agriculture). In addition, the reshaping of floodplains (and sometimes creating new ones) was ideal for restoring wetlands, with which the increasing demands for nature and recreation in Netherlands society could be met, while also meeting the requirements of EU environmental directives.

Thus, from both a broad agricultural interest (not necessarily at the individual farm level) and flood protection perspective, the reshaping of the floodplains could be initiated, and affected farmers compensated or bought out through funds made available from agricultural policy reforms, environmental policies, and averted flood protection investment costs. The result was to encourage them to change their practices towards flood-friendly agriculture or cease their activities in the floodplains. In addition, stricter restrictions were put in place and enforced in order to curb the encroachment of urbanization into the floodplains. For example, in designated flood areas, houses (and farms) are being relocated to higher ground or, as in innovative showcases, floating houses are permitted as “urban waterfronts”.

DRIVERS

The national and EU policies with regard to agricultural and flood protection helped to shape the intensive use of the river floodplains and their adjacent polders in the river landscape of central Netherlands. By the late twentieth century, this had culminated in a situation where the floodplains and polders were: (i) intensively shaped and used by high-production agriculture; (ii) an elaborate network of flood protection works of inner and outer dykes and polders; and (iii) facing continued pressure from urban expansion to further encroach upon the floodplains. The near flood crisis of 1995 brought to public attention the fact that the river peak discharges were being enhanced by urbanization in the Netherlands as well as by land-use practices in upstream riparian countries. In addition, it was recognized that flood crises would increase in the future as a consequence of higher intensity rainfall induced by climate change.

PRESSURES

For several decades before the 1990s, the principle pressures on the floodplains were those associated with the progressive restrictions of the flood retention capacity owing to hydrological management. The flood protection works were aimed at training the rivers into restricted summer (low-flow) and winter (peak-flow) beds. The prime drivers for these actions were: (i) protecting and enabling agricultural expansion and intensification; (ii) securing navigation (not considered further in this chapter); and (iii) protecting urban dwellings and centres. The high peak flows of 1995, which mainly originated from the upstream riparian countries, led to serious flood risks with extreme high water levels within the outer dykes. With this, flood risks became an eminent pressure.

STATE CHANGES

The state changes in the floodplains were characterized by a skewed exploitation of the provisioning services, in particular with regard to facilitating a highly intensive agriculture. The flood protection approach was based on an engineered water control concept that had been developed to enable agriculture, urbanization and navigation. Rather than assimilating the regulating services of flood retention, the flood protection works had gradually but increasingly sought to replace these services and functions by engineered works. The flood crisis of 1995 made it clear that the available flood retention capacity of these engineered works was no longer adequate to cope with the changing and increasing river peak discharge regimes. As a nuance: the floodplains situated between the inner and outer dykes always were part of the flood protection network. However, these became characterized by summer uses as meadows, nature and recreation areas, and increasingly subject to pressures from urbanization and further contraction. As became apparent in the spring of 1995, these pressures were not sufficiently restricted and regulated in terms of enhancing their flood retention capacity. River forelands were dominated by species-rich semi-natural grasslands until about the 1970s. These were often of great botanical importance, also because of the location in a special flora district, connected with Central Europe. Owing to the location in the river foreland, grassland farming was still less intensive than beyond the dykes. By progressive intensification of farming, almost all semi-natural grassland outside nature reserves (including those created in the 1970s and 1980s) disappeared from private farmland. By 1990, 1.5–2 percent of the floodplain system (about 500 ha) was still covered by such grasslands (Dijk, 1991), the main cause of the decline being fertilization. Since the 1990s, new projects to enhance nature values have had several purposes, including the restoration of grasslands, wetlands and riverine forest. Broader than the traditional conservation of semi-natural landscapes, this approach was the result of a new thinking on “nature development”, which became an important pillar of the new Netherlands Nature Policy Plan (1990).

IMPACTS

Two major impacts have informed the different multiple-response strategies that have enabled the turnaround in the Netherlands floodplain policy. Agricultural intensification as fostered by EU agricultural policies culminated in a highly intensive and productive agriculture sector, which by the mid-1980s had led to an EU-wide overproduction. The handling of this overproduction was becoming an economic burden on the CAP that was based on providing price guarantees to farmers. Moreover, the associated state changes from intensified agriculture, in terms of the loss of biodiversity (as a consequence of past colonization and intensification of grassland exploitation) and the pollution burdens of nitrate and water pollution, became regarded as problematic and undesirable. At the same time, the new nature development philosophy, soon followed by corresponding policy (above), became an important driver for new developments that jointly served water management and nature values. The second impact is firmly associated with the restricted flood retention capacity of the floodplains. Increasing the flood retention capacity and securing flood protection by means of revamping the dykes presented government and society of the Netherlands with huge investment costs for years to come.

RESPONSES

The responses to these diverse drivers, pressures, state changes and impacts have been multiple, and they have been embedded in two separate response strategies that have converged over time. The first response strategy has been that of reforming the CAP and associated policies relating to rural development and nature/environment. Responding to the issue of structural overproduction, pollution and the poor state of biodiversity (and possible other factors), reforms of the CAP and EU environmental directives started in 1984 (with milk) and have been ongoing since 1991/92 (other sectors). These reforms target three aspects of the pressure–state–impact interface: (i) limitation of overproduction through the introduction of strict production quotas and conversion of the CAP from production-based to area-based payments; (ii) stricter regulations of the indirect impacts of agriculture on wetlands and the environment in general (e.g. by the Nitrates Directive); and (iii) enhancement and stimulation of cultural and supporting services (specifically, biodiversity) within agriculture and rural development. These helped to pave the way for national nature management and development policies and, later, an enhanced implementation of the EU nature directives and programmes (e.g. the BHD and Natura 2000) that target conserving (and to some extent enriching) the values of the rural landscape with increased cultural and supporting services. The impacts of these policies on the agriculture sector have been, among others, an accelerated consolidation and contraction of highly-intensive, highly-productive agriculture and a revitalization of low-input (or lower-input), diversified management practices (partly by site managing NGOs and the National Forest Service) with enhanced biodiversity and recreational services (Box 6).

The floodplain restoration response strategy initiated after the flood crisis of 1995 has been based primarily on the principle of averting the huge investment costs of an additional “traditional” overhaul of the dykes and flood protection network, opting instead for a revitalization, and in some case re-creation/enhancement of the floodplains and their regulating service of flood retention. The core of the new Netherlands floodplain policy, “room for the rivers”, consists of restoring and enhancing the flood retention capacity/service of the floodplains by means of hydrological landscaping that serves this primary function. This entails: (i) restricting *in situ* agriculture in the floodplains and in a few designated “flood retention polders”¹² to non-flood obtrusive practices; (ii) buying out of agricultural land (for water management and nature conservation purposes); and (iii) the active creation of wetlands (often by means of dredging). In

¹² Basically, polders that are returned to the floodplain.

addition, infrastructural obstacles and urbanization are tackled. This turnaround in national policy has been enabled by, and converged with, the EU reforms of the agricultural, rural development and nature policies. Rather than being a priority growth sector, agriculture is now subject to diversification and regulation, with specific attention given to the enhancement of the cultural and supporting services. (However, owing to rising food prices and biofuel demand, the drivers and pressures to increase agriculture production have mounted rapidly in 2007–08.) The new flood policy brings a fresh impetus to further restore and enhance the regulating services and, as far as the floodplains are concerned, restrict the exploitation of provisioning services to what is feasible within the dominance of flood regulation services.

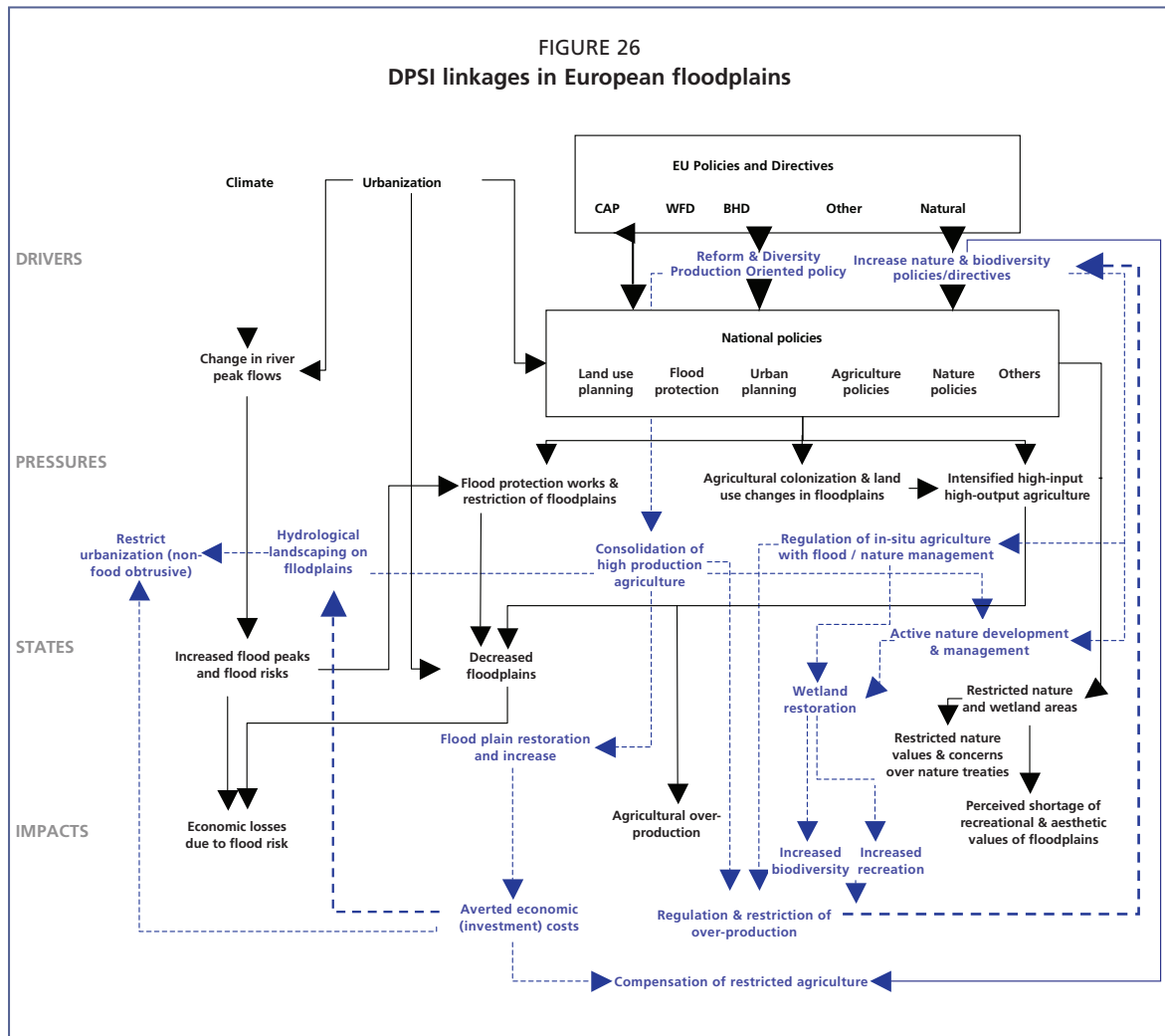
CONCLUSIONS

The rebalancing of the ecosystems services in the Netherlands floodplains, and in general in the EU agriculture sector, is a concerted and multiple initiative being undertaken at different levels and developed/refined over a series of stages (Figure 26). The reform of the CAP has been primarily a response to the economic impacts of structural overproduction and increasing concerns about the ever-decreasing and diminished cultural and supporting services in the rural landscape, in particular with regard to biodiversity and water quality. This initiated the process of rebalancing the ecosystem services in which the provisioning services of agriculture could be curbed and restricted through the imposition of regulations – both in terms of *in situ* interactions in relation with agro-ecological landscapes, as well as by indirect interactions at the basin level – complemented by provisions and facilities to actively foster and stimulate the revitalization of nature and biodiversity. This paved the way for the subsequent Netherlands floodplain policy, which took the rebalancing of ecosystem services one step further by making the revitalization of the regulating services of the floodplains its central objective. The primary impacts and drivers that this policy responded to were: (i) the averted economic investment costs that the revamping of the flood retention capacity represented compared with overhauling the dyke infrastructure; and (ii) the impact of climate change in requiring a higher flood retention capacity in the future. The valuing of regulating services as flood retention has now become a mainstream element of Netherlands flood and water management policy. In the new Netherlands water law (under preparation), flood retention has

BOX 6

Small river valleys with peat meadows

A different trend emerges from the cases in the small river valleys and floodplains where peat is the dominant soil type. The retreat of agricultural activities as a response to changed market conditions and EU policies has disturbed the fragile balance between agriculture, as a provisioning service, and the specific attribute in terms of biodiversity that had been developed as a response to the long-lasting and stable use of these river valleys for haymaking and grazing. Owing to the specific biodiversity that had developed in these hay meadows, large areas of these river valleys have been designated “sites of community interest” under the BHD. However, with the increasing cessation of agriculture in these areas, e.g. for reasons of economic viability, this specific biodiversity is also threatened. Member states are facing problems in meeting their obligations to the EU nature conservation legislation. The Biebrza valley in Poland and the Drentse Aa River valley in the Netherlands are two examples of this. In both, the cessation of active use of peat meadows threatens to transform the vegetation and affect their specific biodiversity. The continuation of agricultural activities in such cases, specifically the active use and maintenance of the meadow system, can be supported by provisions and payments made available under the EU CAP and nature directives. These are seen as being activities relating to cultural patrimony and the delivery of biodiversity services – either to individual farmers or landscape management organizations.



become a formal criterion for land-use planning and governance; one with which land can be dedicated (or codedicated) to the primary function of flood retention. This further enhances the opportunities for the revitalization and creation of wetlands (including cultural and supporting services) that foster the flood retention capacity of the floodplains. The extent to which this turnaround in thinking has penetrated Netherlands society and politics is illustrated by the fact that the notion of revitalizing the flood protection capacity of the coastal deltas through brackish agro-ecological systems is already being contemplated in some quarters.¹³

¹³ Similarly, in the United Kingdom, allowing the sea to reclaim areas previously protected and allowing flooding of agricultural land that was previously kept dry by pumping is becoming increasingly acceptable, primarily because the economic costs of defences and pumping are now considered too high. This is part of a general trend throughout Europe.

Chapter 6

Oil-palm estate development in Southeast Asia: consequences for peat swamp forests and livelihoods in Indonesia

In this chapter, the DPSIR analysis is applied to oil-palm development in the peat swamp forest area of Central Kalimantan, Indonesia. This is an area where the Mega Rice Project was started in the mid-1990s with the clearing of 1 million ha of peat forest for rice farms to be developed by transmigrant farmers from Java. The rice farms largely failed, and the cleared land has been given out in concessions for oil-palm estates (Colchester *et al.*, 2006).

World demand for palm oil has increased substantially in the last decade. The world's two most important producing countries, Indonesia and Malaysia, have reacted to this demand by converting considerable areas of tropical forest to oil-palm estates (Box 7). Indications of this in the decade from 1995–2005 are seen in the production figures, which rose from 5 million tonnes to 15 million tonnes in Indonesia, and from 8 million tonnes to 15 million tonnes in Malaysia. It is predicted that production will double again in the next decade.

Large areas of peatland forests have been given to concession holders for many years, and this has seen selective felling of valuable species of trees. An oil-palm operation starts with the digging of canals to drain the area. This immediately results in a lowering of the water table and the shrinking of the peat layer by several metres.

BOX 7

Other cases of peat swamp forest loss for oil-palm development

There are several other cases of large-scale peat swamp forest loss in Southeast Asia connected with oil-palm development in the case database. For example, in Sumatra, Indonesia, in the Air Hitam Laut River basin, oil-palm development is affecting the Berbak National Park, a Ramsar site since 1991 and an important bird migration area. The Berbak National Park is a good example of the biodiversity that can be found in a peat swamp forest: 224 bird species (including the kingfisher, hornbill, and the white-winged wood duck), almost 30 mammal species (including the Sumatran tiger and the clouded leopard), 93 fish species, and 260 vegetation species (including 150 tree species and 23 palm species). The area is now prone to logging and oil-palm development. Associated developments occur as local inhabitants make use of the railway tracks (built to export logs from the area) to enter the area to produce crops or collect marketable products from the forest.

In Borneo, Malaysia, an extensive peat dome has been given the status of a national park. The area is known as the Maludam National Park. The area is a former logging concession, which implies that all valuable species of trees have systematically been removed from the area. Pressures on the area now come from illegal loggers and plans to develop oil-palm estates at the fringes of the peat dome, which will seriously affect the hydrology that is the basis of the dome (Berg *et al.*, 2004).

Lead author: Aart Schrevel (WUR)

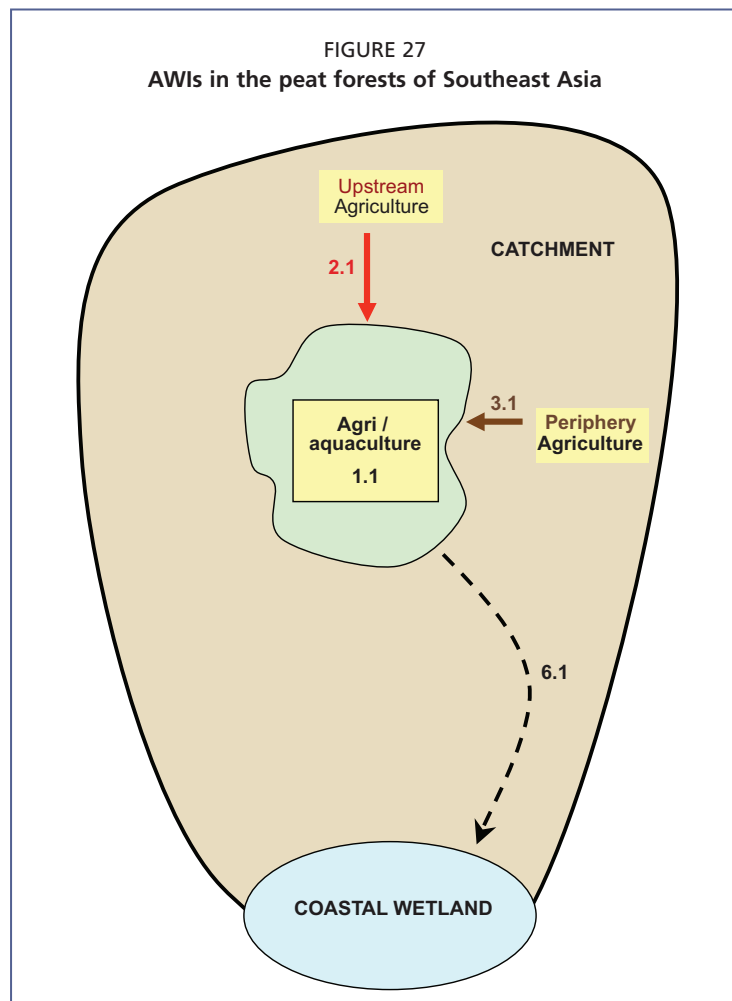
Fire is often used to eliminate the dead branches and leaves. The area gradually becomes accessible and roads are constructed. Once the area has been cleared, oil-palm seedlings can be planted. Once the water table is below the grass-root level, a process of oxidation starts and the peat is destroyed. In this process, CO₂ is released. The scale at which land clearing takes place is enormous, and so are the amounts of CO₂ released. The conversion of Southeast Asian peat forests is estimated to account for 6–7 percent of the total global release of CO₂ into the atmosphere (UNEP *et al.*, 2007).

Conversion of natural peat forest to oil-palm estates is initiated and implemented by stakeholders from outside the forest area, e.g. national companies, governments and international companies. Although local inhabitants may be hired to do manual work, this work is often done by outsiders. In the best of cases, the local people receive compensation for the land on which they have lived for generations being taken for estates. However, eventually, they lose access to at least part of the resources they depend on for their survival. An increase in poverty is usually the result. Impoverished local people often become involved in illegal logging activities as a livelihood response, which thus becomes another pressure on the peat forest and in itself constitutes a negative feedback loop. The logging is also facilitated by the presence of the oil-palm estates, as these provide improved transportation infrastructure through which the logging products can be taken to markets.

This case represents an example of the extension of commercial commodity agricultural into peat swamp forest wetlands that were previously used for subsistence economies. Where estates are established, the natural wetland ecosystem is transformed into a

monoculture. The provisioning services of the latter are positive for those with access to the land, usually large companies, and for the state (which receives revenues from the concession holders). However, development of the estates is often undertaken in an unsustainable way, with negative impacts on ecosystem services and with pressures placed on the remaining natural environment. As a result, state changes may be irreversible, and socio-economic impacts largely negative for the local population.

Figure 27 shows the main AWIs that occur in this type of case.



DRIVERS

The drivers that are leading to the destruction of the peat forests are global market forces. Indonesia's increasingly open economy, its export development policies, and its vast tracks of "suitable" land further enhance this driver, as increasing demand for palm oil, coupled with investment opportunities, transforms large

tracts of swamp forests in the country. The increased global demand for oil-palm products is driven by a number of uses, especially in the food industry, and the growing demand for biofuels.

National policies present a further set of drivers in that, at best, they are incapable of regulating the peat forest conversion in a more sustainable way. At worst, they facilitate the conversion to oil-palm estate. Foremost among these is the concession policy, without which oil-palm estates cannot be established, and which drastically changes the land tenure situation as entitlements are accorded to national and international companies at the expense of traditional usufruct rights of the local population. Although these concessions are supposed to be subject to environmental regulations (including environmental impact assessments [EIAs]), these are frequently weak or not enforced for various reasons.

Another driver of peat forest destruction is local poverty. The local poor who have lost access to the forest resources they used to rely upon, because of their conversion to oil-palm estates, search for new livelihoods. Local businesses offer attractive alternatives with illegal logging of remaining peat forests, thus exerting additional pressures on the forested wetland systems.

PRESSURES

The pressures stemming from the conversion of peat forest to oil-palm estates lead to a drastic transformation of the ecosystem. Foremost among these pressures are the clearing of the natural vegetation and the changing of the hydrological regime through drainage. Both have severe effects on the state of the wetlands (below). Typically, canals are dug to drain the area where the oil-palms are to be planted. Often, areas as large as 5 000 ha are developed in a single project. Because of the relatively open and light structure of peat, the effect of draining is not restricted to the area converted – a much larger area is affected by the lowering of the water table. The extent of this wider effect depends on the topography. Associated with the drainage and forest clearance are fires that have serious impacts on these peat areas, as well as regional impacts through air pollution.

Related pressures come from improved road and railway infrastructure. These improve access to the estates and neighbouring areas and facilitate further logging beyond that linked to the oil-palm development.

STATE CHANGES

Where an oil-palm estate replaces a peat swamp forest, the environmental state changes are dramatic. The hydrology of the area is changed, with the groundwater table lowered from the high and relatively constant one found in the natural peat forests to a level that allows the oil-palm trees the necessary rooting zone. This new hydrological regime has a negative effect on the natural biodiversity, and the natural forest species cannot survive. Although most of these trees on the estate itself are removed to make way for the oil-palms, the effect of peatland drainage spreads well beyond the boundaries of the estate. Overall, the biodiversity in these areas changes completely as one set of natural climax organisms is replaced by another that is human-created. Typically, the former is much more diverse than the latter.

The state changes in neighbouring areas that are not transformed into plantations but experience pressures from altered hydrological regimes are more subtle and take place at a slower rate. Nonetheless, these can be severe and extensive. In the long run, the biodiversity in these areas also suffers from a changed hydrological regime. Drainage causes water-loving species to die out, with species suited to drier environments colonizing and replacing those that survived in the wetter environment. The areas outside plantations may also have their biodiversity affected because of selective logging and harvesting of forest products made possible by the improved access associated with the oil-palm estates.

The peat soils are also affected, and this constitutes a globally important state change. This is because of the way the lower water table exposes the peat to the air and oxidation, which in turn releases CO₂ (Hooijer *et al.*, 2006). Where the effects have been measured, the peat layer has decreased by several metres. The top layer changes in composition: from a mix of water, dead branches, organic material and water-loving plants, which is hardly accessible, to become a more solid, although far from firm, organic soil. Water storage and flow moderation are also affected by the changing hydrological situation and the state of the peat soils.

Overall, the original wetland system, with its diverse ecosystem and regulating services with local and global benefits, is replaced by a much less diverse ecosystem, although one which is more economically productive, at least in the short term.

