Guidelines on Agriculture and Wetland Interactions

Framework Document

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<td>Agriculture and Wetland Interactions</td>
</tr>
<tr>
<td>CA</td>
<td>Comprehensive Assessment of Water Management in Agriculture</td>
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<tr>
<td>CBD</td>
<td>Convention on Biodiversity</td>
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<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
</tr>
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<td>COP</td>
<td>Convention of the Parties</td>
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<tr>
<td>CPWF</td>
<td>Challenge Program on Water and Food</td>
</tr>
<tr>
<td>DPSI</td>
<td>Drivers, Pressures, State changes and Impacts</td>
</tr>
<tr>
<td>DPSIR</td>
<td>Drivers, Pressures, State changes, Impacts and Responses</td>
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<tr>
<td>DU</td>
<td>Ducks Unlimited</td>
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<td>DUC</td>
<td>Ducks Unlimited Canada</td>
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<td>FAO</td>
<td>Food and Agricultural Organisation of the United Nations</td>
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<td>GAP</td>
<td>Good Agricultural Practices</td>
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<td>GAWI</td>
<td>Guidelines on Agriculture, Wetlands and Water Resource Interactions Project</td>
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<td>GBF17</td>
<td>Global Biodiversity Forum 17</td>
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<tr>
<td>GM</td>
<td>Genetically Modified</td>
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<tr>
<td>IAASTD</td>
<td>International Assessment of Agricultural Science and Technology for Development</td>
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<tr>
<td>INGO</td>
<td>International Non-Governmental Organisation</td>
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<tr>
<td>IUCN</td>
<td>World Conservation Union</td>
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<td>IK</td>
<td>Indigenous Knowledge</td>
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<td>IPM</td>
<td>Integrated Pest Management</td>
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<td>IWMI</td>
<td>International Water Management Institute</td>
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<td>MA</td>
<td>Millennium Ecosystem Assessment</td>
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<td>MDG</td>
<td>Millennium Development Goals</td>
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<td>NGO</td>
<td>Non-Governmental Organisation</td>
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</table>
PES  Payment for Environmental Services
RAMSAR  Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat
STRP  Scientific and Technical Review Panel
UN  United Nations
UNDP  United Nations Development Programme
WRM  Water Resource Management
Introduction

The origins of the GAWI initiative go back at least as far as 2002 when in Valencia, Spain, there were, in two consecutive weeks in October, the GBF17 workshop on “wetlands and agriculture” and Resolution VIII 34 at the Ramsar COP8 entitled “Agriculture, wetlands and water resource management”. Together, these put the question of the relationship of agriculture and wetlands clearly on the international agenda, while the latter requested Ramsar’s STRP in 2003-2005 triennium to develop a framework for the dissemination of good agriculture-related practice, site-specific and crop-specific information and policies that demonstrate sustainable use of wetlands for agriculture.

After that date further initiatives such as the Joint FAO/Netherlands Conference on Water for Food and Ecosystems, in the Hague in January 2005 have emphasised 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) by IWMI which follows up on a number of themes raised by the Millennium Ecosystem Assessment. 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-CBD Joint Workplan.

The GAWI group consists of the Ramsar Secretariat, IWMI, FAO, Wageningen University, MedWet and Wetlands International. In addition, Wetland Action joined the group in September 2006. The group was set up at the Ninth Ramsar COP in Uganda (November, 2005) with support from the Dutch and Swiss national delegations. These delegations and the GAWI partners were concerned about the importance of the interaction between agriculture and wetlands and the need to support Ramsar and its STRP in addressing this issue. The GAWI group takes its title from the project it has agreed to collaborate on “Guidelines on Agriculture, Wetlands and Water Resource Interactions Project (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.”

The specific purposes of the project are to:

1. Develop a supporting framework and associated guidelines for the sustainable management of different types of wetland-agriculture systems impacted by the full range of water resources, agricultural and wetland policies, systems, and practices.
2. Build capacity to implement the guidelines.
3. Promote the use of the guidelines.

Specific areas of the COP8 Resolution which 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.
• Include 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 should receive priority, with additional guidance at the policy/planning level.

The GAWI group has identified six work packages, namely:
• Knowledge consolidation and guidance,
• Guidelines,
• Fieldwork,
• Outreach and dissemination,
• Capacity building, and
• Project management and public relations.

This present framework document 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 change, Impacts and Responses model to analyses cases of agriculture-wetland interaction,
• To identify the most pertinent issues affecting agriculture-wetlands interactions around the world,
• To identify the most appropriate responses to these issues/challenges (i.e. to encourage ‘good practice’),
• To illustrate through presentation/application of a set of cases that the issues are ‘real’ – i.e. that they are valid to a wide set of bio-physical and socio-economic settings.

In this framework document the DPSIR model has been use to analyse cases of wetland-agriculture interaction to meet the scope and purpose outlined above. The particular focus has been on the need to identify issues and responses which can inform future work on the development of guidelines for agriculture / wetland interactions.

This framework document is divided into four sections:
• Part 1 which discusses agriculture-wetland interactions and the value of the DPSIR model in analysing them;
• Part 2 which explores the concept of issue-situations and applies this to the case studies available and in some detail addresses four such scenarios and the responses which are being made to achieve sustainable use;
• Part 3 Discussions and Conclusions as to the best ways to respond to the issues which can be identified and in the light of the responses which are being used to date, and
• Annexes of the case study data.
PART I
AGRICULTURE-WETLAND INTERACTIONS

CHAPTER 1:
Exploring Agriculture-Wetland Interactions:
A framework for analysis

1.1 Introduction
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 their use has been limited by this. There is evidence that wetland agriculture has made a significant contribution to the well-being of many societies around the globe over many centuries. In central America, for example, archaeological work has indicated that Mayan wetland agriculture dates back 3000 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 over 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), and in Africa, agriculture has traditionally been practised on the floodplains of the continent’s major rivers such as the Niger, Zambezi and Nile. Indeed, wetlands have been, and remain, a multiple benefit resource for people in many parts of the world.

The importance of wetlands, in terms of their benefits to human populations, rests on their capacity to provide and support a range of ecosystem services. The Millennium Ecosystem Assessment (2005) suggests these can be classified as provisioning services (e.g. food, water, fibre and fuel), regulating services (e.g. water regulation and purification, erosion control, 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 in Section 1.3.

Recent research has drawn attention to a global trend in wetland degradation and destruction. According to the MA (2005), more than 50% of specific wetland types in North America, Europe, Australia and New Zealand have been converted during the 20th century. Throughout the world, population pressure and economic development have driven the over-exploitation and pollution of wetland resources, and across the globe, the development of agriculture has played a major role in wetland degradation (CA, 2007). In the past this has stemmed from a perception that wetlands were unproductive wastelands with no economic, or wider societal, value. Hence their conversion to agricultural areas, through field drainage, was widely adopted in Europe (Baldock, 1984; Williams, 1991). In many areas wetlands were completely drained for crop production, to the extent that they no longer retained any natural wetland characteristics. In some areas, however, less intensive agricultural practices have
been implemented, and wetland characteristics have been conserved, albeit in a managed form. For example in lowland Britain 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 of the traditional rice production systems that incorporate aquaculture, have effectively and sensitively combined human manipulation of the environment with natural flooding regimes, thereby minimising environmental degradation.

However, it is arguably in the developing world where the majority of wetland degradation is now occurring, as rapidly developing economies and growing populations require the intensification of food production, often in previously marginal or little used areas. As a result of the lack of planning infrastructure, and increasingly common view of wetlands as resource rich environments suitable for conversion to agriculture, many wetlands have undergone drainage and cultivation; the short-term economic benefits being valued above the often less tangible long-term environmental benefits.

The effect of a global shift towards intensive mono-agriculture in and around wetlands, fuelled by the need for food production, is that more wetland areas are undergoing drainage and conversion, more freshwater is being abstracted for irrigation, and the propensity for agricultural pollution is increasing. In effect, the provisioning services of wetlands are being increasingly exploited at the cost of the regulating, cultural and supporting services. Whilst this is undoubtedly creating benefits for people in terms of food production, there is a concern whether this is sustainable given the way regulating and supporting ecosystem services of the wetland environment have been altered or destroyed.

With growing recognition of the importance of the interconnectedness of these wetland ecosystem services, attempts have been made worldwide to conserve and rehabilitate wetland areas. For example, recognition of the capacity of wetlands to mitigate flood events has led to the implementation of river basin management plans that seek to restore and conserve wetlands. As evidence of the ability of wetlands to purify contaminated water increases, more rehabilitation of existing wetlands and construction of new ‘artificial’ wetlands have taken place (Denny, 1997; Gopal, 1999; Kivaisi, 2001) A key challenge for wetland conservation and rehabilitation, however, is to appreciate the wider socio-economic importance of wetland resources, particularly wetland agriculture, for people around the world. Attention has been given to this recently in parts of the Millennium Ecosystem Assessment (MA, 2005) and the Comprehensive Assessment (CA, 2007) which consider the nature of the challenges faced in balancing the demands on the different ecosystem services provided by wetlands. This is taken further here in the GAWI initiative, which seeks to develop guidelines which will help strike a balance in terms of the exploitation of wetland ecosystem services, and achieve sustainability in agriculture-wetland interactions. Critically, however, GAWI also seeks to identify the ways in which agricultural outputs from such sustainable agriculture-wetland interactions can be maintained at a level compatible with the needs of society, thereby providing economically, socially and environmentally sustainable alternatives to intensive mono-agriculture.

In this discussion wetland agriculture is interpreted in a wide sense to include not just grazing and other “farming” types of activities as well as cultivation, but also aquaculture and other forms of coastal and inland fishing, as well as gathering activities.
1.2 Wetlands – Diversity and Definition

1.2.1 Definitions and Typologies
Much of the literature on wetlands in recent years has addressed issues of definition and classification, principally because it makes the task of developing management approaches and policy development for wetlands much easier. 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 characteristic of being strongly influenced by water. Since 1971 the 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, p3)

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).

Table 1.1 highlights 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 of the cases in this study (see Chp 2).

Dugan (1990) suggests that the 42 categories of Ramsar wetlands can be grouped and simplified according to seven common landscape units, indicative of specific geomorphologies:

1. **Estuaries** which constitute bodies of water where a river mouth widens into a marine ecosystem, where the salinity is intermediate between salt and fresh water, and where tidal action is an important bio-physical regulator;
2. **Open coasts** which are not subject to the influence of river water and lagoon ecosystems;
3. **Floodplains** which include areas of land between a river channel and the valley sides, which are subject to periodic flooding;
4. **Freshwater marshes** which occur where groundwater, springs, streams or runoff cause seasonal inundation. Where standing water is permanent, these areas are also classified as swamps;
5. **Lakes and Ponds** which occur as a result of several geomorphological processes including folding, faulting, volcanic disturbances, glaciation or fluvial processes;
6. **Peatlands** which are characterised by the accumulation of partially decomposed organic matter, which occurs as a result of conditions of low temperature, high acidity, low nutrient supply, water-logging and oxygen deficiency;
7. **Swamp forests** which develop in still waters around lake margins and floodplains.

To this should be added man-made wetlands: paddy systems, irrigation tanks, fish ponds, waterlogged areas, reservoirs and so on. It appears that the MA has built on this and
developed a similarly generalised categorisation which is used in Table 1.2. (It should be noted that the classification in Figure 1.1 is slightly different as the MA drew this from the Global Lakes and Wetlands Database.)