IMPACTS

As is often the case with AWIs, the socio-economic impacts are diverse. The financial returns from the oil-palms benefit the plantation owners (mostly people from outside the area, often from other countries) and national treasuries. Positive socio-economic impacts at the local level are primarily limited to improved roads and rail infrastructure that open up the area and provide improved access to forest resources to local people, and to the employment and income opportunities provided by the estates.

The negative socio-economic impacts are seen most clearly where oil-palm estates have replaced other forms of land cover and land use on which entire villages and communities had long relied for their livelihoods. They are now left with fewer and less diverse resources to exploit, often at increased distances from where they live, and these generally yield lower income with less security. As a result, many people, especially the young, migrate out of the affected areas and try to make a living in the nearby urban centres.

Insecurity in terms of land tenure is also increased, and access rights to natural resources are changed. These are particularly important changes as they cut right through the dynamics of the situations described above. Typically, local people in areas where oil-palm estates are developed do not have documented titles to the land they cultivate, let alone to the forest resources they exploit or the hunting grounds they frequent. In some cases, compensation is granted, but this is never enough to start other livelihoods elsewhere.

RESPONSES

In general, in Central Kalimantan, there have been limited and rather superficial responses by the authorities to the negative changes in ecosystem services resulting from oil-palm development. Here, the emphasis has been mainly on measures to prevent forest fires in the dry season. There seems to be no attention given to the need for hydrological measures that would limit the widespread effect of drainage, even though this kind of management could help to curtail the fires.

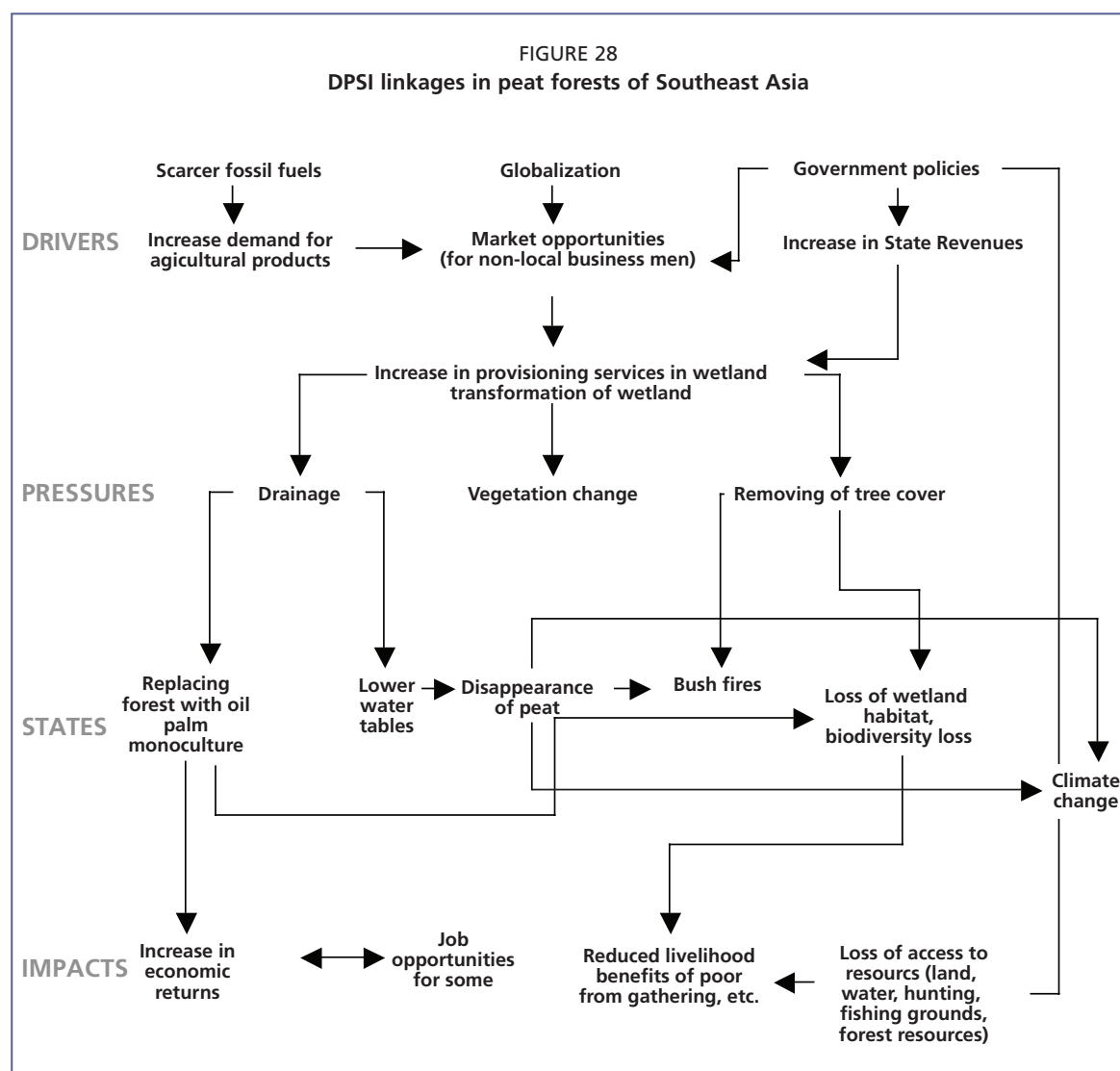
However, a response was seen in part of the global market in early 2007. In the Netherlands, the press carried the message that Indonesian palm oil was produced unsustainably and was being used by a large electricity companies to fulfil the EU obligation that a certain percentage of energy should be produced sustainably. As a result, this company stopped buying palm oil from Indonesia and started cooperation with the World Wide Fund for Nature (WWF) to establish sustainability criteria for palm oil. Similar discussions have now entered the political domain of the EU with regard to its energy policy, which sets out targets for the increased use of biofuels within the EU to reach 5 percent of total road fuel (a policy largely driven by the need to curb CO₂ emissions in view of climate change). With examples like these from peat forest conversions to oil-palm estates, NGO lobbying has been successful in qualifying the “greenness” and sustainability of biofuels. The EU is now responding by

introducing a system of certification for biofuels, based on the environmental impacts of different production practices. This issue is now further debated, also in view of the extent to which biofuels may compete with global food production and security.

These responses at the global/regional market level are astute and strategic when viewed through a DPSIR perspective as they targeted direct one of the principle drivers. The effectiveness of such a response will, at a minimum, be a curbing of the exceptional growth in the global demand for palm-based fuels by restricting one major market. To what extent this will also be effective in curbing overall global demand remains to be seen.

CONCLUSIONS

The DPSIR analysis here (Figure 28) shows the linkages between the loss of peat swamp forests and global market forces, mediated by national export policies and international investment. The increasing demand for a product in one part of the world is transforming a wetland system in another continent. In this process, the sustainability of the tropical peat land system in Indonesia is threatened. Ultimately, the peat lands are destroyed; the rights of indigenous people and other local people living from in the area are neglected; and through the CO₂ released, the integrity of the global ecosystem is compromised. Addressing this set of negative AWIs to achieve a less negative result



in terms of state changes, and also in terms of socio-economic impacts, is complex. However, a number of levels at which this can be addressed are indicated here. Attention needs to be given to the drivers of change at international level, especially the demand for biofuels and other palm oil products, and this is currently being debated in EU policies. However, local, *in situ* management addressing the hydrological regime must also be given attention if a sustainable balance between the different ecosystem services is to be achieved in these tropical peat forests. This should include a focus on minimizing hydrological changes in areas selected as suitable for transformation into oil-palm estates, the establishment and recognition of formal rights to resources prior to taking decisions on transforming an area, and on CO₂-neutral or near-neutral transformations. Finally, the development of positive drivers, in the form of carbon markets, needs to be explored as this might provide further support for the regulating services and help to achieve the balance in ecosystem services needed for long-term sustainable use of these peat forests.

Chapter 7

Agriculture in tropical river basins – impacts on aquatic lagoon and estuary ecosystems

OVERVIEW OF KEY CHARACTERISTICS

Tropical river basins contain both dryland and aquatic ecosystems that provide a rich environment and habitat for biodiversity, freshwater and saltwater fish and marine life, as well as forests and agricultural crop production, and livestock (to a lesser extent). They provide ample opportunities to exploit the provisioning services of both terrestrial and aquatic ecosystems, and have long attracted human settlement and use of the natural resources – in particular, for exploitation of forest resources, upland and irrigated agriculture, and fisheries and aquaculture.

The characteristics of sustainable interactions between agriculture and wetlands in the context of tropical river basins that discharge into rich and typical aquatic ecosystems at their estuaries (lagoons and deltas) are typically twofold:

- basin-level interactions between upstream agriculture and forestry use and their downstream impacts on the river and lagoon ecology;
- *in situ* and periphery exploitation of aquatic ecosystems and natural resources that infringe directly on the resilience and sustainability of the present state of the ecosystems.

Irrigated rice, which is generally a major agricultural activity within these tropical river basins (especially in Asia), has received substantial government investment and support to provide for the necessary water storage and conveyance infrastructure. As a result, large tracts in the river basins have been converted to irrigated rice cultivation, especially in the cases of Viet Nam and Sri Lanka. Primarily designed to expand and intensify rice production, these irrigated systems change the aquatic ecosystems in the basin through resulting modifications in water quantity (negative in the river flow, and positive in storage and lagoon drainage discharge) and quality (negative through pollutants and through diminishing salinity levels in coastal ecosystems).

Dryland agriculture, as well as forestry management and exploitation in the upper catchments of a basin, may substantially alter catchment runoff and water retention capacity. Irrigated development in the floodplain may affect river regime and water quality. Together, they may affect the coastal aquatic ecosystems through sedimentation of eroded topsoil and altered water inflows. In general, these transformations lead to changes in the flow regime of both the river and the water regime and quality in coastal

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* This chapter is based on work by: Lorenzen, Khoa and Garaway (2006); IUCN, Thua Thien Hue PPC and FAO (2006); Pattnaik (2005)

BOX 8

The issue of water quality in coastal aquatic ecosystems

Fisheries, irrigated agriculture and aquaculture in and around lagoons affect and are affected by the quality of the lagoon water in numerous and intricate ways:

- in the level of salinity (fresh for agriculture, specific level of brackishness for aquaculture; fluctuating levels of salinity for capture fish and lagoon species);
- in the refreshment rate at which aquaculture waste (pharmaceutical and solid) and agricultural waste (agrochemical) can be washed out;
- oxidation/eutrophication rates.

lagoons and estuarine ecosystems. This often creates conflicts of interest between involved sectors over the quantity and quality of water resources.

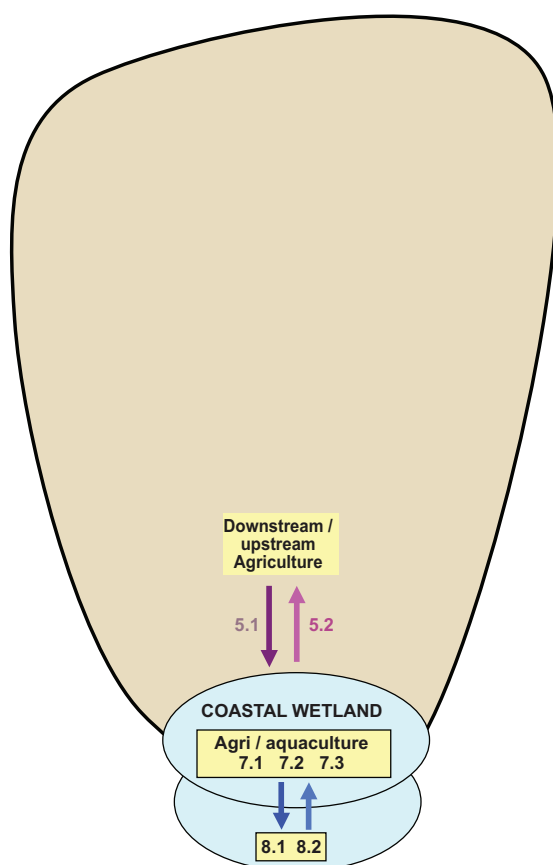
In the past two decades, the aquaculture of shrimp and other marine species for commercial global markets has risen exponentially, especially in coastal brackish environments as provided by (tropical) lagoons. Aquaculture has a direct impact on the aquatic ecosystem by affecting both water quality and water circulation. Moreover, it is a productive system that imposes water quantity and quality standards often in direct opposition to those for the agricultural production systems. Aquaculture also has the potential to release exotic aquatic species into the environment that may compete for ecological niches with native species or be agents of disease and parasites.

The combined effects of agriculture and aquaculture systems often lead to severe transformations and degradation of the coastal aquatic ecosystems, especially through water quality changes (Box 8).

The fishery sector of both riverine and marine fish is also affected – positively in some locations and at some times, negatively in others. This is of particular social concern in this context as such fisheries are traditionally an important sector for the poor and landless to supplement both their income and food security (in particular, in terms of nutrients).

The involved sectors of agricultural crop production, fisheries and aquaculture have

FIGURE 29
AWIs in tropical river basins and lagoons



generally conflicting interests with regard to management of water resources (in quantity, timing and quality). These conflicts are played out both *in situ* (especially at the periphery of the coastal aquatic ecosystem) and at basin level, where upstream practices affect downstream uses. Figure 29 shows the main AWIs in this issue situation.

CASE STUDIES

The case studies used in this issue situation are those of:

- Chilika Lagoon – a coastal wetland, and designated Ramsar site, in India, that has been severely degraded owing to the combined impact of aquaculture and siltation resulting from expansion of agriculture and deforestation.
- Kirindi Oya Irrigation and Settlement Project in Sri Lanka, where irrigation development for paddy cultivation has taken precedence over other developments. This has created fish and aquatic ecosystem habitats through the creation of freshwater reservoirs and tanks. However, it has affected the salinity and marine species stocks in the coastal lagoon by increased freshwater drainage.
- Huong River Basin and Tam-Giang Cau Hai Lagoon in Viet Nam, which are characterized by priority development of irrigated paddy and a recent boom in shrimp cultivation in the lagoon, which has led to severe degradation of the aquatic ecosystem in the lagoon and serious problems of salt intrusion that even affect the freshwater supply to the city of Hue.

Similar issues concerning the interrelation between irrigated rice, fish and aquaculture and their impact on the state of aquatic ecosystem commonly emerge in other similar settings, especially in Asia (e.g. the Mekong Delta, river basins and catchments in Cambodia and the Lao People's Democratic Republic, and coastal Bangladesh).

Of these three cases, Viet Nam and Sri Lanka have strong similarities in that they share a strong history of purposefully-supported irrigated paddy development. These cases are discussed in Boxes 9–13. The case of Chilika is slightly different. It does not share this strong support for irrigated infrastructure development, and it is characterized by the impact of subsistence upland agriculture and forestry exploitation. Therefore, the case of Chilika is discussed separately and presented as the main case of this chapter.

DRIVERS

The most commonly shared and general driver is that of a steadily increasing population that is attracted to the rich natural resources of both the tropical river basin and its aquatic ecosystems (both inland fresh and coastal brackish) to support an increasing need for food security and to sustain economic livelihoods (Box 9).

In the catchment of the Chilika Lagoon, agriculture expansion and intensification has been driven primarily by population growth and associated needs of livelihood support and food security. The population living in the catchment

BOX 9

Drivers in tropical river basins and coastal lagoons

In the Huong River and Kirindi Oya cases, food security (through irrigated paddy rice development) has been the major driver to which the respective governments have responded. This has seen major investments in the development of irrigation infrastructure (storage and conveyance) for paddy cultivation in accordance with the “green revolution” agricultural development paradigm. In turn, this has led to more specific pressures such as agricultural intensification, agricultural colonization (actively supported by settlement policy in the case of Sri Lanka) and the general priority use of the available water resources for paddy cultivation.

In both cases, but especially in the Huong River case, the increasing global market demand for shrimps and other marine species has become an important driver of the recent boom in aquaculture in these coastal lagoons. In the Huong River case, this is actively supported by government policy directed towards the accession of Viet Nam to the World Trade Organization (WTO), which should further facilitate and support the access of Vietnamese aquaculture products (and others) to the world market. However, WTO accession in this regard does not necessarily lead only to further negative pressures through further intensification of the aquaculture sector. The more stringent international criteria for GAPs and the norms for food hygiene may in turn produce pressures for a transformation of aquaculture towards more sustainable, and less environmentally damaging, practices.

BOX 10

Pressures from urban water supply, irrigation and shrimp farming

In the case of Huong, the expanding city of Hue and its concomitant increasing demand for water supply and sanitation is increasing the pressure on the limited freshwater resources available in the dry season. Hue city, at the mouth of Huong River on the edge of the lagoon, is fully dependent on the Huong River water supply, which at times of low flow is affected by salt-water intrusion from the lagoon.

In both Huong and Kirindi Oya, the expansion and intensification of irrigated paddy rice constitute some of the major pressures on the river basin and coastal aquatic ecosystems. They have led to significant state changes in both the rivers and the lagoons. The water storage and conveyance infrastructure associated with irrigated rice leads to the specific pressures of water abstraction, conveyance and the consumptive and non-consumptive use by irrigated rice of the freshwater resources in the river. The historic and current priority allocation and objective of rice cultivation, along with the increasing population, is leading in both cases to specific pressures on the available water resources in the river basin. This is creating further demands for increased water storage and management capacity to enhance the intensification of rice cultivation (both in terms of increased cropping intensities and higher yields). In the case of the Huong River, this is leading to the expansion of the surface storage facilities through construction of new dams. In contrast, in the case of Kirindi Oya, the pressure is on changing the operational management of the reservoir (at the head of the system) and the tanks (within the command area of the irrigation scheme) to allow intensification of paddy cultivation in the dry season. In both cases, the pressure to intensify rice cultivation is leading to significant alteration of the freshwater flow regimes.

The exponential growth in shrimp and aquaculture in the Huong River lagoon is leading to intensified pressures on the available land and water resources – and direct competition with irrigated paddy. The agricultural polders at the fringe of the lagoon are being converted from paddy cultivation to aquaculture; whereas the prime concern for water requirements for aquaculture lies in the management of desirable levels of brackishness. The difficulty of managing this water quality aspect in aquaculture has led to a high incidence of disease and yield failure in aquaculture. In turn, this increases the pressure on the lagoon ecosystem as aquaculture expands further and encroaches into the lagoon in search of better water quality.

is about 0.8 million people, with about 0.2 million people around the lagoon). Agricultural development in the Chilika catchment, particularly within the Mahanadi Delta region, was enabled through an extensive channellization of the Mahanadi River floodplains, and the construction of a series of hydrological structures to enhance water availability for agriculture. However, designation of the lagoon as a Ramsar site enabled significant investment into conservation measures in order to conserve the ecological character of the systems as well as to restore the livelihood resource base of the communities. Nonetheless, agricultural development has taken place, primarily in two forms in the catchment of the lagoon:

- cultivation of cashew, which is driven directly by market demand and opportunity;
- cultivation of rice, which is driven primarily by subsistence or transition (semi-commercial) agricultural livelihoods.

Analysis of this situation shows that there are two principal drivers that lead to the possibly unsustainable use of forest resources in Chilika: (i) the cashew market, which leads to pressures of deforestation for cashew plantations; and (ii) the consumption of fuelwood by households in the catchment.

The lagoon fishery comprises capture and culture sources, traditionally managed by the communities. However, food and nutritional security needs have been the key drivers of the fisheries. The introduction of shrimp farming on the fringes of

Chilika as a part of a poverty alleviation package led to rampant expansion of shrimp cultivation within the lake. This also brought non-fisher communities into fishing within the lake, creating a nexus of profit-driven, capital-intensive, moneylender-trader

systems, with severe conflicts with the traditional fishers. The expansion of aquaculture was further fuelled by devaluation of the local currency and export liberalization policies. Conversion of agricultural fields within the delta for shrimp culture has also been attempted but with limited success (and resulted in long-term soil degradation and conflicts).

PRESSURES

Agricultural expansion in the upper catchments of the Chilika Lagoon for subsistence agriculture and transitional market-oriented agriculture (rice, upland food crops and cashew) is leading to increased pressures on available land and water resources in the catchment. The transformation of forestry and upper catchment areas into cashew plantations is causing the forest resource base for traditional homestead fuel consumption to dwindle, exacerbating the pressure on forestry resources. At the same time, the relatively low yields of rice and upland crops lead to further expansion of agricultural areas in the catchment, at the cost of natural vegetation, in order to satisfy food and livelihood requirements.

In Chilika Lagoon, the capture and aquaculture pressures on the ecosystems have primarily become an issue as a result of the state changes of the ecosystems (mainly siltation of the mouth leading to a progressive shift to a freshwater-dominated system with comparatively lower biodiversity) and their diminishing carrying capacity of fish stock, that is sought out by an ever increasing human population.

STATE CHANGES

The Chilika aquatic lagoon ecosystems have undergone severe degradation and shifted into a seemingly vicious cycle of further degradation and diminishing resilience of the lagoon ecosystem. The state changes that have caused these developments are primarily excessive silt deposition in the lagoon from erosion in the upper catchment as a result of poor agricultural and forestry management practices. The siltation has led to decreasing water circulation and refreshment, which is further exacerbated by nature as it leads to a boom in aquatic weeds. The situation has been compounded by the effects of long-shore drift and the increased sediment levels that have limited the outlet of Chilika to the sea and so led to reduced salinity levels. Overall, these changes in the lagoon environment have led to a transformation in the ecological habitats in the wetland, especially a “sweetening”, or salinity reduction, of the brackish environments, and to dwindling fish stocks and species diversity.

BOX 11

State changes – hydroecological degradation in lagoons

In the Huong River, the reduction in water circulation and the refreshment capacity is caused primarily by: (i) colonization of the lagoon by aquaculture; and (ii) reduced freshwater outflow into the lagoon in the dry season from both the river and the agricultural polders. (A negative hydraulic gradient in the dry season leads to salt intrusion in the river, polders and groundwater table). The decreasing water quality in the Huong Lagoon is undermining the productivity and sustainability of agriculture and aquaculture, while natural aquatic habitats are being colonized by aquaculture in search of “fresh” (non-stagnant) water.

In the case of Kirindi Oya, the state changes are different and primarily two-fold:

- The expansion and intensification of irrigated paddy has led to an increase in diffused drainage of freshwater into the lagoon. This affects the brackishness of the lagoon by reducing salinity levels, and hence the ecological habitats and fish stocks it can support.
- In the initial stages of Kirindi Oya, the new reservoir and tanks created new aquatic freshwater habitats for fish stocks and aquatic species. Biodiversity thrived in these so-called “human-made wetlands”. However, in the present stage of further intensification of irrigated rice, these freshwater habitats are threatened by excessive drawdown in the dry season. This may not only threaten fish stocks and other aquatic species numbers, it may also undermine the resilience of the system.

BOX 12

Competition and economic diversification impacts of shrimp cultivation

Shrimp cultivation and aquaculture tend to lead to increased competition for and conflicts over coastal land and water resources as they create opposing demands on water quantity and quality compared with that of, in particular, irrigated rice cultivation. Segregation and polarization of these sectors, and their respective practitioners, are common features with an increased incidence and intensity of conflicts – sometimes even violent (as in Bangladesh and the Philippines). The situation is exacerbated by water management and governance structures that are traditionally centred around, and supportive of, irrigated agriculture. Shrimp culture and aquaculture tend to be individual entrepreneurial activities that affect and “free-ride” the water management arrangements of agriculture. Early adopters of shrimp culture and aquaculture quickly form a new wealthy economic class, which enables them to increase their enterprises.

In Huong, the shrimp and aquaculture business has gone beyond the economic boom stage. The present state of degradation of the lagoon is affecting the aquaculture sector significantly, leading to a sharp fall in yield and economic failure among enterprises. Thus, the state and fate of aquaculture in Huong is becoming an issue that may open up opportunities for common-resource-pool management strategies in the aquaculture sector, and links with the rice irrigation and city water management structures and strategies.

IMPACTS

The impacts of state changes in the Chilika situation include a decline in the yields from the subsistence and semi-market (transition) agriculture in the catchment as a result of soil erosion. As a consequence, households are prone to shocks of food and economic insecurity that tend to lead to further extensification (i.e. low input–output) of agricultural practices as they no longer possess the means to invest in GAPs. The increasing scarcity of fuelwood tends to have a similar impact in that it erodes the household livelihood base as more time and resources need to be diverted from productive activities towards securing household fuel. In the wetland, fish yields have declined while the competition for fish, both as a primary livelihood source and dietary supplement, has increased. Declining catches have eroded the livelihoods of fisher folk as well as food and nutrient security of the poor.