Table 1.1 Categorisation by Wetland Type (Ramsar categories)

<table>
<thead>
<tr>
<th>CODE</th>
<th>Wetland Type</th>
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<tbody>
<tr>
<td><strong>Marine/coastal Wetlands</strong></td>
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</tr>
<tr>
<td>1</td>
<td>Permanent shallow marine waters</td>
</tr>
<tr>
<td>2</td>
<td>Marine subtidal aquatic beds</td>
</tr>
<tr>
<td>3</td>
<td>Coral Reefs</td>
</tr>
<tr>
<td>4</td>
<td>Rocky marine shores</td>
</tr>
<tr>
<td>5</td>
<td>Sand, shingle or pebble shores</td>
</tr>
<tr>
<td>6</td>
<td>Estuarine waters</td>
</tr>
<tr>
<td>7</td>
<td>Intertidal mud, sand or salt flats</td>
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<tr>
<td>8</td>
<td>Intertidal marshes</td>
</tr>
<tr>
<td>9</td>
<td>Intertidal forested wetlands</td>
</tr>
<tr>
<td>10</td>
<td>Coastal brackish/saline lagoons</td>
</tr>
<tr>
<td>11</td>
<td>Coastal freshwater lagoons</td>
</tr>
<tr>
<td>12</td>
<td>Karst and other subterranean hydrological systems</td>
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<tr>
<td><strong>Inland Wetlands</strong></td>
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<tr>
<td>13</td>
<td>Permanent inland deltas</td>
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<tr>
<td>14</td>
<td>Permanent rivers/streems/creeks</td>
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<tr>
<td>15</td>
<td>Seasonal/intermittent/irregular rivers/streems/creeks</td>
</tr>
<tr>
<td>16</td>
<td>Permanent freshwater lakes</td>
</tr>
<tr>
<td>17</td>
<td>Seasonal/intermittent freshwater lakes</td>
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<td>18</td>
<td>Permanent saline/brackish/alkaline lakes</td>
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<td>Seasonal/intermittent saline/brackish/alkaline lakes and flats</td>
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<td>Permanent saline/brackish/alkaline marshes/pools</td>
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<td>Seasonal/intermittent saline/brackish/alkaline marshes/pools</td>
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<td>Shrub-dominated wetlands</td>
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<td>Freshwater, tree-dominated wetlands</td>
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<td>Forested peatlands</td>
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<td>Freshwater springs;</td>
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<td><strong>Human-made Wetlands</strong></td>
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<td>33</td>
<td>Aquaculture (e.g., fish/shrimp) ponds</td>
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<td>34</td>
<td>Ponds</td>
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<td>Irrigated land (?? Wetland created by irrigation)</td>
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<td>Wastewater treatment areas</td>
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<td>Canals and drainage channels, ditches</td>
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<tr>
<td>42</td>
<td>Karst and other subterranean hydrological systems</td>
</tr>
</tbody>
</table>
1.2.2 Global Diversity and Distribution of Wetlands
Recent studies suggest that wetlands occupy in excess of 1,280 million hectares 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 sub-arctic zones favour the development of extensive areas of peatland which, arguably account for a third to a half of the world’s wetlands (Mitsch et al. 1994; Finlayson et al., 1999). In tropical areas peatlands are not as widespread with most located in highland areas which receive abundant rainfall or in specific low-lying areas of Southeast Asia – peat forests (Hughes, 1996). Similarly, mangrove forests are the tropical and sub-tropical equivalent of temperate saltwater marshes (Hughes, 1992).

Figure 1.1: Global distribution of wetland types (Lehner and Doll 2005).

1.3 Ecosystem Services
1.3.1 Ecosystem services concept
Attitudes towards the value of wetlands have changed significantly within the last 50 years. Throughout much of the developed world, where the majority of wetland degradation has occurred through transformation by the mid 20th century, there has been a growing recognition that rather than being unproductive wastelands in their natural state that benefit from conversion, wetlands are in fact multi-functional natural resources which provide a range of services of inherent value to human well-being (Maltby, 1986; Dugan, 1990; Barbier et al., 1997; Roggeri, 1998; Silvius et al., 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 (2005 p31) 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, 2005), and considerable research has been carried out on the specific roles wetlands play and how these interact with the local environment. Despite the wealth of literature, however, classifications of these services (often called functions and benefits) have rarely been consistent. Hence, the recent MA 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, fibre etc),
- ‘regulating’ (benefits from the processes of ecosystem regulation, e.g. water partitioning, climate regulation, etc),
- ‘cultural’ (non-material benefits from ecosystems, e.g. spiritual, recreational, aesthetic) and
- ‘support’ (factors necessary for producing ecosystem services, e.g. hydrological cycle, soil formation, nutrient cycling, etc) (MA, 2005).

These are discussed below.

It is important to note, that not all wetlands support the full range of ecosystem services and that specific services may be associated with specific types of wetland (see Table 1.2). However, the key lesson from this conceptualisation 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.
Table 1.2: Relative magnitude of ecosystem services derived from different wetland ecosystems.

<table>
<thead>
<tr>
<th>Services</th>
<th>Inland Wetlands</th>
<th>Provisioning</th>
<th>Regulating</th>
<th>Cultural</th>
<th>Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permanent &amp; temporary rivers and streams</td>
<td>Permanent Lakes and Reservoirs</td>
<td>Estuarial Lakes, Marshes, and swamps including floodplains</td>
<td>Forested Wetlands, Marshes, and Swamps including Floodplains</td>
<td>Alpine and Tundra Wetlands</td>
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<tr>
<td>Food</td>
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<tr>
<td>Fresh water</td>
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<tr>
<td>Fibre and fuel</td>
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<tr>
<td>Climate regulation</td>
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<tr>
<td>Hydrological regimes</td>
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<tr>
<td>Pollution control and detoxification</td>
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<tr>
<td>Erosion protection</td>
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<tr>
<td>Natural hazards</td>
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<td>Spiritual</td>
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<td>Recreational</td>
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<td>Aesthetic</td>
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<td>Educational</td>
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<td>Biodiversity</td>
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<tr>
<td>Soil formation</td>
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<td>Nutrient cycling</td>
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<td>Pollination</td>
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</tbody>
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Table 1.2 Continued

<table>
<thead>
<tr>
<th>Coastal Wetlands</th>
<th>Estuaries and Marshes</th>
<th>Mangroves</th>
<th>Lagoons, including Salt Pans</th>
<th>Intertidal Flats, Beaches and Dunes</th>
<th>Kelp</th>
<th>Rock and Shell Reefs</th>
<th>Seagrass Beds</th>
<th>Coral Reefs</th>
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</thead>
<tbody>
<tr>
<td><strong>Provisioning</strong></td>
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<td>Food</td>
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<td>Fresh water</td>
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<td>Fibre, timber, fuel</td>
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<td>Biochemical products</td>
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<td>Genetic materials</td>
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a) Regulating services
Depending upon 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:

**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). The relationship between groundwater and wetlands, however, 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).

**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 saturated 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 (Acreman and Bullock, 2003).

**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 build up of sediment in a wetland also causes its water holding capacity to deteriorate and can change its vegetation, soil characteristics and agricultural
productivity.

**Maintenance of water quality/ water purification**
The practice of discharging wastewater into natural wetlands has been used as a means of waste disposal for hundreds of years (McEldowney *et al.*, 1993). Research on the ability of wetlands to purify water has shown that the 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 also able to store large quantities of nutrients and heavy metals (Gopal, 1987). Even paddy rice fields are seemingly able to act as a sink for synthetic agro-chemical pollutants.

**Biosphere and micro-climate stabilisation**
The conditions of high humidity and evapo-transpiration found in many wetlands, may significantly affect local and regional climates (Roggeri, 1998). In addition, the process of microbial decomposition is encouraged in wetland ecosystems and 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). Whilst the destruction of wetlands undoubtedly results in the release of carbon into the atmosphere, the extent to which wetlands actively mitigate CO$_2$ emissions through photosynthesis remains unclear, and the subject of on-going research.

While recognising the above regulating services it is important to be clear that not all wetlands provide every service, and that in many cases it is difficult to identify precisely the extent of the service and the value which can be put on it. The following qualifications might be made:

- **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:** is 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;
- **Biosphere and micro-climate stabilisation:** limited, except for mist rain forests; too complex and difficult to be exploitable.

**b) Provisioning services**
The provisioning services provided by wetlands tend to be associated with the direct exploitation of wetland products for economic gain or subsistence:

**Agricultural 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 such as those in West Africa, are economically important farming resources. Various methods have been developed which maximise the use of these areas throughout the seasons, both during the flood period and especially after it has fallen (Adams, 1993a). Floodplain soils are very fertile, and clay soils
facilitate water retention in the dry season.

**Plant production (fibre, fuel, medicinal and dietary supplements)**
Natural wetland plants can be used for a variety of purposes from construction to medicine. Soerjani (1992) points out that of the 266 species of weeds associated with wetland rice cultivation in Indonesia, 70% can be utilised in a range of activities including medicine, cattle fodder, household purposes 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).

**Fishing**
Fish production is a basic element in the economy of many wetlands. There is often a localised economic and nutritional dependence on this resource as fish provides a crucial source of proteins. In addition, in recent decades fish farming (aquaculture) has been developed in coastal brackish lagoons in several parts of the tropics (Maltby, 1986; DeMerona, 1992; Bwathondi and Mwamsojo, 1993).

**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 dams 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 hydro-power**
Most wetlands can provide a potable supply of water for the surrounding population (either directly or from springs which contribute to their formation). This is a critical function in many semi-arid or seasonally dry areas (Scoones, 1991). Depending upon their ecohydrological characteristics, wetlands may be able to purify water supplies as a result of the effects of microbial action. A wetland’s ability to regulate and store water can also be beneficial in the production of hydro-electric power by moderating and thereby improving the flow of supply of water for power production.

**Agro-biodiversity as a provisioning service:**
Biodiversity is discussed below under cultural services. However, from an agricultural perspective, agro-biodiversity may have crucial provisioning services to provide to farming systems. Specifically, services such as pollination, harbouring natural predators of agricultural pests (IPM), hatching and breeding for fish, are found in wetlands. Indeed, these niches may be created through some agricultural use of wetlands. However, conversely some pest 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 agro-biodiversity refuges – i.e. provide “agricultural off-season” refuges for species that thrive within crop-systems (or seasonal fishing grounds). From an ecological perspective, these agro-biodiversity refuges are the “stuff” that determine the resilience of the ecosystem, as it provides the basis for temporal growth and contraction of species numbers and their reproductive cycles. From the ecological perspective, agro-biodiversity refuges can thus be considered supporting services to the ecosystem. In an ecosystems management approach the conscious management of agro-biodiversity refuges can thus be expected to be
an important element.

c) 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 psycho-social value.

**Spiritual and inspirational**
There are many examples of cultures around the world where wetlands or water has 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, 2001). For Maori in New Zealand, water has its own life-force or *mauri*, for which people are obligated to have a duty of care (Williams, 2006).

**Aesthetic value**
Maltby (1986) suggests that in Botswana alone, wildlife safaris are worth over $15 million annually and many of these are in the Okavango wetland. Throughout East Africa 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 in return they receive economic and social benefits from tourism (Chabwela, 1992b; Sanyanga, 1994).

**Biodiversity**
Wetlands are host to a rich biodiversity because they offer a range of ecological niches for wildlife both spatially and temporally (Maltby, 1986; Denny, 1994). Furthermore, they often represent areas of high endemicity for rare or endangered species (Dugan 1990). In seasonally inundated wetlands different species have adapted to conditions during the dry season and the wet season, whereas 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 specialised plant adaptations to wetland environments which include among others *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 leche smithemani*) and it constitutes one of Africa’s most important areas for Sitatunga (*Tragelaphus spekei*) (Dugan, 1993). Wetlands provide vital habitats for waterfowl and migrating birds, the main factor which served as the impetus for the Ramsar Convention.

d) Supporting services
These services refer to the key processes or factors necessary for maintaining the ecosystem services as a whole which are provided by wetlands. They include the major environmental cycles involved with hydrology (e.g. groundwater recharge/discharge), nutrient flows (e.g. the nitrogen cycle) and soil formation (e.g. via anaerobic formation of peat). The key point is that these services are the essential underpinning of the wetland ecosystem services and if disrupted they will affect the services which wetlands can provide.
This discussion confirms the wide range of ecosystem services obtained from wetlands. It shows the value which 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 earlier point made about the way in which these services are inter linked and all involved in supporting human well-being.