The trade-off between increased competition by agriculture and aquaculture for

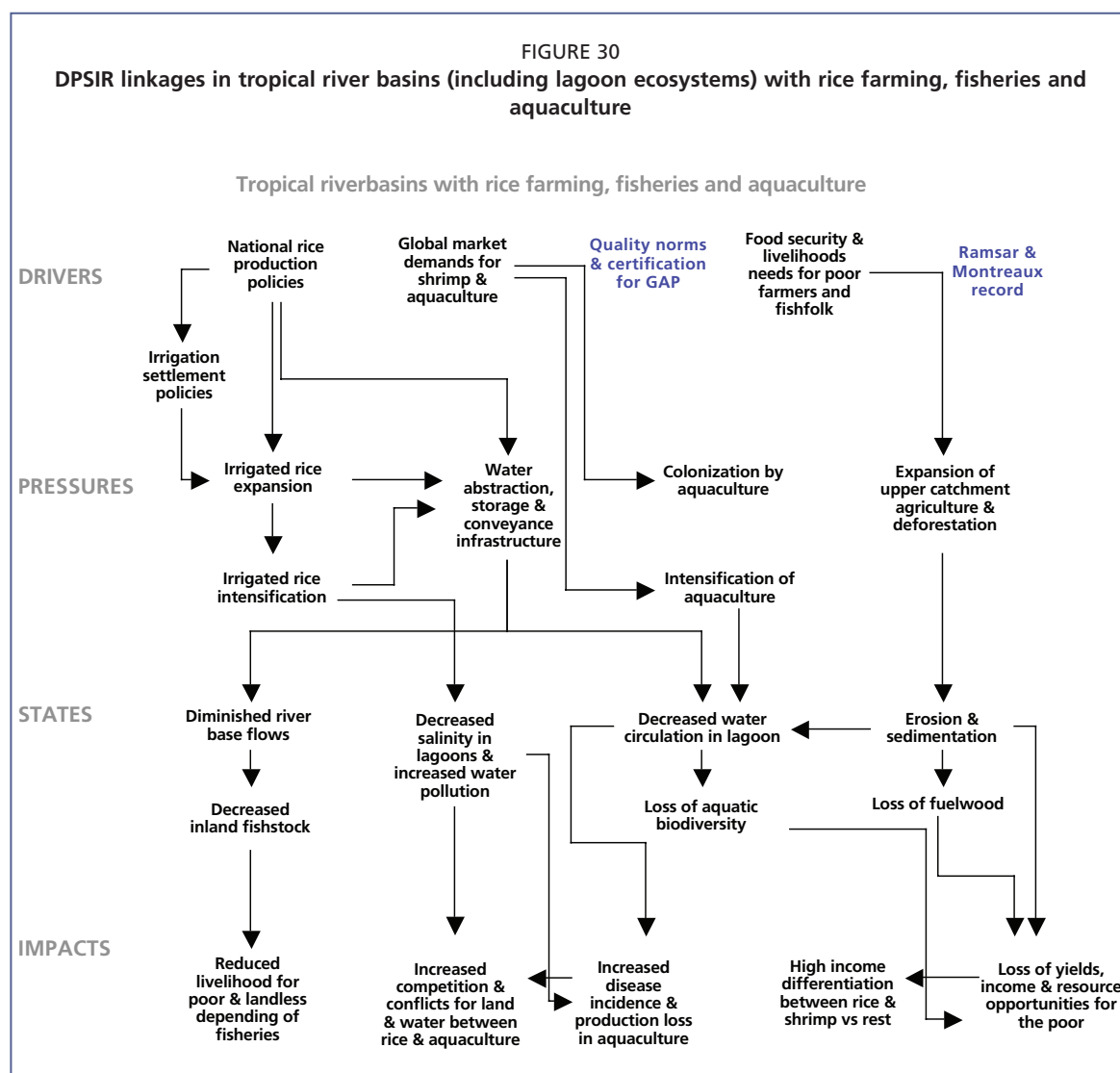
restricted land and water resources is usually the environment and the fish stocks of the inland and coastal waters. The landless and poor, those most dependent on these provisioning services, are the worst affected by a substantial loss in food security and livelihood provisioning. This trait is particularly evident in this Chilika case.

RESPONSES

A comprehensive restoration and conservation programme has been initiated in response to the drivers, pressures and state changes operative in the lagoon and its catchment. This has been driven to a large extent by the inclusion of the Chilika Lagoon in the Montreux Record of endangered Ramsar wetlands, and the resulting political and financial support provided by the government to take Chilika off this list.

The comprehensive multiple-response strategy is directed towards different elements of the drivers, pressures, state and impacts that have been affecting the Chilika Lagoon, its catchment and its population (Figure 30). This strategy includes:

- Establishment of the Chilika Development Authority to develop and provide integration and regulation for the common-pool management strategies, and to provide support and training for community-based natural resources use and management.
- Restoration of the lagoon hydrology by dredging a new outlet to the sea. In combination with other measures, this has led to a marked improvement in water



circulation, recovery in brackishness, reduced weed infestation, and increased fish and marine stocks (and subsequent fish landings by fishers).

- Community-based catchment development and management plans. These are directed towards:
 - (i) sustainable agriculture and forestry management practices that reduce erosion and siltation; and
 - (ii) food and income generation for subsistence agriculture and cashew growing.
- Reforestation and forest management in the catchment.
- Development and dissemination of fuel-efficient stoves that reduce the demand for fuelwood.
- Food processing and natural product processing and marketing programmes that enhance the livelihood means and opportunities of the agriculture and fisheries communities.
- Development of ecotourism in the lagoon as a supplementary economic opportunity of the aquatic ecosystem.

CONCLUSIONS

The cases in this chapter show how catchment, or upstream activities, interact with coastal lagoon ecology, the capture of inland and coastal fish, and how aquaculture

BOX 13

Water management responses to integrate fish/aquaculture with rice cultivation

The immediate response in the Huong River case has been limited to a classical water supply management strategy, and directed towards increasing the surface storage capacity of Huong River infrastructure. The extra available water in the dry season is to be directed towards: (i) hydropower; (ii) intensified rice cultivation; and (iii) ecological base flows. In addition, a salt intrusion barrage will be constructed to protect the dry-season freshwater supply to the city of Hue, and the sea outlet of the lagoon will be enlarged to increase water circulation in the lagoon. The integration of water management for agriculture, ecosystems and aquaculture is in its infancy, and primarily directed towards establishing governance and regulation structures. The former is being achieved by creating a cross-sectoral and interdepartmental Huong River Management Board. The latter is being sought by attempting to regulate the further expansion of aquaculture into the lagoon. However, future responses may be directed towards achieving higher water-use efficiencies and productivity in the irrigated rice sector, and transforming aquaculture into an industrialized closed-culture system that does not affect the water quality and hydrology of the lagoon and conforms to the high quality and environmental standards of GAPs.

In Kirindi Oya, a first step has been taken towards an integrated and participatory approach to devising a water management strategy that will explicitly serve the multiple purposes of rice cultivation, inland and coastal fisheries, and sustenance of aquatic ecosystems. The immediate objectives are to establish minimum water-level management targets for the reservoir and tanks in the dry season (ones adequate to support fish stocks and serve as dry-season harbours for aquatic species). This is to be accompanied by improved water management and agronomic practices that enhance water-use efficiency and productivity within the irrigated rice scheme, and reduce the drainage outflow of excess freshwater into the lagoon.

affects and interact with both lagoon ecology and upstream water uses and users. They also highlight how different agricultural/aquacultural activities are intrinsically linked to different stakeholders and livelihoods, and where emerging trade-offs between provisioning services usually represent socio-economic trade-offs between livelihoods and between sectors. The propensity for these trade-offs to spiral into negative feedbacks, which further increase the pressures for provisioning services, is high for these systems. In turn, this will lead to degradation of the ecological state and undermine the sustainability of the provisioning services, both agriculture and aquaculture. Tackling these negative feedback loops in an attempt to rebalance the ecosystem services by at least reinvigorating the non-provisioning ones will thus require a concerted response at multiple scales, considering the multiple factors and agricultural domains of the river basin that includes the lagoon ecosystem. The response strategies deployed in Chilika and conceived in the Huong and Kirindi Oya basins show these characteristics in which multiple targeted responses are directed towards the diverse provisioning services being used, and the stakeholders that depend on them. The majority of the individual responses are still

technical in addressing specific pressure–state–impact relations by means of promoting GAPs that both improve productivity and livelihood, as well as the interaction of the particular agricultural, fisheries and aquacultural practices with the wetland ecosystem. However, as the Chilika case illustrates, deploying a multitude of these practices can be an effective measure to improve the overall state of the ecosystem and tackle negative feedback loops.

Reinvigoration of the non-provisioning services is being actively pursued in these cases at state level, where wetland restoration and improvement measures are being implemented. Moreover, Chilika is addressing the pressure level specifically with improvements in the agricultural processing (and thereby income and thus impact), and by exploitation of the cultural services through ecotourism. While the driver level has

not been much addressed specifically, the DPSIR analysis of the Huong and Chilika cases has indicated how positive drivers (such as the certification rules for shrimp and the Montreux Record, respectively) may be (or become) important catalysts for positive responses.

Chapter 8

Integrated rice and fish culture/ capture in the lower Songkhram River basin, northeast Thailand

The lowland societies of Southeast Asia have been described as “rice–fish cultures”, such is the importance and interconnection of these two basic food sources (Gregory and Guttman, 2002). Raising fish in rice fields has been a tradition for more than 2 000 years in some parts of this region (Boxes 14 and 15). Rice–fish cultivation may be practised in rainfed and irrigated rice fields, and both upland terraced and lowland rice fields. While certain favourable areas of lowland mainland Southeast Asia have been under wet rice cultivation for many centuries, and have been more or less continually cultivated in that period, far greater areas are more marginal land that has only been converted to rice paddy in the last three decades.

A rice field ecosystem is a simplified version of the natural wetland ecosystem that preceded it. The main provisioning service is rice, with a variety of by-products (often undervalued and poorly understood by external agencies) such as fish and other aquatic organisms. Intensification and modernization of rice cultivation focusing on maximizing yield, exemplified by “green revolution” technologies, involving the transfer of natural wetlands to largely human-affected ones, has tended to further simplify and compromise the multibenefit functions and services of the modified wetland ecosystem (Figure 31). This has frequently resulted in significant state changes in the ecosystems

BOX 14

Wild capture fisheries in rice fields – the hidden harvest

In many instances in Southeast Asia generally, and in particular the lower Mekong basin, farmers harvest more than rice from rice fields, even where rice is the only officially recognized cultivated crop in the farming system. Although not considered rice–fish culture per se, as it is essentially an open system, farmers throughout the floodplain lowlands benefit from the entry of wild fish from outside the system. These usually migrate upstream into the rice field, and use the aquatic habitat as a temporary spawning, nursing or feeding refuge. Fields are often modified to accommodate the entry and harvest of these wild species, which are usually considered common resources. More than 20 species of fish have been found in rice field systems in the south of the Lao People’s Democratic Republic, while 13 species are known to use rice fields for spawning in the lower Songkhram River basin. Apart from fish, other aquatic organisms commonly harvested from rice fields for sale and local consumption include: crabs, shrimp, bivalve molluscs, frogs and tadpoles, insects, water snakes, turtles and edible aquatic plants. Rice fields continue to yield valuable food items, important in local people’s diets, long into the dry season after the rice harvest has been completed. Some aquatic species, such as crabs and insects, burrow into soil and are dug out by villagers in the dry season. This hidden harvest is often a crucial component of rural food security (Gregory and Guttman, 2002; FAO, 2003).

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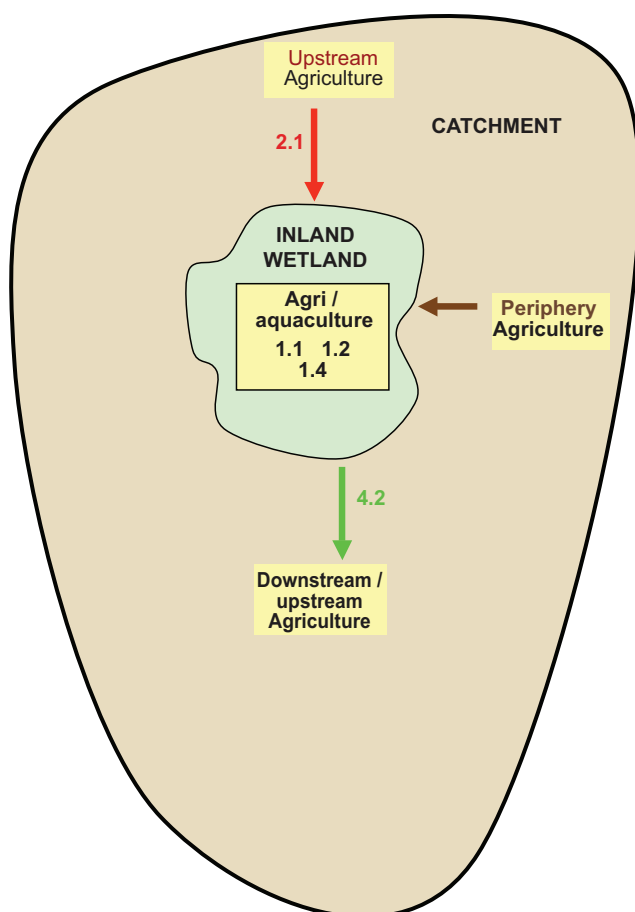
BOX 15

Rice–fish cultures in other parts of South and Southeast Asia

In the rainfed and irrigated rice farming in the south of the Lao People's Democratic Republic three main types of small–medium-scale irrigation technology can be found (weir, dam and reservoir, and pumped irrigation). In this area, fish often play an important role. These water resources have been assessed in order to assess the impacts of irrigation and aquaculture on aquatic resources, important in the livelihoods of local people (Lorenzen, Khoa and Garaway, 2006). Fish are both cultured (usually stocked in small ponds and rice fields) and captured as a by-product of rice cultivation, along with a wide variety of other aquatic organisms that contribute to local diets (FAO, 2003).

In the extensive river floodplains and deltaic lowlands of Bangladesh, where floods last several months (rendering the land unsuitable for crop production), fish are linked with rice cultivation. The freshwater wetlands of Bangladesh consist of the ecologically distinct “haor” (backswamp between levees) and floodplain areas, each subject to a different management regime by local people (Ahmed, Haque and Khan, 2004). Integration of fish culture enables farmers to increase overall production in the flood-prone ecosystem. Both concurrent rice–fish culture in the shallower flooded areas and also alternating rice and fish culture in the deep-flooded areas of Bangladesh through a community-based management system have been trialled and extended to farmers (Dey and Prein, 2004).

FIGURE 31
AWIs in integrated rice and fish culture/capture systems in
South and Southeast Asian tropical river basins



where the system is further skewed towards the exploitation of a single provisioning service. Conversely, attempts to integrate fish cultivation can serve to increase the diversity and complexity of the original ecosystem, by creating a number of new habitats that favour greater aquatic biodiversity and can restore some wetland functions and services.

Large parts of northeast Thailand are typified as “complex, diverse and risk-prone” (or CDR lands) and rely on rainfall rather than irrigation for water supply. Thus, the main rice crop is a single sowing in the early rainy season with harvesting at the start of the dry season (i.e. May–November/December), with relatively few farmers having access to reliable irrigation water for a dry-season crop. This is the case even in the relatively water-rich and high precipitation (1 200–2 100 mm) conditions of the Songkhram basin in northeast Thailand, where estimates show that only about 4 percent of the entire basin

is irrigated (Blake and Pitakthepsombut, 2006a). In most lowland areas, seasonal floods are as much a feature of the annual hydrological conditions as are prolonged periods of low flows and water scarcity.

Rainfed and irrigated rice farming in the lower Songkhram River basin (LSRB) in northeast Thailand forms part of an extensive wetland area largely converted to agricultural uses. However, significant areas of natural vegetation cover remain, such as seasonally flooded forest. These are recognized by local people and fishery scientists as providing valuable spawning, nursing and feeding habitat for a wide range of migratory fish, not easily adapted to monoculture rice fields. However, while large quantities of fish are harvested from rice fields, both in the dry and wet seasons, little deliberate stocking of cultured species occurs. Government policy has tended to recognize only the agricultural potential of the area, at the expense of the rich wetland resources and fisheries sector (Blake, 2006; Blake and Pitakthepsombut, 2006a).

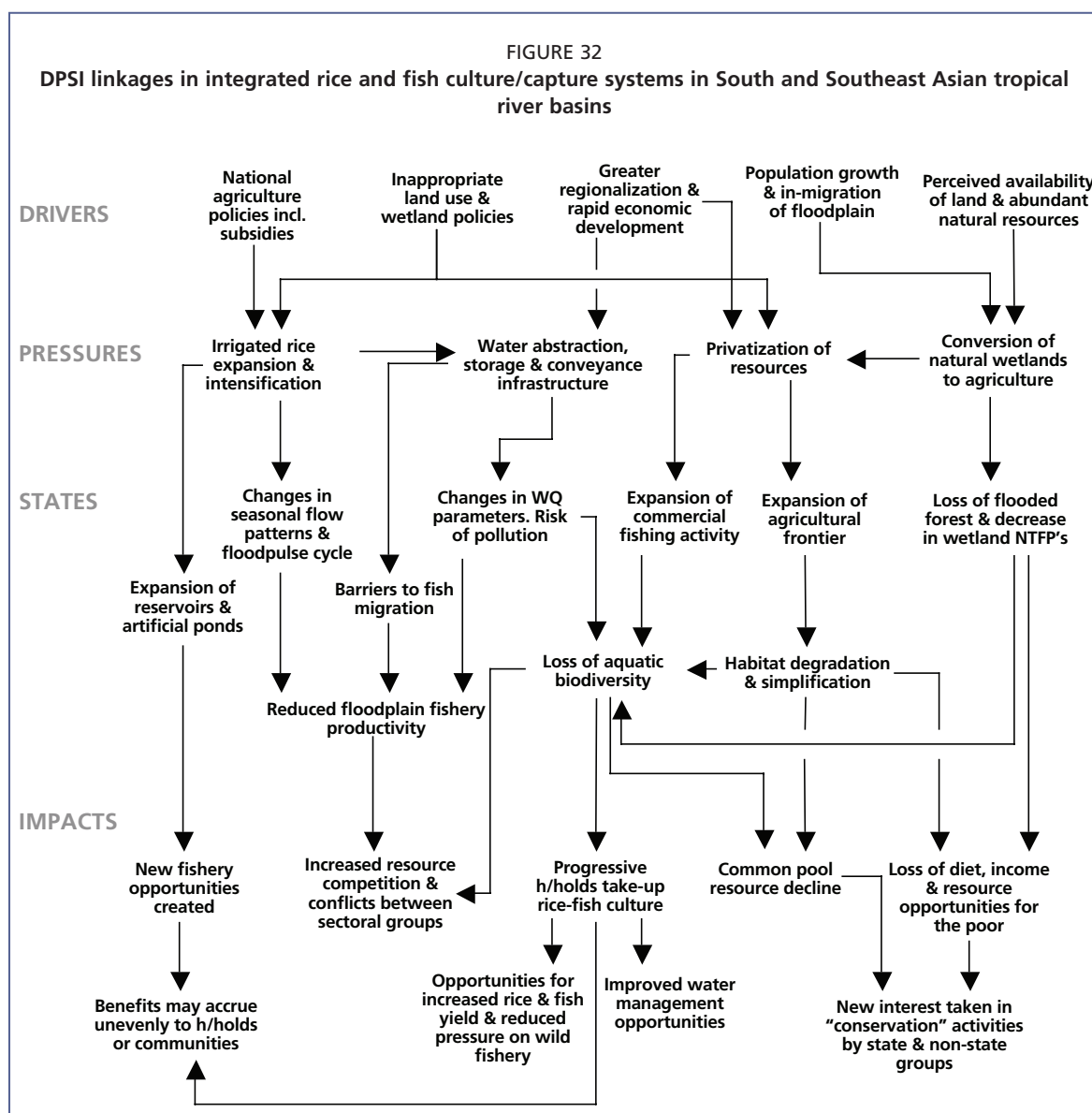
DRIVERS

In the LSRB, the population has been growing steadily in the last four decades as a result of natural growth and in-migration from other provinces. However, the rate of increase has slowed considerably in recent years owing to a successful state-supported birth control programme. Thailand has also been closely integrated into the regional and global economies for decades. This regional integration and population growth have led to growing pressures on natural resources, especially forests (for timber, wildlife, agricultural land and pulpwood plantations) and water (for irrigation and hydropower). These general drivers (Figure 32) have been slightly moderated in the LSRB because of its remoteness and the resilience of the floodplain vegetation to disturbance. Government policies have stressed the importance of “modernization” of rice farming, leading to interventions in wetland ecosystems from irrigation system expansion and intensification of inputs. Fish rearing has also been promoted in Thailand by market forces, and there are opportunities for reaching a wide domestic and export market for capture and cultured fish. These market forces led to the wild capture fisheries of the Songkhram basin being opened up to large-scale commercial fishing in the 1970s. However, only recently has aquaculture started to gain a measure of popularity in this area, but with limited success.

Land-use and market policies have also been drivers of wetland change in the LSRB. State policies have encouraged the privatization of resources, land conversion and agricultural intensification, with a strong emphasis on irrigated rice through subsidies for agricultural expansion, irrigation infrastructure and agribusiness expansion. Fisheries and wetland management have been more or less ignored until recently. Limited funds have been made available for aquaculture promotion, but the focus has been more on intensive cage aquaculture rather than rice–fish culture or other semi-intensive technologies. The natural flood–drought cycle (flood pulse system) is both a facilitator and regulator of the agro-ecosystem, limiting to a large extent the choices and responses of local resource users, but driving system productivity.

PRESSURES

In the LSRB, the state tends to view the flood–drought cycle as an impediment to development. It seeks to alter the cycle through engineering interventions that will regulate the flow, theoretically supplying more water for rice in the dry season and ameliorating the impacts of floods in the wet season. Crop irrigation and intensification provides the main justification, not aquaculture or capture fisheries. The LSRB has seen three decades of sustained wetland conversion to agriculture, irrigation development and attempts to increase rice double-cropping (with relatively little success). Thus, the extent of failed irrigation infrastructure is obvious in northeast Thailand, where weirs, dams and pumping stations lie abandoned or are underutilized. Despite this,



there are new attempts to promote large-scale, transboundary water transfers from Lao rivers to northeast Thailand for basinwide irrigation coverage projects, including the Songkhram basin (Blake, 2006; Molle and Floch, 2007).

As farmers convert land for natural flood cultivation of rice, they will adapt or modify their fields to accommodate fish culture or permit entry and capture/harvest of wild fish from surrounding waterbodies. The modifications may take many forms, including trenches, pits or sumps, trap ponds and raised bunds. These features will tend to alter the flow of water across the landscape, increase the water storage capacity of the floodplain and, thus, the flood retention time. The construction of irrigation infrastructure also creates ecological and socio-economic pressures and alters the floodplain in various ways. These may unintentionally create new aquatic habitats favourable for fish, as where roads and canals alter drainage patterns and create ponds from borrow pits, or where the construction of dams, weirs and reservoirs create new perennial water resources that are often colonized rapidly by aquatic organisms and utilized by local people. At the same time, these infrastructures can create physical barriers to fish migration, alter water quality parameters, simplify aquatic habitats,

and radically alter the dominant wetland fauna and flora. Thus, some species tend to benefit, while others tend to be disadvantaged by habitat modification.

STATE CHANGES

The conversion of natural seasonal wetlands to multicropped rice fields has led to an expansion of surface water and aquatic habitats on the floodplain, both at the local level and the wider basin level, for storage and delivery of irrigation water. This areal and volumetric expansion of water sources is a major state change in the LSRB. As well as a quantitative change in water at different scalar and temporal levels, there is also likely to be a qualitative change with greater external inputs. This is especially the case where rice cultivation has intensified under “green revolution” principles with greater external inputs, as this has led to a concurrent decline in water quality and to occasional pollution incidents and fish kills. Moreover, there are anecdotal observations by local people of the gradual deterioration in water quality for human and animal consumption (Blake and Pitakthepsombut, 2006b).

It has been observed in Thailand that pressures to increase the area of irrigated rice lead directly to loss of the biodiversity and extent of native flooded forest vegetation, itself a vital habitat in which more than 50 Mekong fish species (some World Conservation Union [IUCN] Red List species) feed and complete their life cycles. This would appear to be causing a serious decline in native fish productivity, a factor in itself that would appear to both encourage further floodplain wetland conversion as livelihood options erode and stimulate interest in alternative farm-based livelihoods over capture fisheries.

Riverine and floodplain habitat diversity are changing in the LSRB as rivers are simplified by in-stream hydrological interventions and land-use changes. Dams, weirs, embankments and other infrastructure are tending to delay and reduce peak flows and attenuate seasonal flows at local and river basin levels. Riverine habitats are being replaced by lacustrine habitats, and downstream areas are becoming drier at some locations as water is abstracted for agricultural uses. This suggests that the aquatic environment is becoming more stressed and less resilient to external shocks.

Clearance and conversion of seasonally flooded forest habitat for irrigated agriculture in the LSRB has led to soil degradation, including declining soil fertility, salinization, and increased erosion. Groundwater levels have been raised and soil salts mobilized by reservoirs and irrigation schemes. Intensification of rice cultivation has encouraged greater use of chemical fertilizers, pesticides and non-native varieties of rice, causing localized pollution and further soil degradation in some instances.

IMPACTS

Rice–fish culture has been widely credited with improving the income status, household nutrition, public health and general social well-being of communities. However, figures from Thailand indicate that profitability in the rice–fish fields was only 80 percent that of rice monoculture (owing to the high initial investment costs in rice–fish culture). However, while the main benefit of rice–fish farming is often seen as providing an opportunity to increase income, the benefits through improvements in household nutrition and food security tend to be less well demonstrated or overlooked. An additional benefit of managed rice–fish culture systems is that the fish may help reduce populations of disease vectors such as mosquitoes and certain species of snail; while also encouraging farmers to adopt IPM practices (reducing the use of chemical pesticides in the process) with direct benefits to environmental and public health.

In the LSRB, it was found that villagers with more land and resources were better able than resource poor and landless households to take advantage of new opportunities presented in fisheries and aquaculture. Nevertheless, being largely an open-access resource, even landless villagers are able to exploit the fishery seasonally, which is often

a reason cited for not investing in major technology, as villagers are afraid others will harvest the benefits.

Conflicts between resource users are common occurrences in multi-use environment and livelihood situations, embodied by wetlands ecosystems. In the case of the LSRB, they are relatively well documented and may happen at the intracommunity, intercommunity, “state – resource user”, and “resource user – private business” levels (Blake, 2006). Villagers using small non-commercial fishing gear are frequently in dispute with those using large, commercial or “destructive” gear, seen as harming the interests of the community as a whole. On the other hand, the auction of fishing rights that allow the exclusive use of such gear can provide income for the benefit of the community as whole. At the same time, there have been long and ongoing disputes between fishers using technically illegal, but locally accepted, fishing gear (e.g. stationary trawls) and the Department of Fisheries, which is charged with enforcing national fishery laws and regulations. Increases in cultured fish yields achieved by the minority would not appear to compensate for the resultant losses in wild aquatic resources borne by the majority. A new and growing threat in the Songkhram basin relates to disputes between powerful private pulpwood eucalyptus-growing interests (tied to transnational companies and national politicians) and communities over the loss of common resources, whether capture fisheries, wetlands foraging rights or livestock grazing.

Local communities are vital stakeholders for effective management of the wetland resources, but their participation in key management decisions has rarely been a prominent feature of past development programmes. These have either involved tokenism or have only rather recently been recognized by state institutions as being a worthwhile or valid form of governance. As a result, there tends to be a growing socio-economic differentiation between those resource users that are economically poor and disenfranchised (e.g. small-scale fishers and landless) and those that are relatively more wealthy and powerful in the community, as common-pool resources are usurped through a form of elite capture. Thus, for example, when large rice farmers turn to fish culture or intensify rice farming, they are in a way enclosing a former common-pool resource and privatizing it, where previously the aquatic resources benefits were shared between many users.

RESPONSES

Responses can be considered at several different levels depending on the actor involved and perceptions towards the wetland or farming system in question (Box 16). On the whole, the Government of Thailand tends to be relatively unresponsive to the needs of diverse livelihood wetland users and the unique characteristics and economic potential of wetlands ecosystems. Government bodies vary in their recognition of, and responses to, wetland issues, often with stark differences in policy and opinion between ministries and departments. This is highlighted in the Songkhram basin. Here, the Office of Natural Resources and Environmental Policy and Planning (ONREPP) wants to propose the LSRB as a potential future Ramsar site. However, the Department of Water Resources, under the same Ministry of Natural Resources and Environment, has been actively pushing for a massive transboundary water transfer scheme to bring water from the Lao People’s Democratic Republic into the Songkhram River basin. These differences expose fault lines between the dominant, more-traditional, sectoral developmental paradigms and the more contextual and pluralistic approaches to development that are steadily gaining recognition in Thailand.

In the LSRB, numerous initiatives were undertaken through the LSRB Demonstration Site of the Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme (MWBP) between 2003 and 2007 to: coordinate research; unite common interests between diverse state and non-state institutions; build capacity; and promote awareness

Box 16**Responses in rice–fish cultures in other parts of South and Southeast Asia**

Along the floodplains in Bangladesh, farmers do not try to alter the environment radically to suit the crop. They tend to work within the natural flood–drought cycle by practising: (i) concurrent culture of deepwater rice with stocked fish followed by dry-season rice or non-rice crops in shallow flooded areas; or (ii) alternating culture of dry-season rice followed by stocked fish in the flood season in an enclosed area, such as a fish pen. Thus, the natural hydrological cycle is maintained.

It is unclear from available literature how the Bangladeshi government institutions involved are responding to the issues and opportunities presented by rice–fish culture integration and impacts. FAO and The WorldFish Center (2004) contend that “Bangladesh is one of the few countries actively promoting rice–fish farming and pursuing a vigorous research and development programme.” Some NGOs would appear to be at the forefront of efforts to extend rice–fish culture, e.g. CARE–Bangladesh, which has promoted rice–fish farming in all its projects as an integral part of its IPM strategy. Apparently, thousands of farmers have experimented with rice–fish culture and have developed practices to suit their own farming systems.

In the south of the Lao People’s Democratic Republic, the government had apparently recognized the results of an 18-month study of irrigation impacts and wanted to incorporate fisheries impact assessments into new water resources and irrigation legislation that was being drafted. The central government had demonstrated its commitment to integrating the approach to complex natural resource based livelihoods with a strong focus on fisheries and small-scale aquaculture by its permission to establish the Regional Development Committee (RDC) for livestock and fisheries in four southern provinces. This helped coordinate research and development efforts between provincial agencies, with a strong link to the Department of Livestock and Fisheries at national level. A follow-up research project funded by the Department for International Development (DFID) of the United Kingdom was planned, where guidelines for the integration of aquatic resource issues into irrigation planning and management would be disseminated through a variety of channels and institutions, active both in the Lao People’s Democratic Republic and the wider region.

of wetlands ecosystem management and biodiversity value. The MWBP was able to coordinate effectively between local, provincial, national and regional bodies, leading to a much greater recognition of the LSRB wetlands in basin planning, including their biodiversity, livelihood and conservation importance. Other key activities included the community-led Tai Baan Research for understanding and addressing fisheries and natural resource management issues; an intermediate environmental flows assessment, and various youth and school conservation activities centred on wetlands.

VALUE OF THE DPSIR ANALYSIS

The DPSIR analysis shows that there has been no integrated response in the LSRB to the challenges posed by the intensifying development of the wetlands for rice production and other uses, and the impacts that this is having on the rice–fish system. Sectoral measures are being taken by different agencies, but there appears to be little or no communication between these agencies, and no attempt to develop a coordinated response. While this situation probably has much to do with interagency relations and professional training, it also stems from the fact that the “ecosystems services” concept, and the linkages between the different ecosystem services, are not well recognized. These are essential understandings that need to be applied in order to ensure the long-term sustainability of these key wetland resources and the multiple benefits. The analysis also suggests that there is a need for cross-agency institutions at national (e.g.

Thai National Mekong Committee) and regional (e.g. the Mekong River Commission) levels that can consider the different interests and take a multisectoral approach to building up such understandings.

The analysis also shows that there is a need to recognize how national policies, including agricultural subsidies and land-use policies, as well as population growth and market penetration, can be influenced as they can have negative impacts on wetland-use systems that are well adapted to the natural conditions and to the needs of the local communities.

CONCLUSIONS

Rice and fish are fundamental components of farming systems and diets in many South and Southeast Asian nations. The rice–fish system provides an example of the symbiotic relationships that can exist in wetlands between different provisioning services / livelihoods and be beneficial for other ecosystem services. This system creates a method of wetland use that is sustainable and can strike a balance in terms of provisioning and regulating services in many cases, provided care and sensitivity are exercised. Wetlands throughout the region have been converted from their natural state to rice fields, encompassing rainfed, deepwater and irrigated systems, which provide suitable environments for fish and other aquatic organisms. The real and potential impacts of the rice–fish system and the general utilization of living aquatic resources from a rice field, in terms of improved income and nutrition, are significant but generally underestimated and undervalued. Despite the potential, the uptake of more management-intensive forms of rice–fish cultivation has generally been low in most countries, and it has not been universally promoted across the region by state agencies.

Beyond the direct provisioning services of the food and income elements of rice and fish culture, rice fields are thought to play an important role in providing certain other ecosystem functions and services, including: groundwater recharge and discharge; flood control; water purification; and sediment/toxicant/nutrient retention. The extent to which these functions are enhanced or debilitated by the rice field environment compared with the natural, pre-agricultural wetland is uncertain. However, the key sociocultural role of both rice and fish cultivation and consumption in the lowland societies of the South and Southeast Asian regions should not be overlooked.

Typically, in the past, with single-sector agencies (usually irrigation-oriented) dominating state-led water management interventions in the developing countries of the region, there was little role for more multidisciplinary and holistic approaches to water management that would recognize the importance of living aquatic resources in the livelihoods of smallholder farmers. There is evidence that this situation is changing, with state agencies starting to take an interest in the role of living aquatic resources in the livelihoods of the poor and to create new implementing and research institutions (such as the RDC) that cross traditional governance barriers in order to be more farmer-focused. Rice fields are being recognized as being more than single-product environments. Multiproduct outputs of rice–fish systems, providing services and valuable ecosystem functions throughout the year even in non-irrigated rainfed paddies, are being recognized. This is enabling more flexible strategies to water management that can provide win–win situations to the resource users, product consumers, communities and the wider environment.

Section III

Responses and guidance

This section focuses on responses and on the ways to move towards guidance. Chapter 9 explores in greater depth than Chapter 3 the response experience in the case database, identifying specific clusters of similar responses and key variables that can affect response development and implementation. Chapter 10 reflects on the experience exposed by the analysis in this report and identifies both potential areas in which to develop responses as well as key areas where further information and conceptual development are needed.

Chapter 9

Response scenarios

Chapter 3 provided an initial review of the DPSIR data concerning responses. The data used in Chapter 3 were aggregated from the database. This obscured the fact that most individual cases have multiple actors and multiple responses, and with one or more DPSI elements being addressed. A somewhat fuller discussion of responses has been given in the relevant sections of Chapters 4–8 for the specific cases reported in detail there. This chapter presents a more holistic approach to the responses of all the database cases, recognizing that they have these three constituent parts (actors, response mechanism, and DPSI element addressed) and that these interact. Hence, it is better to conceptualize a response as being a combination of parts, or a scenario. Moreover, response scenarios are situation-specific, or context-specific, with particular facilitating or constricting circumstances. Having a favourable context, as well as involving appropriate actors and addressing the relevant DPSI elements sensitively, is vital for responses to be able to address effectively the negative aspects of AWIs and to facilitate, or promote, positive measures.

The focus in this chapter is on identifying types of response scenarios that have been implemented and that appear to help achieve a better balance between provisioning and regulating services in wetlands. While it is possible to identify the characteristics of the responses used, it is more difficult to judge the degree to which they were successful in meeting their goals as the data are limited. Nonetheless, this chapter provides an exploration of responses that have been used in different situations and so provides some ideas to be developed in the next stage of the GAWI work.

RESPONSES IN THE CONTEXT OF THE DPSIR ANALYSIS

The DPSIR model has shown links between:

- drivers of change;
- pressures that lead to state changes;
- state changes that can undermine regulating and provisioning services;
- impacts of various socio-economic dimensions, including provisioning services and conflicts.

In addition, there are numerous feedback mechanisms that often reinforce changes.

The analysis in Chapter 3 shows that the bulk of the responses are on the state-change element, and then on the impacts and pressures identified in the DPSIR analysis. This suggests that, for the most part, the responses are coping mechanisms, trying to address the symptoms of the situation rather than focusing on the underlying drivers creating the AWI situations. To some extent, this is to be expected as the immediate “problems” can be identified and can more easily elicit responses in a wetland site, river basin or coastal situation, rather than trying to change the international terms of trade, government policies, or poverty that have been driving the use of wetlands for agricultural purposes to the level where negative consequences result. Hence, an initial

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point is that there is a need to pay more attention to addressing the drivers of change in the bigger picture and seeking to redirect drivers to produce more beneficial AWIs where the balance between provisioning and other services (regulating, cultural and support) is achieved.

Linked to this, it is also important to propose that a response scenario should consider all elements in the AWI situation, as identified by the DPSIR analysis, so that the results from the drivers, in terms of pressures, state changes and impacts, and the feedback mechanisms that they set up, can be addressed. Given that there is often a need to address the situation quickly, it is understandable that ameliorating the negative aspects of state changes and pressures be considered first, rather than waiting for policy-level work to feed through to address the drivers. However, such action tends to be palliative rather than to address the root causes.

Further reflections on the findings in Chapter 3 suggest that it is important to note that the socio-economic impacts, in terms of livelihoods and poverty, need to be given attention at the same time as the biophysical state changes are being addressed. The conflicts that can be created between interest groups through agricultural development in wetlands, especially in less developed countries where marginalization may occur, must be addressed to prevent them escalating and to help create a socio-economic basis for sustainability. In particular, agriculture cannot simply be displaced or greatly reduced without consideration of alternative incomes or livelihoods.

Given the complex and multidimensional nature of responses, it is important to involve all stakeholders, as they may have different roles to play with respect to different DPSIR elements. An inclusive and participatory approach is needed, giving the different stakeholders a forum in which conflicts can be resolved, an opportunity to contribute to wetland management decisions, and ownership over the measures to be applied.

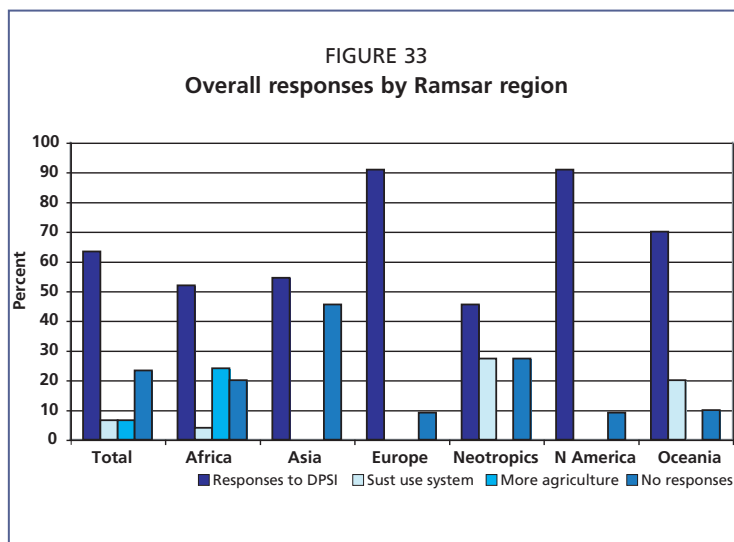
CHARACTERISTICS OF RESPONSE SCENARIOS

In order to analyse the response scenarios, all 90 cases were studied separately (Figure 33).

Almost 63 percent of the cases have responses of some sort attempting to address the DPSI elements of the AWI situations, while 24 percent have no responses reported, or only have proposals for responses. In addition, almost 7 percent show some evidence of an established sustainable-use regime, usually because of a low-intensity and subsistence form of agricultural use. In contrast, there is evidence of ongoing and increasing agricultural exploitation in almost 7 percent of the cases, without any explicit reference to

the need for responses to address negative aspects of this situation where these occur.

The regional analysis of these data shows that the highest level of response was in the cases from Europe, North America and to a slightly lesser degree Oceania, with the lowest rates of response in the Neotropics. This is partly a reflection of the cases that were obtained, and the degree of reporting on responses. However, it is also a reflection of the different levels of awareness of AWI situations and prioritization of these issues relative to other



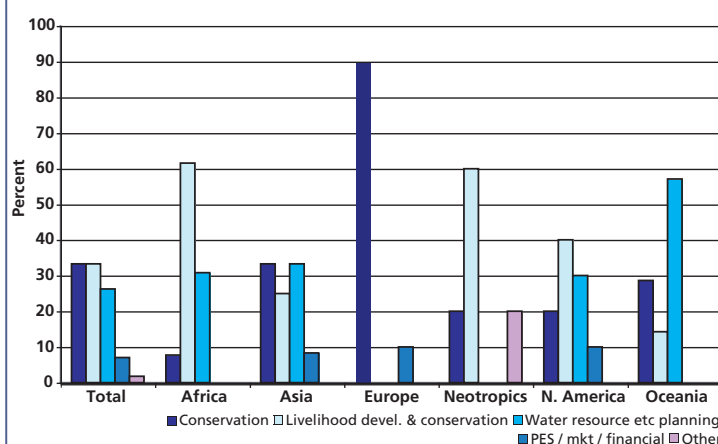
considerations (such as poverty and economic growth), and the differences in the resources available to address AWI issues. The relatively recent development of pressures on wetlands in Africa is reflected in the fact that this is the only region with cases that show responses to include increased agricultural development of wetlands, irrespective of sustainability and environmental issues. Existing sustainable wetland-use systems refer to systems that are of long-standing and where no pressures are reported to exist. These are mostly found in the less developed countries, especially the Neotropics, Oceania (Papua New Guinea and Micronesia) and Africa.

Where there were responses, these were analysed using the initial DPSIR data presented in Chapter 3 and additional information from the checklists. These were then grouped into four scenarios that had some commonality of approach, focusing on: (i) biodiversity conservation; (ii) water resource management; (iii) balancing of conservation and sustainable livelihood development; and (iv) developing market / financial mechanisms. While these categories are not exclusive, and there are considerable variations within the groups, some generic characteristics can be identified for each, as explained below.

Figure 34 shows that there are two leading response scenarios: Conservation; and Livelihood Development and Conservation. The Conservation scenario group (33 percent) includes various cases where protecting or enhancing the natural state of the wetlands, or the human-created biodiversity and/or landscape of a wetland is sought (as with fen meadows and inland fish ponds in the latter case). In most cases, such action is led by the state, with or without some degree of involvement by a local or international NGO, and with varying degrees of community engagement. Some of these cases include the development of ecotourism to create new economic drivers, but this is not explicitly stated in most of these cases. The majority of these cases involve the creation of new drivers, such as incentives for land-use changes and land management practices, state purchase of land for conservation, legislation about the protected status of an area, or the removal of subsidies that had encouraged wetlands cultivation and drainage. In some cases, there are incentives through increased income from ecotourism, or harvesting / fishing / shooting benefits, although these three benefits are more common in the following scenario. Specific technical measures are also common where rehabilitation occurs to address state changes and to reduce pressures. Where displacement of people occurs, responses to address negative socio-economic impacts are also reported, such as alternative income opportunity development.

The Livelihood Development and Conservation scenario group (33 percent) includes cases where there are combinations of conservation/rehabilitation of wetlands or parts of them, with measures to address the livelihoods of communities using wetlands, across a range of market orientations. In these cases, a balance is sought in wetland land use in terms of provisioning and other ecosystem services, and sometimes in terms of the distribution of benefits among stakeholders. One-quarter of the cases in this group (five – eight percent overall) explicitly try to address wetlands and their

FIGURE 34
Detailed response scenarios by Ramsar region



catchments in an integrated manner. This approach seeks to improve the environmental, and especially hydrological, functioning of the system and to produce a better-functioning landscape without the alienation of wetlands from the community for conservation use alone. It also seeks to improve the sustainability of agricultural land use in the catchments and in the wetlands. This is sometimes referred to as a “functional landscape approach”. These cases are typically led by local and international NGOs working with community participation and may involve NGO–government collaboration. There are often specific technical measures to address state changes caused by management practices in the wetlands and catchments, as well as to support the generation of income benefits from semi-conserved wetlands, through fishing, reed-based crafts, and duck shooting. In some cases, these initiatives may involve clarification of community rights to wetlands in order to reduce excessive exploitation caused by open access and to encourage communities to manage wetland resources more effectively.

The third scenario group is Water Resources and River Basin Planning (26.3 percent). This involves a focus on the hydrological system, usually a river basin. As such, it addresses the larger spatial units, rather than individual wetland sites (and catchment) and *in situ* management – which are often the focus in the above two response scenarios. The water resources approach attempts to introduce innovations to manage a river basin in a way that recognizes the multiple stakeholders, the need for efficient use of water, and the importance of environmental flows. These responses are usually led by the state, but with varying degrees of community participation – generally more so in high-income countries. They involve different degrees of rebalancing of water allocations so that in some way the natural hydrological regime prior to agricultural interventions can be replicated to better meet the needs of nature, including wetlands. This response scenario usually includes legislative and institutional development measures to establish management organizations, as well as water allocation arrangements to achieve a more balanced use of water, often with financial incentives to encourage more efficient use. Technical measures are often applied in these cases with respect to water use.

The last specific scenario group is Payment for Environmental Services / Financial / Market Mechanisms (5 percent). It includes three cases where there are a range of financial mechanisms (charges, markets and incentives) that act as new drivers to influence land use and water management in wetlands and their catchments. The experience is difficult to generalize, and it could be argued that these cases should be included in some of the categories above. However, the evidence suggests that these cases involve recognition among stakeholders of the need for the ecosystem regulating and support services provided by wetlands to be better valued (or valued in new ways) and for payments to be made for these and so ensure improved management. To date, there is only one case of PES (for catchment management), one case of tradable water rights, and one case of incentives for land-use change in wetlands to meet environmental management goals (flood control) rather than conservation *per se*.

The regional distribution of these four groups shows that there are major variations by region, with the dominant approaches being: conservation in Europe; livelihood development and conservation in Africa, the Neotropics, and North America; and water resources management in Oceania. Asia shows the most balanced pattern of responses, with conservation and water resources management each accounting for one-third of responses, and livelihood development and conservation accounting for 25 percent (Figure 34).

These variations in responses probably reflect, in part, variations in socio-economic conditions. The richer countries of Europe (and New Zealand) are able to afford to pay for wetland conservation, or use financial mechanisms to achieve wetland land-use change. However, in many of the cases from Africa, the Neotropics and Asia, there is a need to focus on livelihood development in order to address poverty issues. The cases of sustainable livelihood development and conservation in North America are

due to the linkages between the duck lobby and farmers to create wetland conditions that can give increased benefits for ducks, farmers and hunters. Other important regional patterns are the importance of conservation in Asia (33 percent) and Oceania (29 percent), and water resources management in Oceania, North America, Asia and Africa (all more than 30 percent).

SPECIFIC CASES OF SUCCESSFUL RESPONSE SCENARIOS

In order to explore the different types of response scenarios and to identify the links between these and the circumstances that facilitate or constrain them, a number of cases of each type of response are briefly summarized in this section.

Conservation

Lake Kolleru, India

This appears to be an extreme case of removal by government agencies of non-conservation land uses (namely, about 12 500 ha of fish ponds) from the lake and its wetlands to encourage the return of migratory bird species after a 17-year absence. The reason for this was the designation of this lake as a wildlife sanctuary in 1999, as well as its role in balancing water flows between two delta systems. Some alternative land has been made available for a small percentage of the people displaced, while others have been given training opportunities for non-farming/non-fishing enterprises.

Drentse Aa, the Netherlands

Measures have been necessary to respond to the upwelling of polluted groundwater in the Drentse Aa's riverine wetlands in the Netherlands. This has involved using legislation to control pesticide and fertilizer use on farms in the upper valley, as well as the purchase of the lower valley area for use as a nature and cultural landscape conservation area (Chapter 5).