However, despite this importance of wetlands, some recent research has argued that the ecohydrological relationships and socio-economic process in many wetlands remain poorly understood (Acreman and Bullock, 2003; Woodhouse, 2000) (see Table 1.2 and Section 1.7). It is important, therefore, to exercise caution when generalising about the services performed by wetlands, and also the socio-economic benefits that emanate from these services. A key criticism of global wetlands policy to date has been the popularisation of universal wetland values as a means of justifying and promoting wetland preservation. In reality, there is a need for a more site specific approach, with sensitivity to the biophysical and socio-economic diversity.

1.3.2 Application and relevance of the Ecosystem Service Concept to GAWI

The concept of ‘ecosystem services’ is particularly pertinent to GAWI in that most agriculture-wetland interactions can be characterised by their use of, or effect on, provisioning, regulating, cultural and supporting services. A key component of the analysis of agriculture-wetland interactions, therefore, is identifying the linkages and interactions between various ecosystem services, and establishing which services are mutually supportive, or are incompatible with each other. An understanding of these relationships is clearly central to the development of sustainable wetland-agriculture systems.

As outlined below, the MA (2005) regards the balanced use of diverse wetland ecosystem services as synonymous with sustainable utilisation. 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. Any agriculture-wetland interaction that relies heavily on the over-development of one provisioning service alone, arguably facilitates degradation in the resource base. Whilst 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 struck and made compatible with agricultural activities, and the increasing global demand for food.

1.4 Wetland change dynamics

1.4.1 Wetlands formation and loss under natural conditions

Wetlands are areas whose formation is influenced by ecological, hydrological and geomorphological processes. Since these underlying processes are themselves extremely dynamic, so too are the wetlands themselves. As transitional zones between dryland and water bodies, wetlands such as swamps and marshes are continuously evolving in response to local ecohydrological processes.

Many wetlands experience gradual change and are formed slowly through the accumulation of water and sediments, and the partial decomposition of plant material, whilst others are ephemeral in nature, occurring only in response to seasonal rainfall. Some wetlands represent one stage in the succession from a standing water body to a terrestrial environment. Clearly, an understanding of wetland formation and succession is a critical prerequisite to identifying the nature and impact of anthropogenic disturbance in wetlands. In some cases, what has
been considered human induced degradation, may simply reflect the acceleration of natural evolution of a wetland environment.

1.4.2 Global change in wetlands, patterns and rates
It is widely accepted that wetlands are being degraded at an unprecedented rate, vastly beyond that of natural loss, yet there are few reliable accounts of the current situation. The MA (2005, p6) reports that more than 50% of specific types of wetlands in parts of North America, Europe, Australia and New Zealand were converted for agriculture during the 20th Century, but 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% were affected by fragmentation and altered flows, potentially indicative of wetland loss (MA, 2005, p25). Loss of coastal wetlands is, however, better established; the MA (2005, p25) reports that 35% of the world’s mangrove forests (for which data exists) have disappeared within the last two decades due to aquaculture development (mostly for shrimp and prawn production).

However, there are also some gains in wetland areas as a result of water management, specifically through seepage from dams and irrigation systems, the extension of rice cultivation beyond existing wetlands, and through the rehabilitation of former wetlands for recreation, cultural or biodiversity conservation or flood management – mainly in high-income countries.

1.4.3 Key driving forces and their diversity around the world and by type of wetland
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 generalise, 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. In developed and developing countries, 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 value of wetlands for recreation conservation and flood protection.

In an analysis of the key driving forces behind wetland loss and destruction, the recent Millennium Ecosystem Assessment (2005) draws a distinction between inland and coastal wetland systems, and critically 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, (what are termed “pressures” in this study), which are more conspicuous and include infrastructure development, land conversion (to agriculture), water withdrawal, pollution, over-exploitation 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 were again cited as the key indirect drivers of change. Conversion to other land uses, the diversion of freshwater flows, nitrogen loading, over-harvesting, and siltation, have constituted the major direct drivers of wetland destruction.

Figure 1.2 gives some indication of the relationship between direct driving forces or pressures on different wetland types, in the context of impacts on biodiversity.
1.5 Agriculture and Wetland Interactions

In examining the relationship between wetlands and agriculture, it is useful to distinguish between by **direct** interactions - where there is direct agricultural intervention in wetlands, and **indirect** interactions - where the effects of external (upstream, downstream or peripheral) agricultural activities impact on the wetland and its ecosystem services. These relationships are presented in Figure 1.3, where the linkages through a basin, from the headwaters areas, via wetlands at any stage in the basin, to coastal wetlands, are shown.
The nature of the interactions highlighted can be of various types. These can be environmental – where drainage occurs, socio-economic – where livelihoods are affected and political - where conflicts are stimulated.

**Figure 1.3: Conceptual model of agriculture-wetland interactions**
KEY to Figure 1.3

1. Wetland Agriculture (DIRECT 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 eco-agriculture).
   1.4 Enhancement of wetlands / creation of additional wetlands (often used for agric)
   1.5 Reversion to natural wetland

2. Upstream Agricultural activity (INDIRECT) interactions (from distant catchment)
   2.1 Upstream agricultural activity influencing wetland ecosystem & wetland agric downstream
   2.2 Wetland ecosystem influencing upstream agricultural activity

3. Periphery Agricultural activity (INDIRECT) 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 (INDIRECT) interactions
   4.1 Downstream agricultural activity (incl wetland agric) influencing wetland upstream (or wetland agric upstream)
   4.2 Wetland ecosystem influencing downstream agricultural activity (e.g. flooding, constant supply of water, water purification)

5. Coastal-Interrupt Agricultural activity (INDIRECT) interactions
   5.1 Influence of immediately upstream (wetlands & non-wetland agric) on coastal wetland
   5.2 Influence of coastal wetland on upstream non-wetland agricultural activity

6. Coastal wetland – inland wetland (INDIRECT) interactions
   6.1 Influence of inland wetland (natural or altered by agric) on coastal wetland
   6.2 Direct influence of coastal wetland (natural or altered by agric) on inland wetland

7. Coastal Wetland Agriculture (DIRECT / 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 eco-agriculture).
   7.4 Enhancement of wetlands / creation of additional wetlands
   7.5 Reversion to natural wetland

8. Coastal Wetland Agri / aquaculture – other coastal wetlands (INDIRECT) interactions
   8.1 Influence of adjacent / upstream coastal wetlands
   8.2 Coastal wetland aqua / agriculture influencing adjacent coastal wetland functioning

Regional linkages = Groundwater resources, shared wildlife resources (inc. birds), population, ethnic groups, culture, agricultural and conservation policies etc.
International linkages = same, but next scale up.

1.5.1 Direct interactions (in-situ interactions)
Direct interactions, represented by 1.1, 1.2 and 1.3 in Figure 1.3, involve on-site wetland agricultural activities. They can be characterised 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 may include a range of associated practices which create pressures on the wetland ecosystem, such as drainage, the application of fertilisers and pesticides, the use of GM crops, and livestock grazing. Examples would be the seasonal cropping of floodplains in West Africa, the cultivation of upland peat bogs in the Andes, or 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.

Direct interactions, however, also include agricultural exploitation which does not transform the wetland environment, or have any impact on available ecosystem services (1.3). This is most commonly seen in the practice of collecting or gathering activities which involve the harvesting of reeds, fish or other products in a sustainable manner. These are the typical “wise uses” of wetlands as defined by the Ramsar Secretariat. In addition, it should be noted that some wetlands have been manipulated to create ‘artificially’ constructed wetland
environments for agricultural, aquaculture purposes (such as rice paddy fields and fishponds) 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 would be where wetland agriculture occurs at a level which does not disturb the wetland ecohydrology or ecosystem services (1.3). It may be characterised by eco-agricultural practices, where, for example, crops that are well-adapted to the wetland environment are cultivated in an environmentally sensitive manner. An example would be the multi-cropping 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 are so great and the areas of cultivation so limited at present, that there is little or no alteration of the ecosystem services.

The above discussion focuses mostly on inland situations, but could also refer to coastal wetlands with similar interactions due to aquaculture or, to a lesser degree, agriculture. Figure 1.3 also shows such the direct interactions within coastal wetlands – lagoons or mangrove swamps (7.1, 7.2, 7.3, 7.4, 7.5).

Because of the eco-hydrological demands of crop cultivation, 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.

1.5.2 Indirect interactions (basin interactions)
Indirect interactions between agricultural/aquaculture activity and wetlands are represented by interactions 2, 3, 4, 5 and 6 in Figure 1.3. They are typically interactions between the wetland ecosystem and agricultural/aquaculture activities that are external to the wetland itself (either upstream, downstream or on the periphery of wetlands).

a) Upstream agriculture-wetland interactions
Wetlands are most frequently influenced by upstream agricultural activity (Interaction 2.1, 5.1, 6.1). A typical example would be 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 systems. Poor agricultural practices in the upland areas may also lead to soil erosion or the runoff of agricultural waste which impacts on wetlands. The subsequent pressures may lead to an alteration in the state 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 would be 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, 6.2). An example would be where wetlands contribute to the overall reduction in velocity of river
flow, and their capacity to store water and retain sediment causes upstream water-logging that may affect agricultural activity – this may also lead to the extension of the wetland.

**b) Periphery agriculture-wetland interactions**

Wetlands interactions with periphery agriculture (3.1 and 3.2) are arguably similar. Wetlands in their natural state or those directly transformed by agriculture can affect periphery agriculture in the adjoining / neighbouring / peripheral areas in terms of the regulation of water table and accommodation of runoff. Similarly, periphery 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).

**c) 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 hydrological gradient and result in the more rapid release of water from wetlands upstream lowering 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 – see interactions 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 due to features such as saline influxes.

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

It is important to recognise that these wetland-agriculture interactions typically occur in chains which 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 indirect wetland-agriculture interactions and that these can become of an international nature in some cases where human or animal populations, as well as water, are moving over long distances.

**1.5.3 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 1.3) 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, 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, local mobilisation 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 agriculture-wetland interactions, pointing to the need to take a wider view than some traditional site specific environmentalists have taken.

**1.5.4 Relevance for GAWI**

Recognition of the different interactions which occur between agriculture and wetlands confirm the emphasis which GAWI has to place on functional linkages, whether these be of an ecological, economic, social or political nature. Further it is clear that in the study of agriculture – wetland interactions there are two major type of interactions which need to be explored, those within wetlands and those between wetlands and other parts of the functioning system, usually the river basin.

**1.6. MA and CA Perspectives on Wetlands and Agriculture**

**1.6.1 Millenium Ecosystem Assessment (MA)**

The MA recognises that with respect to inland wetlands, agricultural development has historically been the principle cause of wetland degradation worldwide. It reports that by 1985, between 56% and 65% of inland water systems had been drained for intensive agriculture in Europe and North America, 27% in Asia and 6% in South America (MA, 2005). 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. Further, poor agricultural practices, rather than agriculture per se, such as polluted agricultural runoff and erosion which 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, whilst most agricultural activities in and around wetland ecosystems fundamentally alter their structure and functioning, impacting upon the services 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 regulatory and support services is “compensated” for by increased provisioning services.

In considering various scenarios for the future of wetlands, the MA (2005) predicts an increase in wetland degradation and wetland conversion to agricultural land during 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, whilst the actual capacity
of wetlands to provide these services will decrease. In particular the MA notes that the over-
development of provisioning services can damage regulatory and support services which in
turn can 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
which occurs in many agriculture – wetland interaction situations, and achieve a more
balanced use of the services with the value of each recognised. 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
regulatory and support services so as to achieve more ecologically balanced and functioning
wetland and river basin systems.

The view is presented that whilst agriculture inevitably has some impact on wetland
ecosystems and their regulating services, this is not necessarily disastrous for the wetland
environment as a whole, which can still potentially retain a range of regulating services
(albeit reduced or altered). Conversely, a level of support and regulatory services is critical
for the maintenance of provisioning services. In addition, there can also be positive impacts
from agricultural development in terms of biodiversity, such as that supported by irrigation
tanks in Sri Lanka.

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
recognises that in the wider context of the Millennium Development Goals, 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 new skewed use of ecosystem services
(over time and in space) to meet MDG goals. At the same time, the MA also advocates the
use of ‘ecosystem approaches’ to wetlands management and planning, which focus on
managing environmental resources and human needs across landscapes; balancing trade-offs
at a level beyond the wetland alone.

1.6.2 Comprehensive Assessment of Water Management in Agriculture (CA)
The recent Comprehensive Assessment of Water Management in Agriculture, published in
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 Millennium Development Goals, especially given the fact that
850m people remain undernourished at present. The question framing the CA was “How can
water for food be developed and manage 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 and 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-dependant ecosystems and
  maintain environmental flows;
- seeking multiple use and multifunctional agricultural systems;
- managing agriculture for diversity in the landscape;
- paying the poor for environmental services provided; and
- addressing policies outside agriculture which 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 recognises that
in many parts of the world food production has a negative or degrading impact on
biodiversity and ecosystem services. This has had 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,
• in land and water management, incorporating an understanding of the importance of
  biodiversity in supporting ecosystem services,
• recognising 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 MA, the CA advocates the adoption of integrated approaches to managing land, water
and ecosystems, which recognise 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.

1.6.3 Conclusions for GAWI
Overall, what this discussion shows is 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 over-allocated (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 but that the perfect
balance will not always occur due to priorities such as the MDGs. The CA fouses 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 working drawing attention to
different concepts and scales of analysis, including the ecosystem services, the functioning of
river basins as a whole, multiple use in agro-ecosystems and the landscape scale of management.

1.7 Livelihoods, Poverty Reduction and Wetland Stakeholders

1.7.1 Introduction
As the MA and CA point out, the pressures on wetlands are growing and new ways of thinking are needed to address the issues involved in agriculture – wetland interactions. 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 contributions to exports. In understanding this situation it is necessary to identify the pressures which are being put upon wetlands, what are their origins and who are the actors involved.

1.7.2 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. CHECK. Despite growing pressures on wetlands for agriculture, it is necessary to try to maintain these multiple benefits and try to ensure their availability across the socio-economic spectrum. Often with wetland agricultural development there are winners and losers, with conflicts and marginalisation resulting. For instance, large-scale commercial agriculture has often appropriated open access wetlands for estate production with the positive provisioning outputs offset by negative effects not just on regulatory ecosystem services, but on previous users of the area (Bondestam, 1975). Smaller-scale use of wetlands also raises many debates about the socio-economic implications, with pre-existing low intensity users of wetland loosing 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, 2000) with wetland 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. The different view of different groups seeking livelihood and other benefits needs to be given due consideration in understanding agriculture – wetland interactions.

1.7.3 Local Level Stakeholders
At the community level, there are also 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 successfully mobilise resources to use these areas in response to market opportunities (Woodhouse, et al., 2000). In other cases local government is interested in appropriating wetlands for its own uses, sometime to address land shortages (Rwanda) or to provide investment opportunities (Ethiopia).

1.7.4 National Level Stakeholders
At the national level one regularly finds quite deeply 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, hydro power etc. It was often the case that national economic development goals tended to dominate and win out in the competition for national resources and political support, so that food security and export earning are pursued through national
water policies which failed to take a holistic view of wetland ecosystem services. While there is still evidence of this, especially in the developing world, with political pressures leading to an emphasis on short-term goals and policies, there is 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.

Table 1.3: Agriculture / wetland interest groupings and stakeholders at different scales

<table>
<thead>
<tr>
<th>GOALS</th>
<th>SCALE</th>
<th>International and Regional</th>
<th>National</th>
<th>Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation</td>
<td>UN Departments, Ramsar Convention, International NGOs (biodiversity, wetland conservation), donors etc</td>
<td>Ministries / Departments for Environment / Conservation, etc, local environmental NGOs, etc</td>
<td>Local NGOs, community organisations and institutions, local people</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>CGIAR Centres, UN departments, international NGOs, donors, international agri-businesses, etc</td>
<td>Agriculture departments NGOs, Farmer Unions, agricultural companies, national, etc</td>
<td>Farmer co-operatives / institutions, local farmers, local agricultural development agents, etc</td>
<td></td>
</tr>
<tr>
<td>Water resources</td>
<td>International treaty organisations, donors, International NGOs, etc</td>
<td>Water Resources / Environment Departments,</td>
<td>NGOs, Womens’ groups, etc</td>
<td></td>
</tr>
<tr>
<td>Human development</td>
<td>UN Departments, donors international aid and development NGOs (rural development, humanitarian etc)</td>
<td>Various govt departments Inc. health, local NGOs, etc</td>
<td>Rural development agents, local people</td>
<td></td>
</tr>
<tr>
<td>Sustainable development</td>
<td>Donors, international agencies, conventions, NGOs, etc</td>
<td>Government, local NGOs, etc</td>
<td>Local people (esp if have IK of wetland-agric interactions), etc</td>
<td></td>
</tr>
</tbody>
</table>

1.7.5 International Community and Wetlands
The international community level has a range of stakeholders interested in wetlands, from those which focus on agricultural production to those which focus on conservation. Some of these international organisations 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 regulatory services in order to maintain provisioning services, these organisations may focus on sustainable use rather than purely on agricultural production.
In recent years there has been increased recognition amongst most of the international organisations 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 consideration, 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 wetlands, and the functioning of hydrological systems are increasingly recognised.

1.7.6 Relevance to GAWI
The GAWI initiative has to consider its task with reference to the current development priorities outlined in the MDGs, especially that of poverty reduction. This stresses the need for wetlands to be seen 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. To achieve this, there is a need to understand the actors involved, the forces which are driving wetland use and the different socio-economic impacts.

1.8 Conclusions
This overview confirms the complexity of the agriculture-wetland interaction situation. There is diversity in terms of the wetlands and the ecosystem services which 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 are a range of actors involved in agriculture-wetland interactions, operating at different scales and with different interests. This complex situation suggests that any analysis will require a clear framework and a rigorous approach. This is the issue addressed in Chapter 2.
CHAPTER 2

Methods and Sources

2.1 Introduction
In order to explore the diverse experience of agriculture - wetland interactions, the GAWI partnership decided in February 2006 to search for cases of such interaction across the world and to apply to these a standard analytical tool. In order to obtain cases all GAWI partners volunteered to submit some, drawing directly from their own experience, or indirectly from materials obtained through partner organisations with whom they work. In terms of the standardised analysis, it was recognised that cause and effect chains were common in the experience to be studied, but that this was a rather simplified conceptualisation of the situation. Consequently the Drivers, Pressures, State Changes, Impact and Response (DPSIR) model was chosen for use in analysing these cases (see 2.3 below) as it was felt to be more comprehensive than any simple cause-effect model. It was felt that the DPSIR model would provide a framework which would allow comparability between this analytical work and that of the MA, which had used the DPSIR concepts but in a slightly different form.

2.2 Acquiring the Case Studies

2.2.1 Sources
The GAWI partners provided around one third of the cases which were obtained for analysis, the majority of these coming from Wetland Action (with an African focus), Wageningen University with a European and Neotropics focus, Wetlands International with an Asian focus and FAO with an Asian focus. In addition a request for case studies was posted on the Ramsar listserv 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 (www.scopus.com) (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 on-line content, was undertaken, and this yielded 1093 references between 1985 and 2007. Subsequently, the search was widened to include the keywords ‘marsh’, ‘swamp’, ‘irrigation’ and ‘drainage’. 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:

a) A quick examination of the title of each article to ascertain whether it reflected agriculture-wetland interactions, and whether the text was likely to contain information relevant to the DPSIR framework. It was noted that the vast majority of articles were not particularly useful as they focused at great depth on only one or two particular elements of wetland-agriculture interactions, e.g. plant performance in constructed wetlands, chemical properties of agricultural runoff, etc. These were
considered unlikely to yield information relating to the various elements of the DPSIR framework, resulting in incomplete case studies. Hence they were discarded.

b) If the title of the article was deemed suitable, a subsequent 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.

c) If the above two criteria were met, the article was downloaded, analysed, and a DPSIR case study sheet compiled simultaneously (See 2.4.1). 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, hence the article was discarded.

Table 2.1: Search terms and results of academic database interrogation

<table>
<thead>
<tr>
<th>Search terms</th>
<th>Number of articles listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>'wetland' + 'agriculture'</td>
<td>1093</td>
</tr>
<tr>
<td>'wetland' + 'drainage'</td>
<td>1545</td>
</tr>
<tr>
<td>'swamp' + 'agriculture'</td>
<td>150</td>
</tr>
<tr>
<td>'marsh' + 'agriculture'</td>
<td>259</td>
</tr>
<tr>
<td>'wetland' + 'irrigation'</td>
<td>554</td>
</tr>
<tr>
<td>No. articles downloaded for preliminary analysis</td>
<td>85</td>
</tr>
<tr>
<td>No. used in GAWI case studies</td>
<td>43</td>
</tr>
</tbody>
</table>

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 data added to the DPSIR case study sheet. General web searches (using Google and Google Scholar) were also undertaken to triangulate information and consolidate the case studies. This often involved the identification of relevant grey literature contained on government or NGO websites.

Further cases were obtained from participants at the Experts 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 websites and emails with contact persons (See Annex 7).

Despite the problems in identifying cases and obtaining literature on them, after a considerable period of intermittent work over 100 cases have been identified from the various sources and of these 91 have been processed using the DPSIR model. (See Annex 4 with cases analysed and Annex 5 with other cases identified.)

2.2.2 Methodological Limitations

The coverage of agriculture-wetland interactions which was 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. The latter point about profession was also seen in the literature search where it was clear that certain types of agriculture-wetland interactions, water quality being a particular example, attracted funding for studies and hence were reported in the
literature more than others. As a result, care should be taken when comparing the cases as the absence of a comment on one aspect of AWI may be more a result of the professional skills of the author, rather than the actual situation. For instance, in one case soil characteristics may have been studied, while in another case this was not done, while in several cases socio-economic differentiation is given limited attention compared to water tables and flooding regimes.

Further, it should be noted that the use of the DPSIR model (see 2.3 below) ultimately biased the selection of case studies. For example, more general articles describing sustainable or traditional wetland-agriculture interactions did not fit the model well, since pressures, impacts and state changes were not elaborated upon. 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 some important findings. Some of these cases did remain where there was reasonably full information and these are discussed in Chapter 10.

In a small number of cases, some articles considered potentially relevant were not available to download (these being published prior to the mid-1990s). In view of the time and logistics involved in obtaining hard copies, such articles were not followed up. However, it should be stressed that the bulk of the database search covered the period from 1985 to 2007.

It is important to note how little 'joined-up' work on wetland-agriculture interactions in particular locations, or sites, was found in the cases studied. For example, many articles discuss management issues in depth, without addressing the drivers and pressure that are fuelling emerging issues. Others papers focused entirely on bio-physical state changes, without any appreciation of the wider socio-economic context. This is a clearly a key area for future research and one which GAWI should address.

2.3 Analysing Agriculture / Wetland Interactions

2.3.1 Drivers-Pressures-State-Impact-Response (DPSIR) Model / Framework

The DPSIR model 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 OECD and Eurostat. It has been used by environmental economists, not so much as an analytical tool, but more as an auditing framework (Turner et al, 2000). Turner’s use of the model was specifically with reference to the Fen wetlands in UK, while his particular focus on auditing meant that his definitions of the elements in the model were rather specific.

Operationalising some elements of the model, especially with respect to pressures and state changes, proved confusing at times, but in the end an agreed terminology was achieved, similar to that in the paper by Turner. The definitions of the elements in the model are outlined below.