Lake Ellesmere, New Zealand

This coastal lagoon has been seriously affected by the development of commercial farming in the catchment. In particular, effluent entering the lagoon has negative cultural and spiritual implications for the local Maori population. There has also been a decline in local fish stocks, with potentially negative implication for tourism (fishing and duck hunting). Recognizing these negative developments and their implications, a trust was set up to articulate the views of local stakeholders and to develop a joint management plan with the Department of Conservation.

Uganda wetlands policy

Uganda has a strong wetlands policy that seeks to move the country from conversion to conservation. This goal has come about as the result of major destructive uses in wetlands, associated with rice cultivation and grazing, among other agricultural activities. While in the two cases from Uganda, both recognize the national wetlands policy and agree for the need to seek conservation, one specifically addresses the limits of this policy given the intensive agricultural use of wetlands. In this case, wetland conservation measures are applied only in limited areas, and mainly to prevent degradation caused by bank-side cultivation.

Livelihood development and conservation

Wetlands for ducks, the United States of America

Initiatives from an NGO, Ducks Unlimited (DU), in North America has sought to combine the interests of farmers and the duck conservation / hunting lobby in innovative ways. With respect to rice cultivation in the United States of America, DU is working with the Rice Growers Federation to develop hydrological regimes that suit

the ducks – stable winter water levels – and that allow the ducks to undertake weed control during their sojourn on the fallow rice fields. A similar balance of farmer and duck interests has been achieved in Lizard Marsh in Manitoba, Canada. Here, changes in the water management regime and hay-harvesting practices have allowed more hay to be obtained while higher water levels have been kept in parts of the marsh to allow the ducks to breed. Other wetland maintenance and rehabilitation activities in the United States of America have been facilitated through a combination of government policies that provide incentives, or drivers, for wetland maintenance. These are the Clean Water Act (which prevents the filling-in of wetlands) and the Food Security Act (which withholds payments to farmers who convert or modify wetlands).

Functional landscape approach, Africa

There are a number of cases of this approach in Africa, where field-based organizations, usually NGOs, work with communities to improve the livelihood benefits they can obtain from wetlands in a sustainable way and also to maintain the wider environmental functioning – of the catchment for the wetland, and of the wetland for downstream users. One of the most interesting cases is where a local NGO is working in collaboration with the Working for Wetlands Programme (of the South African government), which is trying to re-establish wetlands in order to improve the functioning of the national hydrological system. In another case, a local NGO in Ethiopia is involved in supporting communities to resist government policies that encourage complete wetland transformation, and instead are trying to generate a better balance of catchment and wetland farming that can maximize benefits from the overall natural resources base.

Esmeraldas Province, Ecuador

In response to extensive destruction of mangroves caused by immigrants engaged in fish pond production of shrimps and the negative impacts that this had upon the local gathering economy based on cockles, crabs and fishing, a mangrove reserve has been created. This has given clear rights to the local population and reduced the pressures on their economy. With donor project support, local mangrove committees have been developed to control the size of cockles collected and improve the long-term sustainability of their livelihoods.

Ganges Delta, Bangladesh

There has been involvement of government, NGOs, local community and international agencies in wetland conservation and development initiatives in recent years in degraded sites in the Ganges Delta. The approach combines traditional conservation, including the designation of Ramsar sites, with more bottom-up development approaches. The IUCN Bangladesh Country Office, in collaboration with Ministry of Environment and Forests, the United Nations Development Programme (UNDP) and three national NGOs, has implemented the “Community-based Haor and Floodplain Resource Management Project” in five degraded areas. Responses have focused on both capture and culture fisheries. More attention has recently been paid to developing rice–fish culture systems that are in tune with the flood–drought cycle and that do not seek to alter the environment yet improve household livelihoods.

Water resources and river basin planning

Environmental flows in Australia

As a result of increased environmental awareness in Australia, and especially the adoption of ecologically sustainable development by the government as a guiding principle in 1992, there has been increased awareness of the damage to wetlands as a result of irrigation water offtake disrupting river flows. Responses to this have been

seen in the development of community-based river/floodplain advisory committees or other institutions, with government and local stakeholder representation. Key outcomes have been attempts to improve the efficiency of irrigation water use in order to allow the retention of sufficient water for environmental flows that will to some extent replicate pre-irrigation hydrological flows. However, there are reports that there is sometimes a lack of commitment in government agencies to these goals, poor follow-up by government staff and conservation groups, and continued resistance from the irrigation industry.

Jewel Project, Hadejia-Nguru wetlands, northern Nigeria

River basin water resources planning and management was introduced more than 20 years ago in the Hadejia-Nguru wetlands in order to improve irrigation development in the area. However, poor design and maintenance led to sedimentation and weed buildup in the channels. This is now being addressed through a more participatory approach that is trying to create a hydrological system that also addresses the need for environmental flows to maintain wetlands as well as meeting irrigation needs.

River projects in Canada

In Canada, there is a long history of river management for irrigation and other commercial needs. With increased community awareness and interest in water management for environmental and recreation needs, new river management structures have been developed. These involve wider participation and include the needs of the environment and recreational groups in the formulation of water resources / river basin plans.

Market, PES and financial mechanisms

Deschutes River, the United States of America

Owing to shortages of water for farm irrigation and increasing recognition of the need for improved water quality for recreational activities (which could generate farm income), a community of local and regional stakeholders formed a not-for-profit river conservancy. Through this organization, they created a system of water rights that could be transferred or leased, allowing the holders of these rights to be compensated for not using their full allocation. They also developed target flows for habitat restoration and wildlife in order to meet recreational needs and develop tourism, with a view to diversifying farm income.

Bhoj Upper Lake, Bhopal, India

This is a collaborative programme involving an international non-governmental organization (INGO) working with the local government to fund catchment rehabilitation through voluntary contributions from the tourism industry. This seeks to create improvements to the lake and wetland ecology that will benefit the tourism operators and also improve the livelihoods of the catchment farmers.

RESPONSE SCENARIOS AND FACILITATING CIRCUMSTANCES

A key finding from studying the individual response scenarios is that, in most cases, there is a combination of country-specific or site-specific circumstances or factors that have made particular responses feasible or led to responses being implemented. (This is also seen in the detailed case studies in Section II.) These may relate to: public awareness and support; community motivation and local organization; government policies; national or international legislation; resources availability for actions with respect to wetlands; and pressures/interests from international agencies, INGOs, national or local NGOs, and interest groups.

The dominance of the “conservation” responses in Europe is very much influenced by EU legislation, especially in the cases from the new EU members. However, this builds

on national interest groups and legislation in many countries, with public concerns and national lobbies interested in wetlands, biodiversity and bird conservation. Ecotourism is mentioned in many of these cases as a way of generating additional funds to meet the opportunity costs of land-use change for wetland conservation or the maintenance of less-productive, but more ecologically desirable, uses. However, in most cases, the state is the major source of funding for land purchases for conservation, for payments to farmers (which redirect the drivers for wetland transformation and exploitation through agriculture towards conservation uses), and for technical measures applied to achieve conservation goals.

Conservation in other high-income countries, such as New Zealand and those of North America, is also the result of similar state, community and interest group actions, with state funding important. In the cases of conservation in lower-income countries, there is more involvement from INGOs or local NGOs in support of the state or even local communities. However, in India, the national government and state governments are reportedly funding directly some “rigorous” conservation measures in lake wetlands owing to recognition of their ecological importance. Similarly, in the United Republic of Tanzania, livestock have been “removed” from the Usangu wetlands for both conservation and water resources reasons.

In Africa, and other lower-income continents, the major responses are “Livelihood Development and Conservation” owing to the considerable and diverse uses made of wetlands by communities for provisioning services and the inability of the state or other agencies to displace large populations without political implications or major costs. In these cases, there is often a combination of local or international NGOs working with community-based initiatives, with varying degrees of government involvement. There are also cases of Livelihood Development and Conservation in North America, where DU is working with farmer groups to create win–win situations, where the benefits to farmers and interest groups coincide, and are in line with government policies and incentives that can contribute to these initiatives.

Water resources and river basin planning usually involves government leadership, but it may have different facilitating circumstances. In Australia, the government policy of ecologically sustainable development, combined with local wetland/conservation interest groups and concerns about water management in drought-affected areas, created conditions where discussions about re-establishing environmental flows were easily taken up. The same is true in some respects in Canada, but community interests, especially recreational concerns, have also been important in the cases there. In Asia and Africa, water resources planning has a strong livelihood/provisioning element, with the state trying to address the different interests as situations become more competitive.

The group of responses listed as “PES, Market and Financial” are very diverse, being found in the United States of America, the Netherlands and India. They appear to be the result of very different stimulating and facilitating circumstances – water shortages and farm income pressures, flooding and EU agricultural policy changes, and sedimentation/pollution, respectively. There are also different response initiators, these being communities, the state and an INGO. These represent new initiatives that require some innovative spark or set of circumstances to start their formulation. In the Netherlands, it was the coincidence of flood regulation with the change in the CAP policy; in Bhopal (India), links between community groups and an INGO; and in the United States of America, a combination of water resources shortages and pressures on farmers that could not be addressed in traditional ways.

CONCLUSIONS

In order to achieve sustainable AWIs, a better balance between provisioning and other ecosystem services in wetlands is needed. This requires reducing the pressures from provisioning services and increasing the role that the regulating, cultural and support

services play in the wetland. Analysis of the case database shows that four groups of response scenarios can be identified. While they have specific focuses, there is some overlap in several between the activities and actors involved in the different scenarios.

From the analysis of the response experience, some further conclusions beyond those reached in Chapter 3 can be identified. Combining the findings in these two chapters, it can be suggested that for responses to be effective they need to:

- include multiple elements that help address several or all elements of the DPSI analysis in an AWI situation, including feedback mechanisms;
- address both *in situ* or on-site issues and basin-level issues, recognizing the functional linkages of wetlands;
- involve all stakeholders in an open and inclusive process so that the skills and contributions of the different groups, organizations and individuals can be utilized and ownership of the responses shared;
- include institutional development, as this is critical to response development and implementation;
- be sensitive to the specific circumstances they are operating in, and respond to facilitating factors and bottlenecks.

Overall, responses must be sensitive to socio-economic, poverty reduction and ecological needs in wetlands in order to ensure the sustainable use of wetlands for multiple ecosystem services that benefit soci

Chapter 10

From analysis to guidance

AIMS AND CONTEXT OF THE GAWI INITIATIVE

The goal of the GAWI initiative is to support the development of “sustainable agriculture–wetlands interactions”. This is seen in terms of achieving healthy wetland ecosystems that sustain human well-being. Using the ecosystem services framework, sustainability requires that a balance be attained, and maintained – among the multiple ecosystem services, and within the service types. Overdependence on one or a limited number of services is the major cause of exceeding the carrying capacity and damaging the resilience of wetland ecosystems, and hence their ability to operate and cope with shocks. In the long term, this leads to the destruction of the ecosystem with the loss of services it provides (provisioning, regulating, cultural and support). In terms of the GAWI work, the emphasis is not so much on realizing such balances through measures that will mitigate the negative impacts of agriculture in wetlands, but rather in rebalancing the state of ecosystem services so that multiple provisioning and non-provisioning services can be put to fruitful use. This will involve support from regulating, cultural and support services for provisioning ones, while the provisioning services are developed in ways that help maintain the regulating and support services.

In searching for this balance in wetland ecosystems, it has to be recognized that there are increasing demands upon these areas as a result of population growth, changing consumption patterns in response to improving standards of living, and measures to help address the MDGs, especially poverty reduction and food security (Chapter 3). As these demands are primarily directed towards enhancement of the provisioning services, there is an urgent need to counter this trend with a more explicit recognition and utilization of the wider services that ecosystems can offer (e.g. regulating, cultural and support). The important and growing role of wetlands in contributing to livelihoods has been emphasized in recent work such as the CA, which points out their high potential in meeting growing demands for food and water. Indeed, the drivers behind such pressures (population and economic growth) are likely to remain for several decades, and the demands for increased economic output and food production are set to grow substantially for the next 30 years. The expectation is that more wetlands will be affected negatively unless appropriate action is taken. In this situation, it is critical to develop and apply guidelines for sustainable AWIs that can: (i) rebalance the ecosystem services; (ii) manage and reduce the negative impacts associated with the use of provisioning services; (iii) stimulate the generation of income from other ecosystem services; and (iv) ensure the maintenance of the full range of ecosystem services in these areas.

PROBLEMS, SCOPE AND “ISSUES” OF SKEWED ECOSYSTEM SERVICES IN AWIS

A first step in moving towards such guidance is to develop appropriate tools to understand the situation of wetlands today as they interact with agricultural pressures.

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The DPSIR framework has been used for this purpose in the expectation that better analysis of the situation can help to inform guidance about future responses. The database analysis in Chapter 3 has shown the diverse range of drivers, pressures, state changes, impacts and responses that are encountered in AWIs. Population pressures, local and international markets, and government policies are the major drivers, with climate change beginning to be seen in some areas. These are leading to pressures in wetlands in the form of agricultural expansion, agricultural intensification, and increased alteration of water resource conditions. State changes in the biophysical characteristics of wetlands affected by agriculture are seen mainly in the form of changes in the hydrological regime in the wetlands, biodiversity loss, sedimentation in wetlands, loss of soil fertility and increased soil erosion, and water pollution. The socio-economic impacts are mostly seen in positive increases in crop production and to a lesser degree in aquaculture, while subsistence agriculture and other gathering practices in wetlands have declined. Negative socio-economic impacts are found in up to almost half of the cases in some regions, with increased socio-economic differentiation and conflicts. Responses are mostly seen at the field level with technical measures to address state changes and, to a lesser degree, pressures.

The five cases subjected to detailed DPSIR analysis show the diversity of experience and confirm the need for individual and context-specific application of the DPSIR method. They include examples of the potential for applying PES where markets are sufficiently developed, and the need for GAPs in catchments as well as wetlands, including methods to adjust wetland agriculture towards the conditions in these areas rather than changing the conditions completely. Moreover, there is evidence of the need to consider how to address major external drivers, such as in the demand for palm oil and rice, as well as the question of how to maintain symbiotic relationships between rice and fish/shrimps/prawns within wetlands and in upstream/downstream situations.

Overall, the GAWI analysis confirms the picture that the MA and CA have identified, with a skewed pattern of exploitation of ecosystem services in wetland ecosystems. The exploitation of one, or a limited set, of specific provisioning services, such as rice cultivation, aquaculture, and irrigated vegetables, is frequently re-enforced and overdeveloped by increased market access and/or demand for the product in question. Such drivers may lead to a mono-use of ecosystem services, even to monocropping, and cause major changes in the state of the ecosystem. This is especially the case with agriculture in wetlands, where the resources base and environment are purposely altered and optimized to maximize food production through water control infrastructure, drainage and land development, and fertilizer and pesticide use. At the same time, the consequences of these interventions on the other specific functions and services of the ecosystem have frequently been disregarded and not controlled.

The analysis also confirms that this imbalance often has implications for the medium-term and long-term sustainability of the wetland agriculture and aquaculture, and more immediately for the regulating and support ecosystem services of wetlands. As a result, it is suggested that the way ahead has to involve a rebalancing of the use of ecosystem services. This must ensure that the provisioning services are not exploited to the state where the regulating and support ecosystem services are undermined with negative *in situ* and downstream consequences, such as through flood control and an altered hydrological regime. Moreover, these regulating and support ecosystem services need to remain functioning in order to maintain the provisioning services.

SCOPING OUT REBALANCING OPTIONS

Building on these global and case study levels of analysis, a number of areas for action can be identified in order to move towards sustainability in AWIs, and at the same time to help meet the increased demands being made of wetlands. These include:

- reducing the pressures from agriculture on wetlands and the negative state changes and impacts by diversifying the provisioning services used;
- diversifying the demands on wetlands so that different ecosystem services can generate income, especially through PES;
- managing basin-level land use in ways to facilitate the maintenance of ecosystem services;
- improving agricultural practices so that they are more sensitive to ecosystems and their requirements;
- redirecting the drivers of change so that the specific needs can be met in other ways that do not create negative state changes in wetlands or elsewhere in the river basin system.

These activities can and need to be undertaken at different scales, *in situ* within a wetland site, and basinwide – including catchments and wetlands. They are discussed below in order to explore some of the major conceptual and practical issues involved.

Diversifying provisioning services

In order to reduce the pressures operating on wetlands while maintaining or increasing the total livelihood benefits from these areas, a diversification of the provisioning services that are used is being proposed, as in the two “ecosystem” scenarios of the MA, “adapting mosaics” and “techno gardens” (MA, 2005b). (Some examples of this approach were identified in Chapter 9 with respect to the “Livelihood Development and Conservation” responses and traditional sustainable-use wetland management regimes.) The diversification of provisioning services (consisting of crop production, livestock, fisheries and gathering) has the potential to cut two ways into the problem of unsustainable AWIs:

- Diversified agriculture and other provisioning services are deemed to be more in line with the diverse ecosystem characteristics, resulting in overall lower stresses (i.e. pressures and state changes) on the system while providing more scope for non-provisioning services to coexist (or even thrive) with agriculture.
- Diversified agriculture has the potential to sustain multiple livelihoods and thereby address negative socio-economic impacts, such as marginalization, differentiation and conflicts, and their resulting feedback pressures for further expansion/intensification of agriculture in wetlands by affected stakeholders.

The new pattern of provisioning services would be more ecologically suitable for the wetlands and should help maintain regulating and support services with a different, but possibly higher, total value of provisioning output.

The DPSIR analysis is especially useful in helping explore the potential trade-offs and value of such a multiple-use regime as it can identify which provisioning services are affecting which livelihoods and stakeholders, where there are tensions and potential trade-offs, and what is driving the skewed provisioning or overdevelopment of one specific provisioning service. However, the amount of evidence of multiple-use regimes is limited in the database cases, and more attention needs to be given to identifying and exploring the dynamics of such experience. Moreover, it remains a challenging aspect of this approach to identify how to restrict the impacts of market-driven agricultural responses that frequently steer agricultural production into selected products and production systems, often with monocropping. Conversely, it is important that the responses proposed, whether affecting provisioning, regulating or cultural services, reflect market realities.

Diversifying into other ecosystem services for livelihood benefits

The key message of the MA is that ecosystems provide multiple services with which to support human well-being. From this are derived the concept and argument for the conservation and sustainable use of ecosystems through a balanced use of these

multiple services. However, the analysis in this report shows that the general and global benefits from the regulating, cultural and support services, such as climate-change mitigation, a healthy environment, and aesthetic value, do not provide strong enough drivers at the local contextual level to push for the utilization of ecosystem services in this balanced manner. Rather, the very concrete and economic drivers that push in the contrary direction for provisioning services lead to a skewed utilization of ecosystem services.

In order to move towards a more balanced use of ecosystem services in wetlands, there is an urgent need to make non-provisioning ecosystem services economically tangible and relevant in the socio-economic impacts and contexts in which the ecosystems are situated and used. There are two modalities to do this:

- through direct payments/compensations for delivery of specified non-provisioning services (e.g. water purification, flood attenuation, carbon sequestration, and recreation and tourism) by specified service buyers to service providers (UNECE, 2007);
- through sector-wide approaches to regulations, incentives and compensations that are made available by governments to sectors to induce and foster particular non-provisioning services within and by the sector.

The former are known as “payments for environmental services” (PES), the latter as cross-compliance mechanisms.

The great attraction of the PES approach lies in the mechanisms it provides to reap financial benefits for traditional latent services—particularly regulating (water regulation, flood control and purification) and cultural (recreation and tourism) services—from direct beneficiaries (or service derivers) to service providers. It is proposed that these payments can replace the income from provisioning sources, provided a market can be identified and payments for these services obtained. However, more work is needed to develop ways of assigning values / economic benefits to non-provisioning services in ways that are tangible and affect decision-making, and that can also generate concrete economic benefits, usually by means of averted investment, for the stakeholders involved. This is essential if it is to be possible to identify monetary compensation or payments for these services.

To date, the most successful cases of PES have been based on the principle of cost avoidance, where revitalizing the regulating services of ecosystems is cheaper than the technological alternatives of water purification or refurbishing the dykes (Chapter 5). Other potential payments, which may soon be operational, relate to carbon storage in wetlands and peat forests (Chapter 7), where a market is being developed through policy drivers. However, with respect to ecohydrological infrastructure, biodiversity and other cultural services, rigorous methods that can ascribe specific economic value on these services remain to be developed. Moreover, further understanding of the full range of hydrological services provided by different types of wetlands requires further study (Bullock and Acreman, 2003).

The skill with PES is to transform latent regulating/cultural services into alternative provisioning services that provide land and resource users with an alternative source of economic livelihood and thereby reduce the demand for ecosystem transformation for the development of provisioning services. If successful, PES can be a powerful tool in rebalancing ecosystem service exploitation towards a more sustainable equilibrium, as long as it provides tangible and competitive alternative income compared with traditional provisioning services.

However, in this latter aspect, there are problems as the level of financial compensation offered by PES schemes for environmental land uses¹⁴ is generally considerably less than that which can potentially be obtained through the exploitation

¹⁴ For example, specified forms of land use that are deemed to enhance the regulating and supporting services of ecosystems.

of single provisioning services (Kiersh, Hermans and Halsema, 2005). Questions are still raised as to whether PES can truly (i.e. fully) provide for alternative economic income when compared with traditional provisioning services. Hence, it appears that PES may be primarily a means of providing (additional) secondary economic benefits for land uses that are already predominantly earmarked for environmental uses, a type of economic insulation against sliding into a market-oriented overexploitation of a single provisioning service.

Another key challenge with PES is to ensure that the ecosystem services compensation is actually accrued at the local level, compensating local users and managers for their sustainable use and management, as well as compensating losers for restricting the overdrive of provisioning services. This requires major institutional development as well as mechanisms for measuring the ecosystem services maintained and the different contributions of the various stakeholders and members of the communities.

The value of the DPSIR analysis in this area is that it can help to assess the tangibility of socio-economic impacts from these regulating and cultural services and to identify potential service buyers and service providers. It can also show which ecosystem services are most relevant and where further work is needed in the development of valuation processes. This is especially so for hydrological functions and biodiversity values as discussed above.

Functional and strategic planning at basin scale

The idea of strategic and functional planning of ecosystem services at basin level is another area where actions to improve AWIs are possible. While conceptually sound, there is in practice little evidence of this being applied, even in integrated water resource management. Such planning of ecosystem services, with wetlands as a focus, would involve a development of strategic land-use planning to identify the most appropriate patterns of catchment and wetland use in order to ensure the sustainable functioning of the wetlands. Part of this work would include a technical analysis to identify which wetlands should be kept pristine, in which others to allow development, and the appropriate nature or intensity of this use. In other words, the primary function of some wetlands would be in providing regulating services, while the primary function in others would be in provisioning. However, in each case, there would also be secondary functions from the other ecosystem services, and there would be a need to try to ensure that the primary function did not completely undermine the secondary functions. Hence, where agriculture in a wetland is assigned a secondary function, it would probably be very different to where agriculture is assigned as a primary function (below).

Implementation of such basinwide planning requires the development of technical and institutional support. It also faces various problems, such as existing land uses, winners and losers of land-use changes, and how to enforce changes. As such, this is a highly political process, which supposes, or imposes, a high and probably unrealistic level of governance and regulatory capacity. This concern points to the importance of the DPSIR analysis, as it is more through influencing drivers that progress towards a desired pattern of land use is most likely to be achieved.

To take this approach forward, it is necessary to explore how to address the following building blocks that are not yet sufficiently developed:

- How to select the primary function in subcatchments/systems and wetlands between provisioning (well-established), regulating (emerging for water purification and flood control), and cultural (limited to nature/biodiversity and tourism) ecosystem services.
- How to foster and enhance as much as possible the exploitation and “existence” of the “secondary ecosystem services” to coexist with, and support, the primary services, so that multiple-ecosystem services can be derived from the wetland.