2.3.2 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 agriculture-wetland interactions. The MA equivalents are given in lower case after the title for each category. (Full details of the DPSIR elements found in these cases can be found in Annex 6).

**DRIVERS (Indirect Drivers):**
These are any natural (bio-physical) or human-induced (socio-economic) factors that directly or indirectly lead to a change in the wetland ecosystem, or in socio-economic processes which influence wetlands and agriculture / wetland interactions. Simply put, drivers are the underlying causes which lead to pressures on wetlands or agriculture / wetland related processes.

Examples: Population dynamics, market development, natural environmental processes, government policies, community behaviour.

Some drivers operate directly in terms of how they influence ecosystem processes. For instance market opportunities may lead to establishing a sugar estate, population growth may cause agricultural expansion into a wetland. Other drivers operate more diffusely, by altering the more direct drivers. These less direct drivers are often “deeper causes”, such as broad policies or their failings, as well as international economic circumstances, or may be seen as the cultural value systems in a society and motivations which influence people’s behaviour.

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. They are seen here as processes, or activities, which are operating on a generalised scale.

Examples: Agricultural colonization in wetlands, vegetation clearance, agricultural intensification, nature conservation, water resource management and use, etc.

STATE CHANGES (Changes in Ecosystem Services):
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, supply resources, etc). In other words, the state of the ecosystem and especially its regulating and support services.

Examples: Water resources, water quality and pollution, soil characteristics – chemical and biological, biodiversity, etc.

IMPACTS (Human well-being and poverty reduction):
These are the socio-economic results of changes in the state of the wetland environment. In other words the way in which the wetland society’s socio-economic characteristics and condition are affected and especially the provisioning services which can be supplied.

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

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, and can be implemented by a range of actors.

Some examples of responses are as follows:
- technical or socio-economic actions try to address specific impacts,
- communities who respond to state changes by wetland site management coordination and institutional development,
- basin level organisations who respond to pressures with river basin planning initiatives for water and land use management,
- national level policies and economic development measures which try to address the demands in the society and especially achieve sustainable and ecologically sound economic development, and
- international-level responses, including government to government types of cooperation, actions of international NGOs, and international agreements to which national governments agree.

Exploration of responses has been limited in most uses of the DPSIR model. As a result some 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, and
- Divers Addressed.

**a) 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, and
- state – involving policies, policy implementation and legislation, major engineering measures and formal research.

**b) Type of Response /Measure**
A second perspective on the responses can explore their nature:

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

**c) DPSIR Focus**
A third perspective for thinking about responses is to explore how they address different elements of the DPSIR model and what measures or actions are relevant at these different levels. For instance it is possible to see responses which try to address drivers as needing to have a much wider remit – policy responses perhaps, compared to ones which address state changes which may be specific technical measures.

**2.3.3 Applying the DPSIR Framework to Case Studies**
Two examples are developed below in a summarised form to clarify the interpretation of the elements in the framework outlined above. These have different levels of detail due to their sources.
Box 2.1 Dutch Flood Plain Policy
(Note: Lettering links drivers to pressures etc)

Drivers:
- a) EU-CAP production subsidies
- b) Urbanization (in NL, GER, CH)
- c) Climate Change (through increase in high intensity rainfall)

Pressures:
- a) Intensified high-input, high-output agriculture
- b) Colonization of floodplains by agriculture
- c) Higher runoff in river catchment (originated across the border)

State:
(in ecosystem services)
- a) maximization of provisioning services through intensive agriculture
- a & b) shortfall in regulating services (especially water regulation for flood control)
- a & b) perceived shortage in aesthetic services (recreation and nature/biodiversity)
(in specified qualifications of ecosystem-services)
- a) agricultural induced pollution
- a & b) intensive land use and colonization
- a, b & c) too low water storage and river training capacity
- a, b & c) higher flood peaks
- a, b & c) little recreation
- a, b & c) little nature

Impacts:
- a) agricultural overproduction
- b & c) high perceived flood risks and their economic high consequences
- a & b) perceived dissatisfaction with aesthetic value of river plains
- a, b & c) bio-diversity and nature treaty commitments are not met
- b & c) high cost implications of up-grading existing dike infrastructure

Responses:
- at driver level:
  - a) amend EU-CAP away from production toward multi-functionality of agriculture in landscape management or rural livelihood support subsidy
- at pressure level:
  - a) adjustment of the land-use planning in the river flood plains, “rebranding” agriculture land into natural flood plain land, with permissible non-flood intrusive agricultural use
- at the state level:
  - a & b) re-engineering of populated/cultivated areas to enhance flood absorption capacity and protect housing (i.e. put houses on flood hills)
  - a, b & c) nature-ecosystem restoration projects (like Blauwe Kamer, although this precedes this policy)
  - a, b & c) development of water/nature recreation facilities

These multiple responses are all aimed at achieving a new state where the ecosystem services are re-balanced in a more equitable level, through a number of actions - provisioning services and pressures reduced through non-obtrusive agriculture; increasing the regulating services, in specific the flood management capacity; revamping the aesthetic services by ecosystem restoration and recreation development. The changes in state will then presumably result in the resolving of the negative impacts. This aim for state change is also more or less the issue: centred on flood protection and rebalancing nature-agriculture.
Box 2.2 Ethiopian case study – wetland cultivation tradition and recent expansion

Drivers:
- Population growth and land shortages - often linked to upland degradation
- Food insecurity – due to pests and crop storage problems
- Land shortages due to coffee (and chat?) planting on uplands, market
- Land tenure change – giving more people access to wetlands & encouraging use
- Government policy and task force to improve national food security by drainage agriculture
- In-migration due to land degradation in north leading to resettlement & land allocations

Pressures:
- Drainage and cultivation in wetlands
- Double cropping of some wetlands (intensification)
- Sediment deposition from uplands associated with upland degradation
- Uncontrolled & heavy cattle grazing

State:
- Lowered water tables and soil acidity increased
- Soil nutrient decline and soil structure changes with prolonged low water table
- Decline in soil quality at fringes of wetland
- Soil compaction
- Destruction of the wetland vegetation
- Biodiversity in wetlands increased due to more diverse conditions

Impacts:
- Food security improved, but not for all households, some thro cultivation & some through piece work – on wetland farms
- Some upper middle income farmers are gaining at the expense of others in the community who traditionally use wetlands for collecting purposes, e.g. women for water collection, poor men for reed harvesting
- Urban food supply improved
- Springs drying up and women having to walk further to get domestic water supplies
- Tensions between different user groups in very few cases
- Forage resources enhanced where wetland degraded
- Recognition of value of wetlands in government and more widely in communities

Responses:
- at driver level:
  - 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:
  - Development of community based institutions to manage wetlands
  - Development of local guidelines for the selection of wetlands for agriculture
- at the state level:
  - Use of techniques, such a ditch blocking, to assist in maintaining water table level.
  - Farmer experimentation on land management
2.4 Analysing the Cases

2.4.1 Checklists
The understanding of the DPSIR model outlined above was turned into a checklist format (see Annex 3) in order to provide a way of summarising the case studies obtained. This checklist was shared with colleagues at WUR and FAO for comment. Adjustments were made in response to these comments and in the light of initial practical experience.

While the checklist is primarily a means of identifying the various DPSIR elements in each agriculture-wetland interaction, it is also a means for identifying areas of common experience between cases, in terms of similar drivers, pressures, state changes and impacts. This helps identify common experiences, or common issue situations, which may benefit from similar responses and problem-solving approaches (see Chapter 4).

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

- type of wetland (using all 42 Ramsar categories as in Table 1.1),
- economic development status of the country (using World Bank data),
- market orientation of the agriculture
- degree of water control
- Ramsar region
- type of agriculture-wetland interactions (as in Figure 1.3).

It should be pointed out here that the construction of the checklists was undertaken by ten different people in total, although the vast majority were compiled by the three person team from Wetland Action (WA). This compiling of the checklists from literature and other sources involves a filtering out of information and hence each compiler could “stamp their mark” on the work at this stage, or bias the information selected for the next stage in the work. To guard against this, guidance was provided on the checklist sheets of the meaning of the different terms in the DPSIR model, while each checklist was checked by the WA person responsible for the work overall.

2.4.2 Database, Coding and Analysis
In order to analyse the cases a database created and a coding regime developed to prepare the cases for entry. This coding was undertaken in a two stage process. For the initial analysis undertaken with 29 cases in March 2007 categorisation of the different variables in each DPSIR element was undertaken on an empirical basis, grouping the variables on the basis of similarity. After this a review was made of these categories with a stronger and more explicit theoretical basis. The revised categories were then used to recode all of the cases (see Annex 6 for coding).

Despite the attempt to create a rigorous base for the coding, there was again a potential for subjectivity given the interpretation of text into specific codes. To reduce the variability in this process it was undertaken by one person.

Once the coding was complete, 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 on the cases – wetland type, Ramsar region, market orientation and water management. This analysis sought to identify patterns within the
DPSIR variables in order to develop a better understanding of agriculture-wetland interactions.

2.5 Reflections
The experience of using the DPSIR model was positive. It provided a rigour in the analysis of diverse cases and forced a diverse body of information into a form which has allowed comparison. This is particular important given the variations in data outlined here and the diversity of experience referred to in Chapter 1.

The main area where the model did not work particularly well was when applied to cases of apparent sustainability and stability in agriculture-wetland interactions, as these do not appear to have current drivers and pressures leading to present changes. However, state changes from the natural conditions could be explored with varying accuracy and also some impacts identified. In the future it may be possible in these cases to undertake some historical analysis of past drivers and pressures, as well as past responses which have led to the present state of apparent balance.

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

Database Analysis of Agriculture-Wetland Interactions

3.1 Case Studies
From various sources 91 cases have been obtained for analysis. (See Annex 4). The global distribution of the cases used in this chapter’s analysis is summarised, together with the distribution by national economic development in Figure 3.1. This shows that almost half of the cases are drawn from low income countries, and only 13% from high income countries.

![Fig. 3.1 Distribution of case studies by region and development situation](image)

Of perhaps greater importance for this study are the wetland and agricultural characteristics of the sites studied (Figure 3.2 and Table 3.1). These show that the major types of wetland captured in this study were seasonal/intermittent freshwater marshes/pools (usually floodplains) (Type number 23), permanent freshwater marshes/pools (22), permanent rivers/streams/creeks (14), coastal brackish/saline lagoons (10) and irrigated land (35), with seasonal/intermittent/irregular rivers/streams/creeks (15), permanent freshwater lakes (16), non-forested peatlands (24) being of lower importance but still having 5 or more cases.

Regionally it should be noted that permanent rivers/streams/creeks (14), permanent freshwater marshes/pools (22) and seasonal/intermittent freshwater marshes/pools (23) quite widely distributed, while a number of types tend to be found mainly in Asia e.g. irrigated land (35).
Fig. 3.2 (a) Cases distribution per RAMSAR Wetland type

Fig. 3.2 (b) Wetland type distribution per region

Note: wetland type per region with 63 cases, not yet updated to 91 cases.
Table 3.1: Global distribution of case studies by wetland type

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

Note: each case may include more than one wetland type
In the analysis by agricultural category, the majority of cases are in the market-oriented agriculture with full water management, or the transition to market-orientation with intermediate levels of water control (Figures 3.3 and 3.4).

(It should be noted that this has required independent assessment of the most important categories as several states of market and water control existed in the majority of cases.)

In terms of the wetland interactions outlined in Chapter 1 (Figure 1.3, page 15), the cases show a predominance of within wetland transformation (Interaction 1.1 and 1.2) with almost half of the cases having interactions with their catchments, mostly through downstream impacts from the catchments upon the wetlands (Interaction 2.1).