For these issues to be addressed, knowledge is lacking in a number of areas. This is

especially true in the following areas that this GAWI study has identified as requiring further consideration, and often research, in the immediate future:

- a. Carrying capacities of wetlands under different agro-ecological and socio-economic conditions so that the ecological bounds for different provisioning uses can be identified.
- b. Good agricultural practices (GAPs) in wetlands or basins for agriculture as the primary provisioning service; practices that will address/minimize negative pressures and state changes, in particular with regard to indirect basin-level AWIs, and maximize production in a sustainable manner.
- c. Good agricultural practices (GAPs) for secondary provisioning services, where agriculture is assigned a secondary rather than primary function/role in a wetland and is subservient to regulating or cultural services. Hence, this is primarily directed to *in situ* interactions.
- d. Enhancement of biodiversity and other cultural services as a secondary livelihood support or supplement to the income for wetland agriculture.
- e. Developing regulating services, in particular hydrological ones, as the primary ecosystem services in wetlands, as in the Netherlands floodplains, and the Katskill and the Deschutes areas in the United States of America.
- f. Developing cultural services, especially biodiversity conservation, as a secondary productive service – through income generation, when other ecosystem services are the primary ones allocated to specific wetlands. The question here is how to exploit secondary provisioning and regulating services economically to the fullest to provide economic insulation against provisioning pressures and drivers.

In most of these cases, there are potential agencies whose research agenda could cover the issues raised. The CGIAR group in particular could address the first three of the above, especially “b)” and “c)”, with the latter being a particular challenge and area never addressed before. Both “a)” and “c)” need expertise from ecologists. In some cases, such as “d)”, some work is already being undertaken. However, this is mostly within a framework of the EU or the United States of America, and is always dependent on government compensation and regulation. The question is how such enhancement can be achieved in other socio-economic contexts. On the hydrological issues, there remains much work to be done to clarify, measure and value the hydrological roles of wetlands, with inputs needed from wetlands and hydrologists competent in integrated water resources management (IWRM).

Basin-level strategic planning also faces major problems with offsetting impacts. As emerges from the analysis in this report (and this is considered a strong point of the DPSIR approach), AWIs are found to have diverse socio-economic impacts, both within provisioning services, as well as between ecosystem services that directly affect different stakeholders and sectors. Any rebalancing of ecosystem services is consequently bound to involve a redistribution of the benefits derived from the ecosystem among these stakeholders and sectors. This makes the problem of strategic basin planning very complex, and also non-technical, or rather political, in many aspects. Offsetting these impacts will be helped by diversifying the exploitation of provisioning and other ecosystem services (above), as the more diverse the benefits are, the more stakeholders/sectors that can benefit. However, this is not merely a question of technical responses. It is one where attention needs to be given to the differential impact of drivers and pressures upon different groups, as well as the overall demands from powerful drivers (e.g. market forces), or perverse incentives for overdrive.

The DPSIR analysis is useful in exploring the differential socio-economic impacts of AWIs, in other words how diverse benefits relate to diverse stakeholders and DPSI elements. It can also show how negative impacts can be addressed by diverting pressures away from the ecosystem by providing alternative livelihood/economic benefits from other sectors of society. In terms of functional and strategic planning at

basin level, more work needs to be done to specifically adapt the DPSI analysis to a spatial pattern of the drivers, pressures, state changes and impacts.

SCOPE FOR GAWI GUIDANCE

There is much to think about in terms of further scoping and development of the ways of addressing AWIs. However, in regard to meeting the goals of the GAWI initiative, the guidance in terms of where this guidance should be directed is clearer. From a pragmatic point of view, it can be suggested that the GAWI project should focus on areas or fields that are: (i) feasible; and (ii) deemed desirable.

This scoping for which, what and who are meant to be addressed with the GAWI in general, can (and needs) to be conducted on several grounds, including rate of wetland loss, importance of wetlands for various reasons, and the ability of GAWI to achieve a positive impact. A key consideration is the type of agriculture–wetland situations to be considered. In view of the old divide between nature conservation and development (i.e. wetlands vs agriculture), there is little scope to address either of these two extremes with the GAWI – or for that matter imply that there is a “middle way” that can encompass the whole range of AWIs from pristine wetlands to agricultural production systems. There are ample good reasons to pursue a conservation strategy for biodiversity hot-spots, and these have been pursued by Ramsar since its inception. Similarly, the development of highly intensive agricultural production areas are adequately covered and pursued by the agriculture sector.

In the light of this argument, it can be suggested that the primary area for GAWI support should be in the middle ground, and especially in areas where the agricultural frontier is expanding into wetlands and where there are opportunities to pursue more efficient resources use (especially water and nutrients) and higher productivity, and to further limit or mitigate negative impacts (CA, 2007). The reason for this focus is based on the MA view that the largest and continuing loss of wetlands is to be found in the large “middle ground” of “ordinary” aquatic ecosystems (MA, 2005a and 2005b). Similarly, the CA indicates that the additional land and water resources to meet growing demands are increasingly set to be taken from suitable “ordinary” ecosystems (CA, 2007).

For the purpose of scoping, the large “middle ground” of “ordinary” or common aquatic ecosystems that are set to interact with agriculture will have to be defined in a more specific manner. A possible way to do this is to take Table 3 as a basic wetland typology, and to assess in more detail the suitability and likelihood of agriculture interactions to develop in the coming decades. This should yield a considerably narrowed-down typology of wetlands liable to severe agriculture/aquaculture pressures.

TOWARDS GUIDANCE

To conclude this report, it is appropriate to confirm what the study has achieved and what the key challenges are.

The key points are:

- Agriculture–wetland interactions are governed by very diverse and situation-specific configurations of DPSIR elements, with particular diversity in the state changes and impacts reflecting how drivers are translated into agricultural exploitation.
- The DPSIR analysis has provided a new and informative conceptual approach to the analysis of AWIs by incorporating the ecosystem services concept of the MA. Apart from showing how AWIs lead to negative impacts in state changes (primarily through diminishing regulating, supporting and cultural services), this method also shows that there are direct trade-offs between stakeholders and livelihoods that benefit from different provisioning services within wetlands.
- Restoring ecosystem services and obtaining a symbiotically beneficial balance

in ecosystem services has little evidence-based information or experience. It is an intricate and difficult issue to resolve as it inevitably means a redistribution of economic benefits among stakeholders in order to redress established trade-offs. To date there is only evidence of this in OECD countries and India, where economic compensation measures have been applied.

- Intensification of agriculture in wetlands is leading to socio-economic and ecosystem service differentiation, with specific groups of people benefiting and those who rely on subsistence uses of wetlands losing out. This constitutes a negative feedback loop where losses in subsistence agriculture and uses lead to further pressures and transformation of wetlands.
- Responses need to be specific to a situation/case and address the DPSI elements of that case in their particular context and with recognition of specific facilitating factors.
- The real driving forces in the AWIs need to be addressed, rather than the symptoms. This action will be more effective if there are interventions at multiple levels based on the DPSIR analysis to identify key elements at the different levels, with, for example, GAPs to address impacts, but policy changes to redirect drivers.
- Responses need to be directed on three fronts:
 - fostering GAPs to reduce negative state changes at both basin and wetland-site levels;
 - restoring and economically exploiting regulating and cultural services, whereby economic benefits can be tapped for associated compensation measures and redressing of benefit redistribution among stakeholders;
 - invigorating permissible multiple provisioning service exploitation, such as fishing, agriculture and gathering, to enlarge the livelihood benefit while staying within the ecological resilience boundary.

To conclude, some potential areas of intervention are beginning to be identified around which specific guidance can be developed. However, there are also major challenges in terms of conceptual understanding, research findings and practical experience. To address these, a number of different organizations need to be engaged to take this work forward. However, this work must be undertaken in a coordinated manner with collaboration and dialogue between the organizations undertaking the various elements described above, and with these seen as a series of interlinked “modules”. The necessary dialogue to develop this collaboration has started in the GAWI process, which has led to this report. It now needs to be driven forward with commitment by an appropriate agency. Of these elements, it is suggested that GAWI initiative take up for immediate elaboration: (i) guidelines for the application of DPSIR in AWI response strategies; (ii) a compendium of GAPs for responses of indirect interactions as scoped out in this report; (iii) guidance for good practices in economically revitalizing regulating and cultural services; and (iv) addressing socio-economic impacts through diversified livelihood responses.

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- Zwarts, L., Beukering, van, P., Kone, B. & Wymenga, E.** 2005. *The Niger, a lifeline: effective management in the upper Niger basin*. Wageningen, Netherlands, RIZA/Wetlands International.

Annex 1

Ramsar COP Resolution VIII 34**RESOLUTION VIII.34****AGRICULTURE, WETLANDS AND WATER RESOURCE MANAGEMENT**

1. RECOGNIZING that agriculture, whether large- or small-scale, shifting or permanent, extensive or intensive, commercial or subsistence, including crop production, animal breeding, pastoralism, horticulture, and plantation, is an essential activity for human survival and food security at local, national and global levels, and for sustaining livelihoods;
2. ALSO RECOGNIZING that in many parts of the world, agricultural activity has been responsible for creating distinctive and characteristic landscapes, including wetland ecosystems;
3. FURTHER RECOGNIZING that agriculture is also a major form of land use and that river valleys, floodplains, and coastal lowlands in particular have frequently been used for agriculture because of their natural suitability and the demands of agriculture for flat, fertile land and a ready supply of fresh water, and that therefore there is a high priority to ensuring that agricultural practices are compatible with wetland conservation objectives;
4. AWARE that wetlands can play important roles in relation to agriculture, such as abating the effects of storm and flood events, thus helping to protect both habitation and agricultural land, contributing to the replenishment of aquifers that are the source of water for irrigation, and constituting the habitat of wild relatives of cultivated crops and grasses;
5. NOTING the high dependence of local communities on wetland resources, particularly in developing countries and notably in terms of small-scale subsistence agriculture, domestic water supply, and other uses that may contribute directly to poverty alleviation;
6. ALSO NOTING that the poor, in particular women, often depend on wetland resources for their livelihoods and can be severely disadvantaged if wetlands are degraded or lost;
7. CONSCIOUS on the one hand that drainage and intensive cultivation of such areas have led to widespread and continuing wetland loss, and on the other hand that sustainable agriculture supports some important wetland ecosystems;
8. AWARE that agriculture can have impacts on water quantity and quality, and in particular that agriculture is a) a major user of water, and b) in certain cases, a major polluter, for example through pollution of surface and groundwater due to the runoff of fertilizers and plant protection products such as herbicides, fungicides and pesticides; and REALIZING that the precise impacts of agriculture on wetlands and water resources vary within and between regions, depending upon natural conditions and upon the type of technologies applied;
9. NOTING that uncertainties relating to wetland tenure systems and user rights over wetlands and water resources can have severe negative impacts on sustainable wetland management and in particular on poor communities that depend upon wetlands resources;
10. FURTHER AWARE that economic hardship in many parts of the world is causing people to practice some forms of unsustainable agriculture, resulting in

- degradation of natural resources, including vegetation, soil and fresh water, and that these phenomena may be exacerbated by the direct or indirect effects of agricultural policies and practices in other parts of the world;
11. CONCERNED that global climate change and accelerated desertification are projected to have major impacts on future patterns of availability and distribution of water, and on the functions and values of wetlands, as well as on agricultural production;
 12. CONVINCED that, in conformity with the Ramsar ‘wise use’ concept (as defined by the Conference of Parties), concerted efforts are required to achieve a mutually beneficial balance between agriculture and the conservation and sustainable use of wetlands, and to prevent or minimize the adverse effects from agricultural practices on the health of wetland ecosystems throughout the world, taking into account the precautionary approach as set out in Principle 15 of the Rio Declaration on Environment and Development;
 13. FURTHER CONVINCED of the important role in the area of agriculture and water of United Nations specialized agencies and programmes and relevant international initiatives;
 14. AWARE of the Dialogue on Water, Food and the Environment coordinated by the International Water Management Institute (IWMI) and involving a broad range of international partners;
 15. TAKING INTO CONSIDERATION the information and guidance contained in the Ramsar Handbooks for the wise use of wetlands, especially the *Guidelines for integrating wetland conservation and wise use into river basin management* adopted by the 7th Conference of the Contracting Parties, as well as the River Basin Initiative being developed jointly by the Secretariats of this Convention and the Convention on Biological Diversity (CBD), and Ramsar COP7 Resolutions VII.8 and VII.21, paragraph 15;
 16. FURTHER TAKING INTO CONSIDERATION the CBD Decision III/11 on Conservation and sustainable use of agricultural biological diversity and the multi-year Work Programme in Decision V/5; and TAKING INTO ACCOUNT the relevant sections of the 3rd Joint Work Plan 2002-2006 between the CBD and the Ramsar Convention, in particular Activity 5;
 17. REALIZING that the present meeting of the Conference has adopted further guidance relevant to agriculture, wetlands and water resource management, notably the Resolutions on *Guidelines for the allocation and management of water for maintaining the ecological functions of wetlands* (Resolution VIII.1), *New Guidelines for management planning for Ramsar sites and other wetlands* (Resolution VIII.14), *The Report of the World Commission on Dams (WCD) and its relevance to the Ramsar Convention* (Resolution VIII.2), *Climate change and wetlands: impacts, adaptation and mitigation* (Resolution VIII.3), *Principles and guidelines for wetland restoration* (Resolution VIII.16), and on impact assessment (Resolution VIII.9); and NOTING that the Resolutions on *The Ramsar Strategic Plan 2003-2008* (Resolution VIII.25), *Incentive measures as tools for achieving the wise use of wetlands* (Resolution VIII.23), *Guidelines for rendering the use of groundwater compatible with the conservation of wetlands* (Resolution VIII.40), and *Conservation, integrated management, and sustainable use of mangrove ecosystems and their resources* (Resolution VIII.32) are relevant for the preparation of guidelines on agriculture, wetlands and water resource management; and
 18. AFFIRMING that this Resolution is intended to focus specifically on the relationship between agriculture and wetlands and is not in any way intended to be used to support agricultural policies that are inconsistent with trade-related agreements;

THE CONFERENCE OF THE CONTRACTING PARTIES

19. CALLS UPON Contracting Parties to ensure that management plans for Ramsar sites and other wetlands are developed within wider integrated catchment management approaches which duly acknowledge the need for appropriate implementation of agricultural practices and policies that are compatible with wetland conservation and sustainable use goals, and URGES Parties to identify and enhance positive incentives for the conservation and sustainable use of wetlands, including sustainable agricultural systems related to these wetlands;
20. FURTHER URGES the Contracting Parties when reviewing land tenure policies to consider, where appropriate, wetland tenure systems and user rights in a manner that promotes fair, transparent and sustainable management of wetlands and their resources;
21. URGES Contracting Parties, when reviewing their agricultural policies, to identify possible subsidies or incentives that may be having negative impacts on water resources in general and on wetlands in particular, in their territories and/or elsewhere in the world, consistent with their other international rights and obligations, and to remove or replace them by incentives that would contribute to wetland conservation;
22. INVITES Contracting Parties that have not yet done so to initiate intra- and inter-ministerial dialogues including, as appropriate, institutions represented in Ramsar/ National Wetland Committees where these have been established, with a view to enhancing integration of relevant policies related to the conservation of water resources, wetlands, and biodiversity;
23. REQUESTS Contracting Parties, when implementing this Resolution, to ensure that the activities and support measures indicated in paragraph 21 should not support agricultural policies that are inconsistent with trade-related agreements;
24. INVITES the International Organization Partners (IOPs) to the Convention, in close cooperation with the Ramsar Bureau, to work with other relevant bodies, in particular the Food and Agriculture Organization of the United Nations (FAO), to expand upon current reviews of the-state of knowledge concerning the interactions between agricultural practices and wetland functions and values;
25. REQUESTS the Scientific and Technical Review Panel (STRP), working in cooperation with relevant international organizations and drawing on the review requested from the IOPs, to:
 - a) establish a framework for identifying, documenting and disseminating good agriculture-related practice, including site-specific and crop-specific information, and policies that demonstrate sustainable use of wetlands for agriculture; and
 - b) use this framework to develop for consideration at COP9, and possible incorporation into the site-management guidelines annexed to Resolution VIII.14, wetland-type specific management guidelines to
 - enhance the positive role that sustainable agricultural practices may have vis-à-vis the conservation and wise use of wetlands;
 - minimize the adverse impacts of agricultural practices on wetland conservation and sustainable use goals; and
 - include examples based on wetland-type specific needs and priorities that take into account the variety of agricultural systems;
26. INVITES the National STRP Focal Points to provide Contracting Parties' input for the preparation of the review and concise guidelines called for in the preceding paragraph;
27. REQUESTS the Ramsar Bureau, with the support of Contracting Parties and IOPs, to identify agriculture-related management practices developed for areas that include Ramsar sites, to contribute this information to the preparation of the

- guidelines as requested in paragraph 25 above, and to share it with the Secretariats of CBD and the Convention to Combat Desertification (CCD);
28. FURTHER REQUESTS the STRP to ensure that adequate consideration of agriculture and wetland issues is incorporated into other relevant areas of work that the STRP may be dealing with, including global climate change, groundwater and its interaction with surface water, toxic chemicals, and desertification, as a contribution in the latter case to the implementation of the Memorandum of Cooperation between Ramsar and CCD;
 29. FURTHER REQUESTS the Ramsar Bureau to ensure that the corresponding information generated by the implementation of this resolution, once approved at COP9, will be incorporated in future updates of the Ramsar Wise Use Handbooks and to work closely with the CBD Secretariat to incorporate appropriate joint actions derived from the content of this Resolution in the next review of their Joint Work Plan;
 30. FURTHER REQUESTS the Secretary General to seek Ramsar representation in the Dialogue on Water, Food and the Environment and to build on existing links with that Dialogue's secretariat; and
 31. INVITES Contracting Parties, IOPs, STRP members and National Focal Points, and others to contribute information on wetlands and agriculture to the Wise Use Resource Centre maintained by the Ramsar Bureau, to the activities of the River Basin Initiative and to the Dialogue on Water, Food and Environment and future meetings of the World Water Forum.

Annex 2

Checklist format

CHECKLIST FOR WA/WUR ANALYSIS OF CASE STUDIES REVISED FORMAT

Name		
Type of wetland	Development situation	
Type of agriculture	Ramsar region	
ELEMENTS OF DPSIR MODEL	NATURE OF ELEMENT	COMMENT
DRIVERS		
Natural or human-induced forces that affect a wetland and wetland-related agricultural system, such as population growth, economic development or climate change (direct and indirect drivers, superficial and deep drivers)		
PRESSURES		
Stresses (positive or negative) on a wetland and wetland-related agricultural systems, resulting from the drivers		
STATE		
Changes in the quantity and quality of various environmental media (soil, water, air, etc) in wetlands and wetland-related agricultural system, resulting from the pressures		
ECOSYSTEM REGULATING SERVICES		
<ul style="list-style-type: none"> ➤ Water storage ➤ Groundwater recharge ➤ Groundwater discharg ➤ Flood contro ➤ Sediment retention function ➤ Nutrient retention ➤ Biological diversity ➤ Storm protection ➤ Microclimate stabilization 		
IMPACTS		
The socio-economic consequences of state changes		
SOCIO-ECONOMIC PRODUCTS		
<ul style="list-style-type: none"> ➤ Forest resources ➤ Wildlife resources ➤ Fisheries ➤ Forage resources ➤ Agricultural resources ➤ Water transport ➤ Recreation/tourism 		
ATTRIBUTES		
<ul style="list-style-type: none"> ➤ Uniqueness to culture 		
RESPONSE		
The actions taken for dealing with those impacts (and their results)		
By 4 areas of DPSIR addressed:		
<ul style="list-style-type: none"> drivers, pressures, state change, impacts 		
ISSUES		

Annex 3

Coding for database

Grouping for DPSIR elements in database		
Code		
D	Drivers	
	Driver details	Driver category
1.1	population growth	natural resource dynamics – population dynamics & land/food shortages
1.2	population concentration	
1.3	in-migration	
1.4	land shortages	
1.5	food shortage	
1.6	increasing food demand (not due to markets, see 2)	
1.7	animal population growth	
2.1	global non-local	markets
2.2	local market	
3.1	land tenure changes	land-use policies
3.2	conservation	
3.3	flood area creation	
3.4	environment policies/forestry	
4.1	subsidies	market & process policies
4.2	tariffs	
4.3	market incentives	
5.1	poor governance	government / community behaviour
5.2	government policies (not in above)	
6.1	climate change	natural environmental processes
6.2	upland degradation (only “natural” erosion)	
7.1	urbanization	
7.2	hydropower needs and development	
7.3	tourism	
8.1	technology introduction	
P	Pressures	
	Pressure details	Pressure category
1.1	colonization	expansion of agriculture
1.2	transforming natural vegetation	(crop, fish, livestock, productive forestry)
1.3	clearing	

Grouping for DPSIR elements in database			
Code			
2.1	increased cropping intensity	agricultural intensification	
2.2	intensification of fisheries		
2.3	intensification of aquaculture		
2.4	intensification of grazing		
2.5	crop and chemical intensification		
2.6	intensified gathering		
3.1	expansion of parks/gazetting	increasing nature conservation	
3.2	designation of flood protection areas		
3.3	designation of drinking-water area		
3.4	formalization of environmental flows		
3.5	extensification of agriculture (including land abandoning)		
4.1	surface water extraction	water resources management and use	
4.2	ground water extraction		
4.3	drainage (& land settlement)		
4.4	water storage facilities		(includes dams)
4.5	water conveyance infrastructure		(altering natural streams)
4.6	fresh & salt water inflow/outflow		(coastal areas and lagoons)
4.7	flood regime management		(timing and quantity)
5.1	pollution	others	
5.2	fire		
State changes			
S	State change details	State change categories	
1.1	longer flooding, more flooding, waterlogging	water resources (base), quantity and timing	
1.2	shorter flooding		
1.3	lower floods, lower flows, smaller flooded area		
1.4	higher floods, higher flows, larger area flooded		
1.5	faster water flow – reduced flood control capacity		
1.6	slower water flow – increased flood control capacity		
1.7	reduced groundwater recharge		
1.8	increased groundwater recharge		
1.9	lower water table in wetland		
1.10	higher water table in wetland / waterlogging		
1.11	reduced water storage in wetland		
1.12	increased water storage in wetland		(including pond creation / inundation)
1.13	drying up of reservoirs		
1.14	drying up of coastal lagoons		
1.15	increased hydrological variability		
1.16	moderation of seasonal variability of water regime		

Grouping for DPSIR elements in database		
Code		
2.1	eutrophication	water quality & pollution
2.2	water pollution / (agricultural) waste	
2.3	increased freshwater level in lagoon	
2.4	increased salinity (mostly in lagoon – also through irrigation)	
2.5	water quality lowered	
3.1	sediment deposition / buildup in wetland	soils, changes in physical character
3.2	reduced infiltration (compacted soils)	
3.3	peat soil subsidence / increased susceptibility to fire	
3.4	eroded soils	
3.5	gullyng / gully erosion	
3.6	reduced sediment retention capacity	
3.7	increased sediment retention capacity	
3.8	physical deterioration	
4.1	soil toxicity	soils, changes in chemical character
4.2	soil salinity	
4.3	less fertile soils	
4.4	acid soils	
4.5	more fertile soils	
5.1	increased vegetation, biodiversity, ground cover	loss or gain in biodiversity and species, or habitats
5.2	decreased vegetation, biodiversity, ground cover	
5.3	increased presence of invasive species	
5.4	less wildlife	
5.5	more fish	
5.6	less fish	
5.7	more wildlife	
6.1	changes in channel morphology, bank collapse, etc.	other
6.2	microclimate change	
I	Impacts	
	Impact details	Impact categories
1.1	rice / starches, maize, millet, sorghum, wheat, etc.	economic/livelihood gains from market-oriented agriculture
1.2	vegetables	
1.3	flowers	
1.4	sugar	
1.5	aquaculture	
1.6	other cash crops – cotton, groundnuts	

Grouping for DPSIR elements in database		
Code		
2.1	Sugar	commoditization of agriculture (company-based)
2.2	flowers	
2.3	aquaculture	
2.4	oil & biofuels	
2.5	wood products	
3.1	crop production – increased	food and nutrition gains/losses in (subsistence) uses
3.2	fisheries (capture) – increased	
3.3	livestock and grazing – increased	
3.4	natural gathering – including wildlife and products – increased	
3.5	agroforestry – increased	
3.6	crop production – decreased	(including wood)
3.7	fisheries (capture) – decreased	
3.8	livestock and grazing - decreased	
3.9	natural gathering – including wildlife and products – decreased	
3.10	agroforestry – decreased	
4.1	flood protection	increases in opportunity costs (lost capacity)
4.2	water purification	
4.3	recreation opportunities decreased	
4.4	negative cultural impacts	
5.1	flood protection	averted investment costs (enhanced capacity)
5.2	water purification	
5.3	recreation opportunities increased	
5.4	water regulation	
6.1	increase/decrease in economic differentiation	socio-economic differentiation & conflicts
6.2	increase/decrease in conflicts	
6.3	marginalization & poverty	
7.1	decreased disease occurrence	health
7.2	increased disease occurrence	
8		other
8.1	institutional / social capital development / changes	
8.2	water transport improved or impacts	
8.3	economic diversification	
8.4	land tenure & societal changes & business changes to add	