Note this are still on case-base N=63, instead of 91
3.2 DPSIR Analysis
In this section, the results of the database analysis of the 91 case studies are presented to explore the diversity, commonality and patterning of experience with respect to the main elements of the DPSIR model. The discussion starts with a global and regional analysis of the groupings of the elements (drivers, pressures etc) at the different stages of the DPSIR model. (Groupings are shown in Annex 6).

3.2.1 Drivers
The case study analysis reveals that population, food and land dynamics are the most reported driver group (36%) followed by markets (28%) and government / community behaviour (16%) – which mostly refers to government policies.

Drivers by region
At a regional scale of analysis, population dynamics remains the most important in Africa and Asia, while markets dominate in the other regions, and are of less than average importance in Africa 14% (28%). (Figure in parenthesis is the overall average for this driver group). Government policies are the second most important driver in Europe 29% and North America 19% (16%).

For Africa population, food and land dynamics are the dominant driver group, with 51 percent. In contrast, for Europe and North America these are of markedly less significance, with 7% and 10% (36%) respectively.

Compared to the overall pattern, Asia shows a remarkable average distribution of driver groups. The Neotropics are further distinguished with a substantial higher than average importance in technology drivers 8% (2%). Oceania is dominated by market drivers 48% (36%) and significant less importance of government and community behaviour 9% (16%).

Drivers by Market Orientation
When set against the market orientations of the case-samples, it is clear that population, food and land drivers are of less importance in market oriented economies 14% (36%), and are dominated instead by market drivers 43% (28%). In contrast, the subsistence and subsistence economies in transition are virtually dominated by the primary drivers of population, food and land dynamics, with 58% and 56% (36%), respectively. Which represent striking confirmations of what was to be expected. In all other respects the driver distribution by market orientation follow fairly neatly the average distribution.
Fig. 3.5 (a) Drivers by region (% of drivers)

Fig. 3.5 (b) Drivers by Market orient. (% of drivers)

Fig. 3.5 (c) Drivers by Water control (% of drivers)

Fig. 3.5 (d) Drivers by Wetland type (% of drivers)
Drivers by water control
Analyzed against the level of water control, marked deviations in the importance of driver groups occur for population, food and land dynamics and, market drivers.

In cases of intermediate levels of water control, population, food and land drivers are dominant with 46% (36%). In the cases of full water control population, food and land dynamics are of slightly less importance at a reported 30%.

Interestingly, for drivers derived from Market processes, the reverse relation to levels of water control occurs. Markets are of less importance in intermediate levels of water control 19% (28%). Whereas situations with full water control report the highest market drivers 35% (28%) and situations of no water control report average influence of market drivers 28%.

Drivers by Wetland type
When the driver groups are set against the major wetland types the reported drivers groups per wetland type follow generally the average distribution over the whole sample of all cases. The saline wetland types have a marked deviation, however, with: less influence of population, food and land dynamics 24% (36%), higher influence of markets 36% (28%), and a higher influence of land use. Also for brackish wetland types the influence of markets and market policies is significantly higher than average with 33% (28%) and 17% (3%), respectively. This can be explained by the strong influence of (global) market demands for aquaculture products that are of particular relevance for these coastal wetland types. In contrast to saline, brackish wetland are subdued to significant population and food pressures 42% (36%).

Other divergences are found in the importance of drivers from government / community behaviour, which is more pronounced for manmade wetlands 25% (16%); and in the population, food and land dynamics for inland wetlands with flowing water, which is slightly less than average with 25% (36%).

Individual drivers
When the individual drivers, rather than the groups, are regarded and analysed against region and wetland types, the general importance of major drivers as discussed above is not only confirmed, but for some cases and drivers also refined. In Figure 3.6 the individual drivers are analysed for their regional distribution – unlike Fig. 3.5 the drivers are listed here as percentage of the case sample in each category (as opposed to percentage of reported drivers).

The single most important driver is that of population growth, which is reported to be of influence in 53 percent of all cases. For both Africa and Asia this is the most occurring driver, with significant higher frequency than average – 76% and 74% of regional cases respectively. Also for the Neotropics this driver is still significant for 54% of cases, whereas for Europe this driver is still of influence in only 22 % of the cases.

As a general trend, the African cases report significant higher than average on all drivers from the population, food and land dynamics group. In particular food shortage is occurring more than twice the reported average frequency with 40 % (14%) of cases – thereby listed as the fourth most frequent occurring single driver in Africa. Secondly, government policies are listed by 56 % of African cases (48%). Interestingly, as third
The most frequent occurring driver in Africa is listed the influence of local markets – 56% of cases, which is significantly more than the average (49%). In contrast, the influence of global markets is significantly lower in Africa with a mere 12 percent of cases, against the average of (43%). The latter explains the initial low influence of market drivers group for Africa. Other drivers occurring with high frequency in Africa are urbanization with 36% (20%) and climate change / variability with 32% (12%).

In the European region the dominant drivers are, government policies 73% (48%), global 55% (43%) and local markets 45% (49%), subsidies 27% (9%), climate change / variability 18% (12%) and urbanization 18% (20%). In the Asian region the case follow closely the global average, with some minor deviations in: population growth 74% (53%), subsidies 13% (9%), an absence of recognized climate change 0% (12%) and an absence of technology driven changes 0% (7%).

**Fig. 3.6 Drivers per Region (% of sample)**
The region of the Neotropics is characterized by higher influences of global 55% (45%) and local 62% (49%) markets, poor governance 15% (3%) and technology 23% (7%). In North America global markets is the single most dominant driver with 80% (45%), whereas in Ocean it is the combination of global 60% (45%) and local 50% (49%) markets.

As can be seen from the above discussion, the drivers identified are mostly socio-economic in nature, being shaped both by changes in society and by the environmental conditions – including feedback processes. As a result they are constantly evolving. The drivers identified here mainly relate to how they encourage agricultural use of wetlands, but the same drivers may also influence agriculture outside wetlands which in turn affects wetlands through such processes as pollution and sedimentation. One further point to note is that in understanding the drivers presented here, it must be recognised that these are the result of other related processes in the society and environment of the study areas and that the deeper causation processes – political, economic and socio-cultural, need to be explored to identify possible responses.

Study of the drivers by wetland types is limited by the small number of cases per wetlands and per driver type. There also appears to be an error in the data set given the small number of cases for 23 – seasonal intermittent freshwater marshes and pools, the most common wetland type.

**Fig. 3.7 Drivers per Wetland type (% of sample)**

![Graph showing drivers per wetland type](image)

Note drivers per wetland type not yet discussed.
3.2.2 Pressures
The pressures produced from the drivers mentioned above are mostly processes related to the transformation of wetlands or the disturbance of their natural ecological conditions. Agricultural expansion is the most important pressure group (32%) followed by water resources management and use (31%) and agricultural intensification (30%).

Pressures by Region
The regional patterns are similar with only slight deviations from the global average. Agricultural intensification is more of a pressure in the Neotropics and Asia – 36% and 37% respectively against (30%). In Africa, as well as the Neotropics, agricultural expansion is more pronounced with 35% and 43% respectively (32%). Only in Europe is agricultural expansion significantly less an issue at 23%. In contrast, other pressures (predominantly pollution) are more pronounced in Europe with 19% (5%), as well as pressures on natural resources management stemming from nature conservation with 10% (1%).

Pressures from water resources management are less pronounced in Europe and the Neotropics – 23% and 17% respectively – as they are for Africa 31%, Asia 35% and the global average (31%). North America is dominated by pressures from water use 46% (31%) and agricultural expansion 42% (32%), and Oceania by water use 46% (31%).
**Pressures by Market orientation**
The pressures viewed by market orientation follow closely the overall average distribution of pressures. Notable deviations are found for agricultural intensification which is of higher importance in subsisting 43% and subsistence economies in transition 40% (30%). Whereas these same two regions report less than average pressures for water resources use, with respectively 20% and 22% (30%).

**Pressures by water control** (Still based on interim analysis of 63 cases)
Wetland conditions under full water control are less than average pressured by agricultural expansion and intensification, 21% (28%) and 29% (33%) respectively. This may be logically explained by agricultural growth having passed its peak in these conditions with the full levels of water control having primarily facilitated the past agricultural growth and intensification. In contrast, pressures stemming from water resources use and water pollution (predominant pressure in others) are more than average under full water control with respectively 39% (30%) and 11% (7%) due to the intensive use of these areas.

Cases with none and none to intermediate levels of water control are susceptible to higher than average pressures from agricultural expansion – 29% and 38% (28%) respectively, and intensification – 47% and 35% (33%) respectively; and significantly lower pressures stemming from water resources uses – 18% and 19% (30%) respectively. This is a result of the way these areas are being developed and coming into agricultural production with expansion and intensification on-going. Agricultural intensification is further more pronounced under conditions of intermediate to full water control 38% (33%), whereas water resources use pressures are more at play in conditions of intermediate levels of water control 34% (30%), again in line with the development of these wetland areas for cultivation.

**Pressures by wetland type**
Agricultural expansion is the most pronounced in peat wetlands 43% (32%), followed by saline and inland seasonal wetlands – 38% and 35% respectively. In contrast, agricultural expansion is significantly less of an issue in manmade and brackish wetlands – 24% and 12% respectively. Agricultural intensification is generally high (at average level) for most wetland types, but slightly less of an issue for peat-lands and inland seasonal wetlands – 22% and 24% (30%) respectively.
**Individual Pressures**

**Agricultural Intensification**

As reported above, agricultural intensification is the second most predominant pressure. This is primarily manifested through increased crop production (or crop intensification) in (51%) of all recorded cases. Increased crop production is more pronounced in the Neotropics and Asia – 69% and 61% of regional cases respectively – and less pronounced in Europe 36% and North America 10%. Intensification of grazing is the next frequent occurring pressure in this pressure group (18%); but predominantly in Africa and the Neotropics where it occurs in 36% and 23% of regional cases respectively. In Europe intensification is also achieved through intensification of agro-chemicals 27% (14%). This also applies for Oceania in 30% of the regional cases. Intensification and growth of aquaculture is limited to Asia 22% (7%), whereas intensification of inland fisheries is predominantly an African affair 16% (5%). But these latter two may be biased by the coverage of cases. Agricultural extensification is predominantly a European matter 27% (4%) and primarily driven by policies to restore flood plains and nature and the changing agricultural environment in eastern Europe.

**Water resources use & management**

This second most dominant pressure group is much more dispersed and diversified over separate and distinct pressures. Dominant among these, however, is the pressure of drainage and accompanying land settlement, which occurs in (38%) of all cases, and slightly more frequent in the Europe 45% and slightly less in Oceania with 30% in regional cases. Secondly, pressure linked to increase extraction and use of surface water resources are frequently reported (21%), especially in Africa 28%, North America 30% and Oceania 40% of regional cases. In Europe the use of surface water resources is conspicuously absent as a reported pressure 0% and reflects a regional bias in our database with no cases emanating from the drought prone Mediterranean, rather than anything else. In Africa furthermore pressures ensuing from increased groundwater exploitation
and developments in storage facilities are relevant – 20% (10%) and 24% (15%) respectively. Groundwater extractions are also reported pressures in North America and Oceania with both 20%. Pressures emanating from fresh and salt water quality issues are predominantly limited to Asia 17% (4%) and particular to these regional saline and brackish coastal wetlands where aquaculture is presently booming.

**Agricultural expansion**
The expansion of the agricultural frontier is distinguished in three interrelated pressure: colonization (54%), transformation of landscape (46%) and clearing of natural vegetation (9%) – which in practice may be difficult to distinguish and thus may be susceptible to a considerable degree of bias. In line with what one may expect, however, is the reported predominance of colonization and transformation of landscapes in Africa and the Neotropics – 68% and 77% for colonization, and 60% and 69% for transformation, respectively. Especially in Asia and Europe these pressures are less pronounced.

**Others**
From the remaining pressures, merged into the collective “others”, water pollution is the predominant one, with frequent reported occurrences in Europe and the Neotropics – 27% and 15% (10%) of regional cases respectively.

As an aside, it should be noted that in a few cases, this transformation relating to farming use is not significant. This is especially apparent in cases of eco-agriculture where the wetland farming has little detrimental impact because choice of crops and the farming methods “go with”, rather than against the natural conditions. Moreover, the use of wetlands for agricultural activities may enhance the wetlands – for example, the flooding of meadows in Europe to create extensive water meadows for fodder production and the grazing of dairy cattle. Other examples have demonstrated how rice cultivation or small dams may create new wetlands with some wetland biodiversity.

**Note: pressures by wetland type not yet discussed.**
3.2.3 State Changes
In terms of state changes in wetlands, the case studies identify a more diverse picture than for the drivers and pressures elements in the model. Indeed it is to be expected that there are different ways in which each driver and pressure may be manifested in state changes and that the picture will become more complex as one progresses through the DPSIR.
The dominant group of state changes is related to changes in the quantity and character of the water resources base: e.g. (over)exploitation of surface and sub-surfaces water resources, drainage, longer or shorter periods of flooding, etc, which is reported as occurring as 33% of all reported state changes. The third most frequent reported state change is related to changes in soil characteristics with 23%: e.g. physical erosion process as loss of fertile top-soils and sedimentation, as well as chemical deterioration of soil characteristics. However, as is evident from figure 3.x.a, this reported state change is strongly biased by a regional perspective and predominantly occurring in Africa. A general and frequently reported state change is subsequently the loss of biodiversity, occurring with a rate of 27%. Comprising both losses in biodiversity due to changes in land use (i.e. clearing of natural vegetation for agricultural expansion) and losses in (aquatic) biodiversity due to intensified exploitation of the resources base (i.e. water and associated pollution). Water pollution is the fourth dominant state change reported with 14%. This category comprises state changes related to water quality, which can be both of chemical-biological nature (i.e. agro-chemical pollution and eutrophication) as well as issues of salt-brackish-fresh water level in coastal wetlands. Gains in biodiversity (e.g. due to restoration of wetlands), in contrast, are scarcely occurring with a mere 1%.

**State changes by Region**

The most striking deviation from the average occurring state changes is found in the changes in soil characteristics, which is predominantly an African affair 40% (23%), and which due to the large African cases sample size pushes the average number up to an unrealistic second most frequent occurring state change. In contrast, changes in soil characteristics are hardly an issue in Europe with a mere 10%. The reverse is the case for state changes related to water pollution, which are predominant in Europe 27% and of less relevance in Africa 5% (14%). In addition, the European region has a more than average reported loss of biodiversity 37% (27%), and which thereby is the most dominant state change for Europe as well as for the Neotropics 34%.

The Asian region has higher than average occurring state changes due to water pollution 19% (14%) – especially also with regard to salt-brackish-fresh water levels of coastal wetlands. With regard to soil characteristics, these state changes occur less frequent than average and Africa in Asia, but still to a substantial degree in 16% of regionally reported state changes. North America is dominated by state changes in water resources 43% (33%) and losses in biodiversity 30% (27%). Oceania follows neatly the overall averages, in which it is noteworthy that state changes in soil characteristics are also significant in this region with 20%.

**State changes by Market orientation**

When set against the market orientation, the reported state changes more or less follow the regional distribution as could be expects. Water pollution is predominantly occurring in market oriented economies 21% (14%), whereas changes in soil characteristics is predominantly occurring in subsistence 35%, subsistence/transition 32% and transition/market 28% economies (23%). Loss in biodiversity is predominant in market economies 30% (27%).

**State changes by Water control**

Under conditions of full water control, reported state changes in the water resources base are dominant with 38% (33%) as could be expected. Also water pollution is more than averagely an issue 16% (14%). That state changes related to water pollution are also
predominant under conditions of no water control 28% (15%), is related to inclusion of salt-brackish-fresh water level issues in this category that predominantly occur in brackish coastal wetlands where active water control is absent (see figure 3.x.(d)).

State changes in soil characteristics are predominant in conditions of intermediate 32% and no water control 28% (23%), which is congruent with the regional distribution of this state change as occurring predominantly in Africa and Oceania.

**State changes by wetland type**

Loss in biodiversity is the predominant state change in saline wetlands with 41% (27%). Whereas changes in the water resources base are predominant in manmade 61%, peatlands 47% and inland flowing wetlands 42% (33%). As stated above, water quality (pollution) issues are dominant in brackish wetlands with 44% at trice the average rate (14%). Changes in soil characteristics are predominantly occurring in inland seasonal wetlands 33% and inland still permanent wetlands 29% (22%).

**Fig. 3.12 State changes by region (% of sample)**

![Graph showing state changes by region](image)

**Individual State Changes**

When the individual state changes are considered it becomes evident that there is a high diversity of reported state changes, as drivers and pressures get dispersed and transformed in different state changes, specific to the (socio-economic, bio-physical and ecological) context in which they operate.

The single most dominant reported state change is # 600: decreased vegetation, biodiversity and ground cover, in the category loss of biodiversity, which occurs in (71%) of all cases. Although this is for all regions the single most dominant state change, there is some regional disparity: Europe 91%, Africa 72%, Asia 61%, Neotropics 69% and N. America and Oceania 70% of regional cases.
Within the category of state changes in the water resources base, the most prominent state changes are those of lower water table in wetland (33%) and lower floods, lower flows and smaller flooded area (22%). The former is predominantly occurring in Africa, as occurring in 52% of all African cases, while the latter is predominant in the Neotropics 23% and Asia 24% of regional cases. Lower floods is not an issue in Europe 0% which is characterised by a wide diversity of water resources related state changes.

Water pollution is primarily related to chemical pollution from agricultural waste as reported in (24%) of all cases. However, there is a strong regional disparity, dominated by Europe 55%, Neotropics 38% and Asia 26%, and less of an issue in Africa 8%. Similarly, eutrophication is predominantly an European issue 27% (13%), whereas fresh and salt water issues in coastal wetlands are predominantly Asian.

As stated above, state changes pertaining to soil characteristics are predominantly African affairs. Two inter-related state changes are prominent in this regard: sediment deposition/build up in wetland and less fertile soils, which are reported in 36% (27%) and 36% (17%) of all African cases.
### Table 3.2: State Changes

<table>
<thead>
<tr>
<th>Water Resources Base</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Longer flooding, more flooding, water logging</td>
<td></td>
</tr>
<tr>
<td>110 Higher water table in wetland / water logging</td>
<td></td>
</tr>
<tr>
<td>120 Reduced water storage in wetland</td>
<td></td>
</tr>
<tr>
<td>125 Increased water storage in wetland</td>
<td></td>
</tr>
<tr>
<td>130 Drying up of reservoirs</td>
<td></td>
</tr>
<tr>
<td>135 Drying up of coastal lagoons</td>
<td></td>
</tr>
<tr>
<td>140 Increased hydrological variability</td>
<td></td>
</tr>
<tr>
<td>145 Moderation of seasonal variability of water regime</td>
<td></td>
</tr>
<tr>
<td>150 Drying up of swamps</td>
<td></td>
</tr>
<tr>
<td>160 Shorter flooding</td>
<td></td>
</tr>
<tr>
<td>165 Lower floods, lower flows, smaller flooded area</td>
<td></td>
</tr>
<tr>
<td>170 Higher floods, higher flows, larger area flooded</td>
<td></td>
</tr>
<tr>
<td>175 Faster water flow – reduced flood control capacity</td>
<td></td>
</tr>
<tr>
<td>180 Reduced groundwater recharge</td>
<td></td>
</tr>
<tr>
<td>185 Increased groundwater recharge</td>
<td></td>
</tr>
<tr>
<td>190 Lower water table in wetland</td>
<td></td>
</tr>
<tr>
<td><strong>Water Pollution</strong></td>
<td></td>
</tr>
<tr>
<td>200 Eutrophication</td>
<td></td>
</tr>
<tr>
<td>210 Water pollution / (agricultural) waste</td>
<td></td>
</tr>
<tr>
<td>220 Increased freshwater level in lagoon</td>
<td></td>
</tr>
<tr>
<td>230 Increased salinity (lagoon &amp; irrigation)</td>
<td></td>
</tr>
<tr>
<td>240 Water quality lowered</td>
<td></td>
</tr>
<tr>
<td><strong>Soil Characteristics (physical)</strong></td>
<td></td>
</tr>
<tr>
<td>300 Sediment deposition / build up in wetland</td>
<td></td>
</tr>
<tr>
<td>310 Reduced infiltration (compacted soils)</td>
<td></td>
</tr>
<tr>
<td>320 Peat soil subsidence / increased susceptibility to fire</td>
<td></td>
</tr>
<tr>
<td>330 Eroded soils</td>
<td></td>
</tr>
<tr>
<td>340 Gullying / gully erosion</td>
<td></td>
</tr>
<tr>
<td>350 Physical deterioration</td>
<td></td>
</tr>
<tr>
<td><strong>Soil Characteristics (chemical)</strong></td>
<td></td>
</tr>
<tr>
<td>400 Soil toxicity</td>
<td></td>
</tr>
<tr>
<td>410 Soil salinity</td>
<td></td>
</tr>
<tr>
<td>420 Less fertile soils</td>
<td></td>
</tr>
<tr>
<td>430 Acid soils</td>
<td></td>
</tr>
<tr>
<td>440 More fertile soils</td>
<td></td>
</tr>
<tr>
<td><strong>Gains in Biodiversity</strong></td>
<td></td>
</tr>
<tr>
<td>500 Increased vegetation, biodiversity, ground cover</td>
<td></td>
</tr>
<tr>
<td><strong>Loss in Biodiversity</strong></td>
<td></td>
</tr>
<tr>
<td>600 Decreased vegetation, biodiversity, ground cover</td>
<td></td>
</tr>
<tr>
<td>610 Increased presence of invasive species</td>
<td></td>
</tr>
<tr>
<td>620 Less wildlife</td>
<td></td>
</tr>
<tr>
<td>630 Less fish</td>
<td></td>
</tr>
<tr>
<td>640 Loss of human maintained biodiversity</td>
<td></td>
</tr>
<tr>
<td>700 Changes in channel morphology, bank collapse etc.</td>
<td></td>
</tr>
</tbody>
</table>
3.2.4 Impacts

The impacts of agriculture-wetland interactions on the socio-economic conditions of wetland-dependent communities and on other groups, from local urban centres to the national and international economy, are diverse. Grouping the individual elements, losses in subsistence agriculture (24%) dominate in this sample, followed by economic gains from market-oriented agriculture (23%). However, the third category is a substantial negative impact (16%) involving socio-economic differentiation and conflicts. The fourth category is gains in subsistence agriculture (13%), followed by a loss in water regulating services (8%).

Impacts by Region

The regional distribution of impacts (figure 3.13) does not deviate substantially from the average, but provides interesting refinements. The dominant impacts in Africa are a loss in subsistence agriculture 25% (24%), which is clearly off-set by gains in market-oriented agriculture 24% (23%) and a reported gain in subsistence agriculture 17% (13%). These shifts and transformation of agricultural production and provisioning services in Africa come, however, at a price, resulting in an increase of socio-economic differentiation and associated conflicts 20% (16%).

In Asia, the single most dominant impact is the loss in subsistence agriculture 35% (24%), which is mainly due to a reported loss of inland and coastal fisheries that particularly affects this sector negatively. This is somewhat off-set by a limited growth in aquaculture 8% (4%) and gains in subsistence agriculture 14% (13%). Gains in market-oriented agriculture are limited for Asia when compared to the average 12% (23%), as in...
the case for Europe 16%; which is most probably due to that market oriented agriculture is already well established in these regions and well past its exponential growth stage.