Grouping for DPSIR elements in database	
Code	
9	treaties
9.1	treaty obligations met
9.2	treaty obligations not met
Responses	
1	Actors
1.1	government
1.2	local NGOs
1.3	community
1.4	international agencies
1.5	international NGOs
2	Action
2.1	policy
2.2	technical measures
2.3	institutional development – government
2.4	planning
2.5	monitoring
2.6	institutional development – community
2.7	conservation / tourism development
2.9	more development & no responses to issues
3	DPSIR element addressed
3.1	drivers
3.2	pressures
3.3	state changes
3.4	impacts
3.5	other

Annex 4

List of case studies

Country & Ramsar region	Development situation	Wetland site	Reference/source
Asia			
Bangladesh	LIC	Sundarban coastal mangroves	<p>Gopal, B. & Chauhan, M. 2006. Biodiversity and its conservation in the Sundarban Mangrove ecosystem. <i>Aq. Sci.</i>, 69: 338–354.</p> <p>Iftekhar, M.S. 2006. Conservation and management of the Bangladesh coastal ecosystem; overview of an integrated approach. <i>Nat. Res. For.</i>, 20: 230–237.</p> <p>Islam, M.A. & Wahab, M.A. 2005. A review on the present status and management of mangrove wetland habitat resources in Bangladesh with emphasis on mangrove fisheries and aquaculture. <i>Hydrobiologia</i>, 542: 165–190.</p>
Bangladesh	LIC	Coastal mangroves	Spalding, M., Blasco, F. & Field, C. 1997. <i>World mangrove atlas</i> . Okinawa, Japan, International Society for Mangrove Ecosystems.
Bangladesh	LIC	Deltaic floodplains of Ganges, Brahmaputra & Meghna rivers	<p>Ahmed, R., Haque, M.R. & Khan, M.S.I. 2004. <i>Introduction to community-based hoar and floodplain resource management</i>. Dhaka, IUCN Bangladesh Country Office.</p> <p>Dey, M.M. & Prein, M. 2004. <i>Community based fish culture in seasonally flooded rice fields in Bangladesh and Vietnam</i>. Paper presented at New directions for a diverse planet: proceedings of the 4th International Crop Science Congress, 26 September – 1 October 2004, Brisbane, Australia.</p> <p>Islam, M. & Braden, J.B. 2006. Bio-economic development of floodplains: farming versus fishing in Bangladesh. <i>Env. Dev. Econ.</i>, 11: 95–126.</p> <p>IRN. <i>Rivers and dams in Bangladesh</i> (available at http://www.irn.org).</p>
Cambodia	LIC	Floodplains & marshes – general paper	Torell, M, Salamanca, A.M. & Ratner, B.D, eds. 2004. <i>Wetlands management in Cambodia: socioeconomic, ecological, and policy perspectives</i> . Penang, Malaysia, WorldFish Center.
China	LMC	Ruoergai Plateau, peatlands	E-mail text source from Wetlands International staff in China
India	LIC	Punjab, incl. Harike	Ladhar, S.S. 2002. Status of ecological health of wetlands in Punjab, India. <i>Aq. Ecosys. Health Man.</i> , 5(4): 457–465 (also available at http://www.punjabenvironment.com).
India	LIC	Chilika Lagoon, Orissa	Pattnaik, A. 2005. <i>The restoration of the Chilika Lagoon, a coastal wetland in India: the achievement of combined integrated water resources management and enhanced community participation</i> . Cases study for the FAO/Netherlands conference on water for food and ecosystems (available at http://www.fao.org).
India	LIC	Bhoj Upper Lake, Bhopal	http://www.environmental-incentives.org/ , Winrock International.
India	LIC	Lake Kolleru	<p>Amaraneni, S.R. 2006. Distribution of pesticides, PAHs and heavy metals in prawn ponds near Kolleru Lake wetland, India. <i>Env. Int.</i>, 32: 294–302.</p> <p>Rao, P.M. & Sekhar, P. (n.d.) <i>A note on the ecological disturbance of Kolleru Lake of Andhra Pradesh</i>. (unpublished)</p> <p>N.A. 2007. <i>Operation Koleru restoration</i>. Unpublished paper, Wetlands International.</p>
India	LIC	Wular & associated wetlands, Jhelum River basin, Jammu & Kashmir	Unpublished paper, Wetlands International.
Indonesia	LMC	Air Hitam Laut River Basin	Checklist from J. van den Berg, WUR.

Country & Ramsar region	Development situation	Wetland site	Reference/source
Iraq	LMC	Marsh of Iraq	Richardson, C., Reiss, P., Hussain, N.A., Alwash, A.J. & Pool, D.J. 2005. The restoration potential of the Mesopotamian marshes of Iraq. <i>Science</i> , 307: 1307–1311. Richardson, C. & Hussain, N.A. 2006. Restoring the Garden of Eden: an ecological assessment of the marshes of Iraq. <i>BioScience</i> , 56(6): 477–489.
Lao People's Democratic Republic	LIC	Rainfed and irrigated rice, & aquaculture	Huxley, T.H. 2000. <i>Impacts of irrigation and aquaculture development on small-scale aquatic resources</i> . Final Report to the Department for International Development Environment Research Programme. London, Imperial College. Lorenzen, K., Choulamany, X. & Sultana, P. 2003. <i>Understanding livelihoods dependent on inland fisheries: Lao country report</i> . Penang, Malaysia, WorldFish Center. Nguyen Khoa, N., Lorenzen, K., Garaway, C., Chamsinhg, B., Siebert, D. & Randone, M. 2005. Impacts of irrigation on fisheries in rain-fed rice-farming landscapes. <i>J. Appl. Ecol.</i> , 42(5): 892–900.
Malaysia	UMC	Maludam, Sarawak	Berg, J. van den, Salleh, N., Demies, M. & Amir, J. 2004. <i>Rapid diagnostic appraisal of non timber forest products of the Maludam National Park Betong Division Sarawak</i> . Sarawak, Malaysia, Forest Department. Joint Working Group Malaysia – the Netherlands: development and management of Maludam National Park.
Myanmar	LIC	Lake Inle	Akaishi, F., Satake, M., Otaki, M. & Tominaga, N. 2006. Surface water quality and information about the environment surrounding Inle Lake in Myanmar. <i>Limnology</i> , 7: 57–62. Sidle, R.C., Ziegler, A.D. & Vogler, J.B. 2007. Contemporary changes in open water surface area of Lake Inle, Myanmar. <i>Sus. Sci.</i> , 2: 55–65.
Philippines	LMC	Mangroves in general	Primavera, J.H. 1995 Mangroves and brackishwater pond culture in the Philippines. <i>Hydrobiologia</i> , 295: 303–309.
SE Asia	LIC	Aquatic systems	Amilhat, E., Morales, E.J., Immink, A.J., Little, D.C., Lorenzen, K., Islam, F., Karapanagiotidis, I. 2005. <i>Self-recruiting species (SRS) from farmer managed aquatic systems: their role in rural livelihoods</i> . DFID Summary report (available at http://www.dfid.stir.ac.uk).
Sri Lanka	LMC	Embilikala, Malala & Bundala wetland lagoon system	Bakker, M. & Matsuno, Y. 2001. A framework for valuing ecological services of irrigation water: a case of an irrigation-wetland system in Sri Lanka. <i>Irrig. Drain. Sys.</i> , 15: 99–115. Piyankarage, S.C., Mallawatantri, A.P., Matsuno, Y. & Pathiratne, K.A.S. 2004. Human impacts and the status of water quality in the Bundala RAMSAR wetland lagoon system in Southern Sri Lanka. <i>Wetl. Ecol. Man.</i> , 12: 473–482.
Sri Lanka	LMC	Kirindi Oya Irrigation Scheme	Meinzen-Dick, R. & Bakker, M. 1999. Irrigation systems as multiple-use commons: water use in Kirindi Oya, Sri Lanka. <i>Agric. Hum. Val.</i> , 16: 281–293. Asian Development Bank. 2000. <i>Project performance audit report on the Kirindi Oya Irrigation and Settlement Project in Sri Lanka</i> (available at http://www.adb.org).
Thailand	LMC	Songkhram River basin	Blake, D. & Friend, R. et al., ex GVH. <i>Local wisdom for river basin management: Thai Baan research in the Sognkhram River basin</i> . FAO / Netherlands Conf. Blake, D.J.H. 2006. <i>The Songkhram River wetlands – a critical floodplain ecosystem of the lower Mekong basin</i> . Paper for 9th International River Symposium, 2006, Brisbane, Australia. (available at www.riversymposium.com). Blake, D.J.H. & Pitakthepsombut, R. 2006. <i>Situation analysis: lower Songkhram River basin, Thailand</i> . Bangkok, Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme. 121 pp. (available at http://www.mekongwetlands.org). Promphakping, P., Pakdee P. & Pholsen, S. 2005. <i>Scoping study of irrigated agriculture in the lower Songkhram River basin, Thailand demonstration site. MWBP</i> . Report submitted to the Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme, Vientiane. July 2005. (unpublished)
Viet Nam	LIC	Mekong Delta	"The Mekong River Delta: effective water control for solving conflicts among agriculture–fisheries–aquaculture in coastal zones" FAO/Netherlands e-forum.
Viet Nam	LIC	Huong River Basin, Phu Vang District	E-mails, R. Friend (IUCN), and Chu Thai Hoanh (IWMI). Halsema, G. van. <i>Water for food and ecosystem issues in the Huong River Basin – examples from Phu Vang District</i> . Mission report

Country & Ramsar region	Development situation	Wetland site	Reference/source
Europe			
Central Europe	UMC	Peatlands	Bragg, O. & Lindsay, R. (n.d) <i>Strategy and action plan for mire and peatland conservation in Central Europe</i> . Publication 18. Wageningen, Netherlands, Wetlands International.
Croatia	UMC	Sava floodplains	Zingstra, H. 2005. <i>Integrated river basin management of the River Sava</i> . Wageningen, Netherlands, Wageningen International. Project documents for “Protection of Biodiversity of the Sava River Basin Floodplains” carried out by IUCN European Office in partnership with Wageningen International. (2007–09) www.ramsar.org/wn/w.n.czech_echydrological2007.htm
Czech Republic	UMC	Trebon fish ponds	
Lithuania	UMC	Rusne Island, Nemunas River delta	Vaiciunaite, R. 2003. Managing the landscape for wetlands, biodiversity and agriculture in Lithuania. <i>Int. J. Ecol. Env. Sci.</i> , 29: 89–92.
Lithuania	UMC	Lake Zuvintas	Zingstra, H. et al. 2006. <i>Management and restoration of Natura 2000 sites in the Dovine Basin. A pilot project for the combined implementation of the EU Water Framework Directive and the EU Birds and Habitats Directives</i> . Wageningen International.
Netherlands	HIC	Floodplains	G. van Halsema / Hans Langeveld, WUR.
Netherlands	HIC	Drentse Aa riverine wetlands	A. Schrevel, WUR.
Netherlands	HIC	Peatlands, Ranstad	A. Schrevel, WUR.
Poland	UMC	Biebrza River valley	H. Zingstra, WUR
Ukraine (Crimea)	LMC	Lake Sivash	Wetlands International communication.
United Kingdom	HIC	Great Fen	Bowley, A. 2007. The great Fen – a waterland for the future. <i>Brit. Wild.</i> , 18(6): 415–423.
Neotropics & Mexico			
Argentina	UMC	Cordoba / Pampas wetlands	R. Jongman, WUR.
Brazil	LMC	Pantanal wetlands	Jongman, R.H.G. & Padovani, C.R. 2006. Integrating stakeholder knowledge and science for river basin management. <i>Int. J. Wat. Res. Man.</i> , 49–63. Jongman, R.H.G., ed. 2006. <i>Pantanal-Taquari, tools for decision making in integrated water management</i> . Final report. Alterra Report 1295. 215 pp.
Brazil	LMC	Lower Campos River delta	R. Jongman, WUR.
Brazil	UMC	Central Amazon floodplain	Junk, W.J., Ohly, J.J., Piedade, M.T.F. & Soares, M.G.M. 2000. <i>The central Amazon floodplain: actual use and options for sustainable management</i> . Leiden, Netherlands, Backhuys Publishers.
Colombia	LMC	Fequene Lake	www.fundacionhumedales.org & e-mails from G.I. Andrade & L. Franco Vidal.
Ecuador	LMC	Mangroves, Esmeraldas Prov.	Ocampo-Thomason, P. 2006. Mangroves, people and cockles: impacts of the shrimp-farming industry on mangrove communities in Esmeraldas Province, Ecuador. In C.T. Hoanh, T.P. Tuong, J.W. Gowing & B. Hardy, eds. <i>Environment and livelihoods in tropical coastal zones</i> , pp. 140–153. Wallingford, UK, CAB International.
Mexico	UMC	Chinampa	Crossley, P. 1998. Sub-irrigation in wetland agriculture. <i>Agric. Hum. Val.</i> , 21: 195–204. Losada, H., Martinez, H., Vieyra, J., Pealing, R., Zavala, R. & Cortes, J. 1998. Urban agriculture in the metropolitan zone of Mexico City: changes over time in urban, suburban and peri-urban areas. <i>Env. Urb.</i> , 10(2): 37–54. Jimenez-Osornio, J.J. & Gomez-Pompa, A. 1991 Human role in shaping of the flora in a wetland community, the chinampa. <i>Land. Urb. Plan.</i> , 20: 47–51.
Mexico	UMC	Yucatan	Smardon, R.C. 2006. Heritage values and functions of wetlands in southern Mexico. <i>Land. Urb. Plan.</i> , 74: 296–312.
Peru	LMC	Lake Titicaca	Erickson, C.L. 1988. Raised field agriculture in the Lake Titicaca basin. <i>Expedition</i> , 30(1): 8–16.

Country & Ramsar region	Development situation	Wetland site	Reference/source
Venezuela	UMC	Merida Andes, Paramo, farmlands	Monasterio, M., Smith, J.K. & Molinillo, M. 2006. Agricultural development and biodiversity conservation in the Paramo environments on the Andes of Merida, Venezuela. <i>In</i> E. Spehn, M. Liberman & C. Korner, C., eds. <i>Land use changes and mountain biodiversity</i> , pp. 307–318. Boca Raton, USA, CRC Press. Llambi, L.D. 2005. Participatory planning for biodiversity conservation in the high tropical Andes: are farmers interested? <i>Mount. Res. Dev.</i> , 25(3): 200–205. Molinillo, M. & Monasterio, M. 1997. Pastoralism in Paramo environments: practices, forage and impact on vegetation in the Cordillera of Merida, Venezuela. <i>Mount. Res. Dev.</i> , 17(3): 197–211.
Venezuela	UMC	Merida Andes, Paramo, grazing lands (similar in Peru, Ecuador & Colombia)	As above.
North America			
Canada,	HIC	British Columbia, Georgia Basin	Ducks Unlimited Canada. 2006. <i>Fact Sheet 11 Natural values: linking the environment to the economy: agriculture and the environment.</i> Ducks Unlimited Canada. (n.d.) <i>Key habitat conservation priority: Georgia Basin. Wetlands for tomorrow.</i>
Canada	HIC	Manitoba, Lizard Marsh	Coley, R. (n.d.) <i>The role of sustainable development in protecting and enhancing wetland habitats.</i> (mimeo)
Canada	HIC	New Brunswick, Canaan-Washadem-oak	Canaan Washademoak Watershed Association. (n.d.) <i>Living with the land. (Issues 1–4 Who we are, community characteristics, land use, the riparian zone.)</i>
Canada	HIC	South Saskatchewan River Project	South Saskatchewan River Project - www.swa.ca/WaterManagement/DamsAndReservoirs Alberta Environment. 2003. <i>South Saskatchewan River Basin Water Management Plan, Phase Two: background studies.</i>
United States of America	HIC	Deschutes River basin, Oregon	http://www.deschutesriver.org/ DRC. 2006. <i>Instream flow in the Deschutes basin: monitoring, status and restoration needs</i> (available at www.ci.bend.or.us). Shelton, M.L. 1981. Runoff and land use in the Deschutes basin. <i>Ann. Ass. Am. Geog.</i> , 71(1): 11–27.
United States of America	HIC	Seepage wetlands and bog turtles, PA	E- mail communication – J. Thorne via Royal Gardner
United States of America	HIC	Prairie potholes	Mulhouse, J.M. & Galatowitsch, S.M. 2003. Revegetation of prairie pothole wetlands in the mid-continental US: twelve years post-reflooding. <i>Plant Ecol.</i> , 169: 143–159. Euliss, N.H. & Mushet, D.M. 1996. Water-level fluctuations in wetlands as a function of landscape condition in the Prairie pothole region. <i>Wetlands</i> , 16(4): 587–593. Heimlich, R.E., Wiebe, K.D., Claassen, R., Gadsby, D. & House, R.M. 1998. <i>Wetlands and agriculture: private interests and public benefits.</i> Agricultural Economic Report No. 765. USDA. Valk, A.G. van der & Pederson, R.L. 2003. The SWANCC decision and its implications for prairie potholes. <i>Wetlands</i> , 23(3) 590–596.
United States of America	HIC	California, Central Valley	Richter, B.D. & Thomas, G.A. 2007. Restoring environmental flows by modifying dam operations. <i>Ecol. Soc.</i> , 12(1): 12.
United States of America	HIC	California, Gulf and Mississippi, rice cultivation	Bird, J.A. et al. 2002. Long-term studies find benefits, challenges in alternative rice straw management. <i>Cal. Agric.</i> , (March–April): 69–75. Fasola, M. & Ruiz, X. 1996. The value of rice fields as substitutes for natural wetlands for waterbirds in the Mediterranean region. <i>Col. Waterbirds</i> , 19: 122–128. Lawler, S.P. 2002. Rice fields as temporary wetland: a review. <i>Isr. Sci. J.</i> , 47(4): 513–528.

Country & Ramsar region	Development situation	Wetland site	Reference/source
Oceania			
Australia	HIC	Lower Murumbidgee floodplain	Kingsford, R.T. 2003. Ecological impacts and institutional and economic drivers for water resource development – a case study of the Murrumbidgee River, Australia. <i>Aq. Ecosys. Health Man.</i> , 6(1): 69–79. Murrumbidgee Catchment Management Authority. 2003 Catchment Action Plan (available at http://www.murrumbidgee.cma.nsw.gov.au).
Australia	HIC	Burdekin River floodplain	Lukacs, G. 1995. Wetlands of the lower Burdekin region, north Queensland. In Finlayson, C.M. ed. <i>Wetland research in the wet-dry tropics of Australia</i> . Barton, Australia.
Australia	HIC	Lower Gwydir	http://www.dnr.nsw.gov.au/water/wetlands_area_gwydir.shtml
Australia	HIC	Mangroves, Pioneer River. Queensland	Hacker, J.L.F. 1988. Rapid accumulation of fluvially derived sands and gravels in a tropical macrotidal estuary: the Pioneer River at MacKay, North Queensland, Australia. <i>Sed. Geol.</i> , 57: 299–315. Jupiter, S.D. & Phinn, S.R. 2006. <i>Natural and anthropogenic changes to mangrove distribution in the Pioneer River estuary, Queensland, Australia</i> .
Australia	HIC	Murray River	Nias, D.J., Alexander, P. & Herring, M. 2003. Watering private property wetlands in the Murray Valley, New South Wales. <i>Ecol. Man. Res.</i> , 4(1): 5–12.
Micronesia	LMC	Forested wetland, Kosrae	Drew, W., Ewel, K.C., Naylor, R.L. & Sigrah, A. 2005. A tropical freshwater wetland: III. Direct use values and other goods and services. <i>Wetl. Ecol. Man.</i> , 13: 685–693.
New Zealand	HIC	Lake Ellesmere (Waihora)	Dept. of Conservation. 2005. <i>Te Waihora joint management plan</i> . Department of Conservation and Te Runanga o Ngai Tahu. www.wet.org.nz http://www.doc.govt.nz/templates/page.aspx?id=35302
New Zealand	HIC	Waituna Lagoon	Johnson, P.N. & Partridge, T.R. 1998. <i>Vegetation and water level regime at Waituna Lagoon, Southland</i> . Science for Conservation No. 98. Wellington, Department of Conservation. Thompson, R.M. & Ryder, G.R. 2003. Waituna Lagoon: summary of existing knowledge and identification of knowledge gaps. Science for Conservation No. 215. Wellington Department of Conservation.
Papua New Guinea	LIC	Huli wetland, Tari basin	Ballard, C. 2001. Wetland drainage and agricultural transformations in the Southern Highlands of Papua New Guinea. <i>Asia Pac. View.</i> , 42(2/3): 287–304. Wood, A.W. 2002. The ecology of Huli subsistence agriculture. <i>Pap. N. Guin. Med. J.</i> , 45: 15–43.
Samoa	LMC	Apia catchment & Lake Lanoto'o	Ramsar Regional Representative
Africa			
Botswana	UMC	Shoshing Hill	Clayton, A. & Woodhouse, P. 2000. Modernizing communal lands: evolving resource use in the Shoshong Hills, Botswana. In P. Woodhouse, H. Bernstein & D. Hulme. <i>African enclosures? The social dynamics of wetlands in drylands</i> , pp. 119–153. Oxford, UK, James Currey.
Botswana	UMC	Okavango Delta	Breen, C.M., Quinn, N.W. & Mander, J.J., eds. 1997. <i>Wetlands conservation and management in Southern Africa: challenges and opportunities</i> . Summary of the SADC Wetlands Conservation Survey Reports. Gland, Switzerland, IUCN. Mbaiwa, J.E. 2003. The socio-economic and environmental impacts of tourism development on the Okavango Delta, north-western Botswana. <i>J. Arid Env.</i> , 54: 477–467. Turton, A.R., Brynard, P. & Meissner, R. 2002. <i>Four strategic policy issues for consideration by the Permanent Okavango River Basin Water Commission (Okacom)</i> . Paper presented at the 3rd WaterNet/ Warfsa Symposium 'Water Demand Management for Sustainable Development', Dar es Salaam, 30–31 October 2002. Scudder, T., Manley, R.E., Coley, R.W., Davis, R.K., Green, J., Howard, G.W., Lawry, S.W., Martz, D., Rogers, P.P., Taylor, A.R.D., Turner, S.D., White, G.F. & Wright, E.P. 1993. <i>The IUCN Review of the Southern Okavango Integrated Water Development Project</i> . Gland, Switzerland, IUCN. Jansen, R. 2002. <i>The Okavango Delta Management Plan Project – application of an ecosystem-based planning approach</i> . Paper presented at the 17th Global Biodiversity Forum, Valencia, Spain, 15–17 November 2002.

Country & Ramsar region	Development situation	Wetland site	Reference/source
Burkina Faso	LIC	Bas-fonds in Sanmatenga	Hottinga, F., Peters, H. & Zanen, S. 1991. <i>Potentials of bas-fonds in agropastoral development in Sanmatenga, Burkina Faso</i> . Part 3b of 'Wetlands in Drylands: The Agroecology of Savanna Systems in Africa. London, IIED.
Ethiopia	LIC	Southwest Ethiopia Highland wetlands	Dixon, A.B. & Wood, A.P. 2003. Wetland cultivation and hydrological management in East Africa: matching community and hydrological needs through sustainable wetland use. <i>Nat. Res. For.</i> , 27(2): 117–129.
Ethiopia	LIC	Rift Valley	Jansen, H. et al. 2007. Land and water resources assessment in the Ethiopian Central Rift Valley. Wageningen, Netherlands, WUR.
Kenya	LIC	Lake Ol Bolossat	Gichuki, C. (n.d.) <i>Community-based wetland management in Africa: a case study of Lake Ol Bolossat, Kenya</i> . Case Study No. 3. Wetlands International.
Kenya	LIC	Kimana Swamp, Kajiado District	Southgate, C. & Hulme, D. 2000. Uncommon property: the scramble for wetland in southern Kenya. In P. Woodhouse, H. Bernstein & D. Hulme. 2000. <i>African enclosures? The social dynamics of wetlands in drylands</i> , pp. 73–117. Oxford, UK, James Currey.
Kenya	LIC	Lake Victoria Finger Ponds	Kipkemboi, J., Dam, A.A. van, Ikiara, M.M. & Denny, P. 2007. Integration of smallholder wetland aquaculture-agriculture system (fingerponds) into riparian farming systems on the shores of Lake Victoria, Kenya: socio-economic and livelihoods. <i>Geog. J.</i> , 173(3): 257–272. Barbier, P., Kalimanzira, C. & Micha, J.-C. 1985. L'aménagement de zones marecageuses en écosystèmes agro-piscicoles. Le projet Kirarambogo au Rwanda 1980–1985. Namur, Belgium, FUCID. Korn, M. 1996. The dike-pond concept: sustainable agriculture and nutrient cycling in China. <i>Ambio</i> , 25: 6–12. Micha, J.-C., Halen, H. & Rosado Couoh, J.-L. 1992. Changing tropical marshlands into agro-pisciculture ecosystems. In E. Maltby, P. Dugan & J.C. Lefeuvre, eds. <i>Conservation and development: the sustainable use of wetland resources</i> , pp. 83–88. Gland, Switzerland, IUCN.
Madagascar	LIC	Lake Alaotora	Bakoariniaina, L.N., Kusky, T. & Raharimahefa, T. 2006. Disappearing Lake Alaotra: monitoring catastrophic erosion, waterway silting and land degradation hazards in Madagascar using Landsat imagery. <i>J. Afr. Earth Sci.</i> , 44: 241–252.
Malawi	LIC	Simlemba	Wood, A.P. 2005. <i>Sustainable wetland management for livelihood security</i> . Simlemba TA, Kasungu District, Malawi. An environmental and socio-economic impact & development assessment. Zeist, Netherlands, Wetland Action.
Malawi	LIC	Lake Chilwa	Ferguson, A. & Mulwafu, W.O. 2005. <i>Irrigation reform in Malawi: exploring critical land-water intersections</i> . Paper presented at the International Workshop on 'African Water Laws: Plural Legislative Frameworks for Rural Water Management in Africa.' Johannesburg, South Africa, 26–28 January 2005. Government of Malawi. 2004. <i>National Water Policy</i> . Lilongwe, Ministry of Water Development. Kambewa, D. 2004. <i>Patterns of access and use in wetlands: the Lake Chilwa basin</i> . Report prepared for Basis Collaborative Research Support Programme, Department of Agricultural and Applied Economics, University of Wisconsin-Madison, October 2004. Mulwafu, W.O. & Nkhoma, B.G. 2001. <i>The use and management of water in the Likangala irrigation scheme complex in Southern Malawi: some preliminary findings</i> . Paper presented at the Second WARFSA/WaterNet Symposium, 'Integrated Water Resources Management: Theory, Practice, Cases', Cape Town, South Africa, 30–31 October 2001. Mulwafu, W., Chipeta, C., Chavula, G., Ferguson, A., Nkhoma, B.G. & Chilima, G. 2002. <i>Water demand management in Malawi: problems and prospects for its promotion</i> . Paper presented at the Third WaterNet/Warfsa Symposium, 'Water Demand Management for Sustainable Development', Dar es Salaam, 30–31 October 2002. Mulwafu, W.O. 2003. <i>The use of domestic water supplies for productive purposes in the Lake Chilwa catchment area in Southern Malawi</i> . Paper presented at the International Symposium on Water, Poverty and Productive Uses of Water at the Household Level, Muldersdrift, South Africa, 21–23 January 2003.

Note: LIC = low income country; LMC = lower middle income country; UMC = upper middle income country; HIC = high income country.

Country & Ramsar region	Development situation	Wetland site	Reference/source
Mali	LIC	Sourou Valley	Woodhouse, P., Trench, P. & Tessougue, M.D.M. 2000. A very decentralized development: exploiting a new wetland in the Sourou Valley, Mali. In P. Woodhouse, H. Bernstein & D. Hulme. <i>African enclosures? The social dynamics of wetlands in drylands</i> , pp. 29–72. Oxford, UK, James Currey.
Mali	LIC	Inner Niger Delta	B. Kone, Wetland International
Nigeria	LIC	Fadama	Saket, K., Hussini, S.M. & Dongs, I.S. 2005. Economics of sustainable vegetable farming under fadama condition in Dass local government area, Bauchi State of Nigeria. <i>Econ. Aff.</i> , 50(1): 46–51. Kolawole, A., ed. 1994. <i>Strategies for the sustainable use of fadama lands in northern Nigeria</i> . Nigeria, Ahmadu Bello University. Kolawole, A. 1991. <i>Economics and management of fadama in northern Nigeria</i> . IIED Drylands Programme.
Nigeria	LIC	Hadejia-Nguru	Hollis, G.E., Adams, W.M. & Aminu-Kano, M. 1993. <i>The Hadejia-Nguru wetlands: environment, economy and sustainable development of a Sahelian floodplain wetland</i> . Gland, Switzerland, IUCN. Adams, W.M. & Hollis, G. 1987. <i>Hydrology and sustainable resource development of a Sahelian wetland, Hadejia-Nguru Wetlands Conservation Project</i> . Gland, Switzerland, IUCN. Schultz. 1976. Hadejia River basin study. Canadian International Development Agency. 8 volumes in an Interim and a Final Report. Cited in: W.M. Adams, Agriculture, grazing and forestry, in G.E. Hollis, W.M. Adams & M. Aminu-Kano. 1993. <i>The Hadejia-Nguru wetlands: environment, economy and sustainable development of a Sahelian floodplain wetland</i> , pp. 89–115. Gland, Switzerland, IUCN.
Sierra Leone	LIC	Inland valley swamps, Eastern Province	Siera Agricultural and Technical Services. 1996. <i>Inland Valley Swamp Study. Annex 5. Socio-economic Issues</i> . Freetown. Siera Agricultural and Technical Services. 1996. <i>Inland Valley Swamp Study. Annex 6. Health and environmental problems associated with swamp development</i> . Freetown. Mulema, J.P. 2000. <i>Evaluation of the plant diversity on the fringe and inland valley swamp topo-sequence for conservation and management</i> . Freetown: Department of Biological Sciences, Faculty of Environmental Science, Njala University College. (BSc thesis)
South Africa	UMC	Mutale River Valley	Lahiff, E. 2000. The Mutale River Valley: an apartheid oasis. In P. Woodhouse, H. Bernstein & D. Hulme. <i>African enclosures? The social dynamics of wetlands in drylands</i> , pp. 155–193. Oxford, UK, James Currey. pp. 155–193.
South Africa	UMC	Craigieburn wetland, Sand River	Pollard, S.R. et al. 2005. <i>Towards wetland and livelihood improvements: an integrated socio-ecological approach to the rehabilitation of a communal wetland in the north-eastern region of South Africa</i> . Paper presented at the WRPR Workshop of Wetlands International, St Lucia, South Africa.
Sudan	LIC	Wadis in north Kordofan	El Sammani, M.O. 1991. <i>Wadis of north Kordofan, Sudan – present roles and prospects for development</i> . Part 3c of Wetlands in Drylands: The Agroecology of Savanna Systems in Africa. London, IIED.
Uganda	LIC	Nakivubo, Kampala	Tindamanyire, T. 2003. Wetlands, water resources and agricultural productivity: an important synergy for biodiversity conservation. <i>Int. J. Ecol. Env. Sci.</i> , 29: 39–46.
Uganda	LIC	Yamariro wetland, Kabale	E-mail text, Ugandan NGO, Aventino Kasangaki
United Republic of Tanzania	LIC	Bahi wetlands	Yanda, P.Z., Majule, E.K. & Mwakaje, A.G. (n.d.) <i>Wetland utilisation, poverty alleviation and environmental conservation in semi arid areas of Tanzania – the case of Singida Region</i> . Unpublished paper. Institute of Resource Assessment, University of Dar es Salaam.
United Republic of Tanzania	LIC	Usangu basin, Ruaha River	Lankford, B. 2004. Resource-centred thinking in river basins: should we revoke the crop water approach to irrigation planning? <i>Agric. Wat. Man.</i> , 68(1): 33–46.
Zambia	LIC	Dambos, Mpika District	Sampa, J. 2007. <i>Dambo cultivation</i> . Mpika, NLWCCDP.

Note: LIC = low income country; LMC = lower middle income country; UMC = upper middle income country; HIC = high income country.

Country & Ramsar region	Development situation	Wetland site	Reference/source
Zambia	LIC	Barotse floodplain, Western Province	<p>Wood, A.P. 1985. A century of development measures and population redistribution along the upper Zambezi. <i>In</i> J.I. Clarke, M. Khogali & L.A. Kosinski, eds. <i>Population and development schemes in Africa</i>, pp. 163–175. Cambridge, UK, Cambridge University Press.</p> <p>Kokwe, M. 1991. <i>The role of dambos in agricultural development</i>. Part 3e of Wetlands in Drylands: The Agroecology of Savanna Systems in Africa. IIED, London.</p>

Note: LIC = low income country; LMC = lower middle income country; UMC = upper middle income country; HIC = high income country.

Annex 5

Tables of individual DPSI elements

TABLE A5.1

Drivers by region (as % of case sample size)

Gr.	Driver	All	Africa	Asia	Eur	Neotr	N Am	Ocea
	Sample size (no.)	92	25	23	11	13	10	10
1	Pop. growth	53%	76%	74%	18%	54%	10%	30%
1	Pop. conc.	5%	12%	4%	0%	0%	0%	10%
1	In-migration	14%	36%	9%	0%	0%	0%	20%
1	Land shortages	15%	36%	22%	0%	0%	0%	0%
1	Food shortage	14%	40%	13%	0%	0%	0%	0%
1	Increased food demand	8%	28%	0%	0%	0%	0%	0%
1	Animal population	9%	16%	4%	0%	8%	10%	10%
2	Global markets	43%	12%	43%	55%	54%	80%	60%
2	Local markets	49%	56%	48%	45%	62%	20%	50%
3	Land tenure	5%	12%	9%	0%	0%	0%	0%
3	Conservation	1%	0%	0%	0%	0%	10%	0%
3	Flood areas	1%	0%	4%	0%	0%	0%	0%
3	Land alienation	2%	4%	0%	0%	0%	0%	10%
4	Subsidies	9%	0%	13%	27%	0%	10%	10%
4	Market incentives	2%	0%	0%	0%	8%	0%	10%
5	Poor governance	3%	0%	4%	0%	15%	0%	0%
5	Government policies	48%	56%	52%	73%	31%	40%	20%
6	Climate change/variability	12%	32%	0%	18%	8%	0%	0%
7	Urbanization	20%	36%	17%	18%	23%	0%	0%
7	Hydropower	1%	4%	0%	0%	0%	0%	0%
7	Tourism	4%	4%	0%	0%	0%	30%	0%
8	Technology	7%	12%	0%	0%	23%	0%	0%
8	New crops	1%	4%	0%	0%	0%	0%	0%

TABLE A5.2
Drivers by wetland type

Driver	All	Inl. flowing	Inl. still perm	Inl. seas	Peat	Saline	Brackish	Human-made
Sample size (no.)	154	27	39	33	15	10	10	20
1 Pop. growth	52%	44%	59%	42%	67%	30%	40%	70%
1 Pop. conc.	6%	7%	8%	9%	0%	10%	0%	5%
1 In-migration	13%	11%	21%	15%	7%	0%	20%	5%
1 Land shortages	14%	7%	21%	12%	7%	20%	10%	15%
1 Food shortage	14%	19%	10%	21%	0%	0%	10%	25%
1 Incr. food demand	6%	4%	10%	9%	0%	0%	0%	10%
1 Animal population	6%	11%	8%	6%	13%	0%	0%	0%
2 Global markets	46%	41%	33%	52%	47%	90%	60%	40%
2 Local markets	50%	52%	46%	58%	40%	40%	60%	50%
3 Land tenure	5%	4%	8%	3%	0%	10%	0%	10%
3 Conservation	1%	0%	3%	0%	0%	0%	0%	0%
3 Flood area creation	1%	0%	0%	0%	0%	10%	0%	0%
3 Land alienation	3%	4%	5%	3%	0%	0%	0%	0%
4 Subsidies	9%	11%	8%	9%	7%	10%	10%	10%
4 Market incentives	3%	4%	3%	3%	0%	0%	10%	0%
5 Poor governance	4%	0%	3%	3%	0%	30%	0%	5%
5 Government policies	53%	56%	54%	58%	40%	40%	40%	65%
6 Climate change	9%	11%	15%	12%	7%	0%	0%	0%
7 Urbanization	19%	19%	18%	21%	7%	30%	20%	20%
7 Hydropower	1%	0%	0%	3%	0%	0%	0%	5%
7 Tourism	3%	11%	5%	0%	0%	0%	0%	0%
8 Technology	7%	7%	8%	12%	13%	0%	0%	0%
8 New crops	2%	4%	0%	6%	0%	0%	0%	0%

TABLE A5.3
Pressures by region

Pressure	All	Africa	Asia	Eur	Neotr	N Am	Ocea
1 Colonization	54%	68%	39%	36%	77%	40%	60%
1 Transformation of vegetation	46%	60%	30%	27%	69%	50%	30%
1 Clearing	9%	12%	9%	0%	8%	10%	10%
2 Increased crop intensity	51%	56%	61%	36%	69%	10%	50%
2 Intens. fisheries	5%	16%	4%	0%	0%	0%	0%
2 Aquaculture growth	7%	0%	22%	0%	8%	0%	0%
2 Intensf. grazing	18%	36%	4%	9%	23%	10%	20%
2 Chemical intensf.	14%	0%	17%	27%	15%	10%	30%
2 Gathering growth	8%	8%	13%	0%	15%	0%	0%
2 Tree planting	2%	4%	0%	9%	0%	0%	0%
2 Extraction of NR	1%	0%	0%	9%	0%	0%	0%
3 Agr. extensif.	4%	0%	4%	27%	0%	0%	0%
4 Surface water extr.	21%	28%	13%	0%	15%	30%	40%
4 Ground water extraction	10%	20%	0%	0%	0%	20%	20%
4 Drainage (& land settlement)	38%	40%	35%	45%	38%	40%	30%
4 Water storage facilities	15%	24%	13%	9%	8%	10%	20%
4 Infrastructure water	12%	4%	22%	9%	0%	10%	30%
4 Freshwater & saltwater inflow/outflow	4%	0%	17%	0%	0%	0%	0%
4 Flood regime management	5%	8%	13%	0%	0%	0%	0%
5 Pollution	10%	8%	9%	27%	15%	0%	0%
5 Fire	2%	8%	0%	0%	0%	0%	0%
5 Increased runoff in catchment	1%	0%	0%	9%	0%	0%	0%
5 Geomorphological changes, e.g. breaching lagoon, bank collapse	1%	0%	0%	0%	0%	0%	10%

TABLE A5.4
Pressures by wetland type

	Pressure	All	Inl. flowing	Inl. still perm	Inl. seas	Peat	Saline	Brackish	Human-made
1	Colonization	53%	56%	56%	64%	60%	50%	30%	35%
1	Transformation of vegetation	46%	56%	44%	61%	40%	70%	30%	15%
1	Clearing	11%	11%	13%	18%	7%	0%	10%	5%
2	Increased crop intensity	51%	52%	54%	58%	40%	50%	60%	40%
2	Intens. fisheries	5%	11%	5%	0%	0%	0%	0%	10%
2	Aquaculture growth	7%	4%	3%	3%	0%	30%	10%	20%
2	Intensf. grazing	17%	26%	21%	24%	7%	0%	20%	0%
2	Chemical intensf.	18%	26%	18%	21%	0%	10%	30%	10%
2	Gathering growth	6%	4%	8%	3%	13%	10%	10%	5%
3	Agr. extensif.	4%	4%	5%	3%	13%	0%	0%	0%
4	Surface water extr.	22%	33%	21%	24%	0%	10%	30%	25%
4	Groundwater extraction	8%	15%	5%	15%	0%	0%	10%	5%
4	Drainage (& land settlement)	37%	22%	46%	33%	87%	40%	30%	10%
4	Water storage facilities	17%	26%	3%	27%	0%	10%	20%	30%
4	Infrastructure water	16%	22%	8%	18%	7%	10%	10%	30%
4	Freshwater & saltwater inflow/outflow	5%	0%	0%	0%	0%	10%	40%	10%
4	Flood regime management	7%	15%	5%	6%	0%	20%	0%	5%
5	Pollution	11%	11%	18%	9%	7%	0%	20%	5%
5	Fire	1%	4%	3%	0%	0%	0%	0%	0%
5	Increased runoff in catchment	1%	4%	0%	3%	0%	0%	0%	0%
2	Tree planting	2%	0%	3%	3%	7%	0%	0%	0%
5	Geomorphological changes	1%	0%	0%	0%	0%	0%	10%	0%
2	Gravel extraction	1%	0%	3%	0%	7%	0%	0%	0%

TABLE A5.5
State changes by region

	State change	Total	Africa	Asia	Eur	Neotr	N Am	Ocea
100	Longer flooding, more flooding, waterlogging	9%	8%	13%	9%	0%	10%	10%
110	Higher water table in wetland / waterlogging	11%	12%	17%	9%	0%	0%	20%
120	Reduced water storage in wetland	11%	12%	22%	9%	0%	0%	10%
125	Increased water storage in wetland	5%	4%	13%	9%	0%	0%	0%
130	Drying up of reservoirs	1%	0%	4%	0%	0%	0%	0%
135	Drying up of coastal lagoons	1%	0%	0%	0%	8%	0%	0%
140	Increased hydrological variability	14%	12%	26%	0%	0%	30%	10%
145	Moderation of seasonal variability of water regime	3%	0%	0%	0%	8%	10%	10%
150	Drying up of swamps	1%	0%	4%	0%	0%	0%	0%
160	Shorter flooding	7%	4%	4%	0%	15%	10%	10%
165	Lower floods, lower flows, smaller flooded area	22%	24%	26%	0%	23%	20%	30%
170	Higher floods, higher flows, larger area flooded	10%	16%	9%	9%	8%	10%	0%
175	Faster water flow – reduced flood control capacity	3%	4%	9%	0%	0%	0%	0%
180	Reduced groundwater recharge	5%	16%	0%	9%	0%	0%	0%
185	Increased groundwater recharge	2%	0%	0%	9%	0%	0%	10%
190	Lower water table in wetland	33%	52%	22%	27%	31%	40%	10%
200	Eutrophication	13%	4%	17%	27%	8%	10%	20%
210	Water pollution / (agricultural) waste	24%	8%	26%	55%	38%	10%	20%
220	Increased freshwater level in lagoon	5%	0%	17%	9%	0%	0%	0%
230	Increased salinity (lagoon & irrigation)	4%	0%	13%	9%	0%	0%	0%
240	Water quality lowered	13%	12%	13%	0%	8%	30%	20%
300	Sediment deposition / build up in wetland	27%	36%	26%	0%	23%	20%	50%
310	Reduced infiltration (compacted soils)	9%	28%	0%	0%	0%	10%	0%
320	Peat soil subsidence / increased susceptibility to fire	9%	4%	9%	36%	8%	0%	0%
330	Eroded soils	4%	12%	0%	0%	0%	0%	10%
340	Gullying / gully erosion	10%	28%	4%	0%	8%	0%	0%
350	Physical deterioration	9%	24%	4%	0%	8%	0%	0%
400	Soil toxicity	2%	4%	4%	0%	0%	0%	0%
410	Soil salinity	7%	8%	9%	0%	0%	0%	20%
420	Less fertile soils	13%	36%	13%	0%	0%	0%	0%
430	Acid soils	2%	4%	0%	0%	8%	0%	0%
440	More fertile soils	4%	12%	0%	0%	0%	0%	10%
500	Increased vegetation, biodiversity, ground cover	5%	4%	4%	9%	0%	0%	20%
600	Decreased vegetation, biodiversity, ground cover	71%	72%	61%	91%	69%	70%	70%
610	Increased presence of invasive species	13%	16%	13%	9%	8%	0%	30%
620	Less wildlife	13%	8%	17%	9%	15%	10%	20%
630	Less fish	11%	12%	17%	0%	15%	0%	10%
640	Loss of human maintained biodiversity	3%	0%	0%	27%	0%	0%	0%
700	Changes in channel morphology, bank collapse, etc.	5%	0%	9%	0%	8%	0%	20%

TABLE A5.6
Impacts by region

	Impact	All	Africa	Asia	Europe	Neo-tropics	N. America	Oceania
100	Cereals	41%	60%	43%	18%	15%	70%	20%
110	Vegetables	26%	44%	4%	18%	23%	40%	30%
120	Sugars	2%	0%	0%	0%	8%	0%	10%
140	Cash crops	8%	8%	0%	9%	8%	0%	30%
130	Aquaculture	11%	4%	30%	9%	8%	0%	0%
220	Com. aquaculture	1%	0%	0%	9%	0%	0%	0%
200	Com. livestock	11%	0%	4%	27%	8%	40%	10%
210	Flowers	1%	4%	0%	0%	0%	0%	0%
230	Oil & biofuels	1%	0%	4%	0%	0%	0%	0%
235	Company-based agriculture	2%	4%	0%	0%	0%	10%	0%
300	Incr. crop prod.	36%	72%	39%	0%	23%	0%	30%
310	Fisheries increased	2%	0%	9%	0%	0%	0%	0%
320	Incr. livestock	2%	0%	4%	0%	0%	0%	10%
330	Incr. gathering	3%	8%	4%	0%	0%	0%	0%
400	Decr. aquaculture	1%	0%	4%	0%	0%	0%	0%
410	Decr. crop prod.	16%	24%	26%	18%	8%	0%	0%
420	Decr. fisheries	30%	32%	74%	0%	15%	0%	10%
430	Decr. livestock	16%	36%	9%	36%	0%	0%	0%
440	Decr. gathering	17%	24%	26%	9%	15%	0%	10%
500	Flood protection	4%	0%	9%	9%	0%	10%	0%
510	Water purification	2%	0%	4%	0%	8%	0%	0%
520	Recreation	14%	4%	13%	27%	8%	20%	30%
530	Negative cultural impacts	8%	0%	0%	45%	8%	0%	10%
600	Water purification	1%	4%	0%	0%	0%	0%	0%
605	Increased flood protection	1%	0%	0%	0%	0%	0%	10%
610	Recreation opportunities increased	8%	4%	9%	9%	0%	30%	0%
620	Water regulation	1%	0%	4%	0%	0%	0%	0%
700	economic differentiation	17%	48%	9%	0%	8%	0%	10%
710	Increase / decrease in conflicts	23%	32%	30%	9%	38%	0%	0%
720	Marginalization & poverty	13%	16%	22%	9%	15%	0%	0%
730	Poverty reducing	1%	4%	0%	0%	0%	0%	0%
800	Increased disease occurrence	4%	8%	9%	0%	0%	0%	0%
810	Institutional / social capital devt / changes	3%	8%	4%	0%	0%	0%	0%
820	Water transport improved of impacts	2%	4%	0%	0%	8%	0%	0%
830	Economic diversification	3%	12%	0%	0%	0%	0%	0%
840	Land tenure changes	1%	4%	0%	0%	0%	0%	0%
845	HEP	1%	4%	0%	0%	0%	0%	0%
850	Treaty obligations met	2%	0%	0%	18%	0%	0%	0%

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Scoping agriculture–wetland interactions

Towards a sustainable multiple-response strategy

Agriculture–wetland interactions (AWIs) are increasingly important as rising demand for food and fuel production exacerbates pressures on wetlands. The Millennium Ecosystem Assessment identified agriculture as the main cause of wetland degradation and loss. Using a drivers, pressures, state changes, impacts and responses (DPSIR) framework to analyse 90 cases drawn from all parts of the world and all wetland types, this report assesses the character of AWIs and their impacts in socio-economic and ecosystem services terms. Identifying the drivers and pressures that cause “overdependence” on specific and limited provisioning services in wetlands, it shows how these skew ecosystem services and lead to socio-economic and livelihood trade-offs that fuel economic drivers and pressures on the system. It argues that sustainable AWIs require multiple-response strategies that are targeted at: diversified agricultural services and livelihoods; the multitude of ecosystem services, and; policy, management and technical measures. The report illustrates how the framework can aid in their formulation by presenting its detailed application in five diverse cases.

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