In Europe, the most dominant impact category is the loss in water regulation services 29% (8%), in particular water purification and flood control. This is followed by a reported loss in agriculture 23% (24%). This is somewhat offset by a gain in market oriented agriculture 16% (23%), and modest gains in commercial (enterprise based) agriculture 10% (4%) in and aquaculture 6% (4%). The reported impacts in socio-economic differentiation and associated conflicts are fairly low for Europe with 6% (16%), which is likely due to the relative low importance of agriculture in the services oriented economies of Europe and the absence of water shortage cases in this sample. The absence of gains in subsistence agriculture 0% (14%) is fully in line with expectations for Europe.
The Neotropics are still characterised by a growth in agriculture as reflected in the dominant impact in gains in market oriented agriculture 24% (23%). Gains in subsistence agriculture are still occurring at modest pace 10% (13%), but entirely off-set by much larger reported losses in subsistence agriculture 17% (24%). These shifts in agricultural provisioning services are further associated with losses in water regulating services 10% (8%) and socio-economic differentiation and associated conflicts 28% (16%).

North America is dominated by gains in market oriented agriculture 50% (23%) and commercial agriculture 23% (4%). These increases in agricultural productivity are associated with equal losses 14% (8%) and gains 14% (3%) in water regulation services. Also in Oceania the gains in market oriented 41% (23%), subsistence 18% (13%) and commercial oriented agriculture 5% (4%) are predominant impacts. These are associated more clearly with losses 18% (8%) in water regulating services than gains 5% (3%). Nonetheless the reported social differentiation and conflicts are modest 5% (16%).

**Impacts by Market orientation**

Within market oriented economies the impacts are more or less conform to the total average distribution, except for the expected absence of gains in subsistence agriculture 1% (13%) and a relative high reported loss of water regulating services 15% (8%). Gains in market oriented agriculture are slightly above average 27% (23%), accompanied by a relative higher gain in commercial agriculture 9% (4%).

In contrast, subsistence economies deviate starkly from the average reported impacts, with two main impacts: loss in subsistence agriculture 47% (24%) and gains in subsistence agriculture 29% (13%). The impact in socio-economic differentiation is slightly below average with 12% (16%). However, conclusions should be drawn cautiously as the size of the sample in this category is rather small.

The economies in transition follow closely the average distribution, and only differ in insignificantly low terms. (This is caused by the large size of these samples.)

**Impacts by water control**

When set against the level of water control, the impact distribution for the individual categories follows closely the average distribution. Under conditions of full water control the loss in subsistence agriculture is, as expected, somewhat less than average 21% (24%), while the gain in aquaculture 8% (4%) and commercial agriculture 5% (3%) is slightly higher. Socio-economic differentiation is the most pronounced under intermediate levels of water control 21% (16%). In wetlands with no water control the gains in subsistence agriculture are slightly higher 17% (13%).

**Impacts by wetland type**

Saline coastal wetlands (e.g. lagoons) have an atypical impact distribution with a more than average loss in subsistence agriculture 38% (26%), which is off-set by a more than average increase in aquaculture 14% (4%), accompanied a substantial increase in socio-economic differentiation and conflicts 28% (16%). Market oriented agriculture is absent in this wetland type 3% (23%), as the market response is manifested through the disproportional increase in aquaculture rather than crop or livestock production. Brackish wetlands have a high reported loss of subsistence agriculture 38% (24%), as well as a high loss of water regulating services 29% (8%). This is off-set by an increase in commercial agriculture 14% (4%).
The inland wetlands – flowing, still permanent and seasonal – all exhibit the general trend of a shift towards market oriented agriculture at the expense of subsistence agriculture, although the latter still shows some growth, be it markedly less than average in the case of inland seasonal wetlands 8% (13%).

Manmade wetlands is the only category where the gain in subsistence agriculture 22% (13%) is larger than the loss 18% (24%) – which is primarily due to a reported increase in inland fisheries. As a strongly regulated water control environment, the socio-economic differentiations and conflicts are higher than average 21% (16%).

**Individual impacts**

On an individual level the reported impacts by region show some significant deviations from the overall average. In Africa, the gains in subsistence agriculture are dominated by increases in crop production [#300], as reported in 72% of regional cases (36%). This is somewhat off-set by a decrease in subsistence agriculture which is, however, much wider dispersed over the different agricultural sectors: decrease in livestock [#430] 36% (16%), decrease in inland fisheries [#420] 32% (30%), decrease in natural gathering [#440] 24% (17%) and a decrease in crop production [#410] 24% (16%). Substantive gains, on the other hand, are made in market oriented agriculture, primarily through increased production of cereals [#100] 60% (41%) and fruit & vegetable cultivation [#110] 44% (26%). Within the socio-economic realms these relative shifts in agricultural production result in a reported increase in economic differentiation [#700] 48% (17%), an increase in social conflicts around resources management [#710] 32% (23%) and further marginalization and poverty [#720] 16% (13%), while effective poverty reduction is only reported in [#730] 4% (1%) of regional cases.

In Asia the individual impacts follow more closely the reported overall averages, except for those impacts relating to fisheries and aquaculture that are predominantly covered in Asian cases. Increases in market oriented agriculture are divided between reported increase in cereal production [#100] 43% (41%) and aquaculture [#130] 30% (11%). This is similar for the increases in subsistence agriculture, with increased crop production occurring in [#300] 39% (36%) of Asian cases and increases in inland fisheries in [#310] 9% (2%). The decreases in subsistence agriculture, on the other hand, are predominantly decreases in inland fisheries [#420] 74% (30%) and natural gathering [#440] 26% (17%). Socio-economically this leads to further increases in conflicts [#710] 30% (23%) and marginalization and poverty [#720] 22% (13%). The latter are predominantly among the rural landless population that disproportionately depends on inland fisheries.

In Europe the shifts taking place in agricultural production are the reverse as those reported for Africa, Asia and the Neotropics, with reported loss in agricultural production higher than the gains. Decreasing productivity in livestock [#430] 36% (16%) is most dominant, but largely off-set by also reported gains in livestock [#200] 37% (11%). Reported decreases in crop production [#410] 18% (16%) are the same as reported gains in cereal production [#100] 18% (41%), but compensated by gains in cash crops and vegetables. Of high concern are the losses in regulating and cultural services, with negative cultural impacts [#530] reported in 45% (8%) of European cases, loss in recreational services [#520] 27% (14%) and a loss of flood protection services [#500] 9%.
(4%). The meeting of international treaty obligations is also highly valued in Europe [850] 18% (2%).

The Neotropics follow very closely the overall average distribution of impacts. Only within the market oriented agriculture does the Neotropics show deviation in that the increases are dispersed over the individual impacts: increase in cereals [100] 15% (41%), fruit & vegetables [110] 23% (26%), sugars [120] 8% (2%), cash crops [140] 8% (8%). Impacts in social conflicts are above average 38% (23%).

North America and Oceania…
Fig. 3.16 Impacts by Wetland Type (% of sample)

Note, this graph is not yet discussed
Table 3.3: Impacts

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Gains in Market oriented agriculture</td>
</tr>
<tr>
<td>110</td>
<td>Cereals</td>
</tr>
<tr>
<td>120</td>
<td>Vegetables</td>
</tr>
<tr>
<td>130</td>
<td>Sugars</td>
</tr>
<tr>
<td>140</td>
<td>Cash crops</td>
</tr>
<tr>
<td>200</td>
<td>Gains in commercial agriculture</td>
</tr>
<tr>
<td>210</td>
<td>Com. Livestock</td>
</tr>
<tr>
<td>220</td>
<td>Flowers</td>
</tr>
<tr>
<td>230</td>
<td>com. Aguaculture</td>
</tr>
<tr>
<td>300</td>
<td>Gains in Subsistence Agriculture</td>
</tr>
<tr>
<td>310</td>
<td>Incr. crop prod.</td>
</tr>
<tr>
<td>320</td>
<td>Fisheries increased</td>
</tr>
<tr>
<td>330</td>
<td>Incr. Livestock</td>
</tr>
<tr>
<td>400</td>
<td>Losses in Subsistence Agriculture</td>
</tr>
<tr>
<td>410</td>
<td>Decr. Aguaculture</td>
</tr>
<tr>
<td>420</td>
<td>Decr. Crop prod.</td>
</tr>
<tr>
<td>430</td>
<td>Decr. Fisheries</td>
</tr>
<tr>
<td>440</td>
<td>Decr. Gathering</td>
</tr>
<tr>
<td>500</td>
<td>Loss of regulating services</td>
</tr>
<tr>
<td>510</td>
<td>Flood protection</td>
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<tr>
<td>520</td>
<td>Water purification</td>
</tr>
<tr>
<td>530</td>
<td>Recreation</td>
</tr>
<tr>
<td>600</td>
<td>Gains in regulating services</td>
</tr>
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<td>610</td>
<td>Water purification</td>
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<td>Recreation opportunities increased</td>
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<td>700</td>
<td>Socio-economic impacts</td>
</tr>
<tr>
<td>710</td>
<td>Increase / decrease in economic differentiation</td>
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<tr>
<td>720</td>
<td>Increase / decrease in conflicts</td>
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<tr>
<td>730</td>
<td>Marginalization &amp; poverty</td>
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<td>800</td>
<td>Poverty reducing</td>
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<tr>
<td>840</td>
<td>Other</td>
</tr>
<tr>
<td>850</td>
<td>Treaty obligations met</td>
</tr>
</tbody>
</table>

63
3.2.5 Responses

The data available shows that the government is the main actor (41%) in response to agriculture-wetland interaction situations. While in most cases these are sensitive responses trying to address the problems of sustaining ecosystem service from wetland, in some cases governments continue to push for increased wetland cultivation without due consideration of the implications. The second most important group was the community (21%) followed by NGOs (14%).

The regional pattern was also dominated by government except in the Neotropics and in North America, the latter having two interesting not-for-profit organisations in the cases identified. In Asia community and international agencies were second with 17% each. Surprisingly local NGOs were reported in more cases in Africa than Asia, 11% and 9% respectively. In Europe, most responses are initiated by government 58% primarily through regulations.

![Fig. 3.17 (a) Response Actors (% of responses)](image)

In terms of actions technical measures dominated (28%) followed by planning activities (19%), policy/legislation (12%) and community institutional development (8%) and monitoring (8%). Regional patterns are similar, although monitoring is more common in the Asian cases 15% and community institutional development is more common in African 13%. Whereas in Europe more responses are taken at the policy & legislation level 25%, which is consistent with the dominant role of European governments in initiating response strategies. North America shows more than average technical responses 45% (28%). Conservation responses are strongest in Europe and Oceania with 13% (8%).

64
Fig. 3.17 (b) Responses types (% of responses)

Responses to elements no text yet.

Fig. 3.17 (c) Response to DPSIR elements (% of responses)
3.3 DPSIR as an Analytical Tool and the Need for a Rational View

The DPSIR model has proved a useful analytical tool to dissect the various case studies. It has provided rigour to this analysis, although also challenging the ability of those using it in their use of qualitative analysis of text. This method has shown the diverse range of drivers that puts pressure on wetlands and leads to state changes thereby affecting the provisioning and regulating services provided by wetlands. However, it is important to note that despite the circumstances outlined by the drivers, farmers are not helpless actors. They still can make choices, even if their options are limited due to unequal power relationships, resource limitations and inappropriate government policies. Rural dwellers regularly face difficult decisions and, at any specific moment in time, may possess different combinations of ‘capital’ (natural, economic, human, physical or social) in their livelihood ‘portfolios’. These endowments affect their livelihood choices and their choices with respect to wetlands, with some using them and some not. Whilst some stakeholders depend on wetlands for subsistence and survival, others use them for appropriation and economic advancement. If a household is lacking in one category of assets, the decision to convert one form of capital into another can be made. Ultimately, changes in the level of assets may affect a land manager’s ability to engage in sustainable practices. In the case of wetland management in the Eastern Province in Sierra Leone, farmers draw on their social networks to mobilise labour forces to transform their wetlands, but their decisions often create pressures for other wetland users.

Another point is the recognition that there are facilitating and limiting factors which impact on the results of the drivers. The Kampala case raised this in terms of there being no alternative land accessible to the poor, so the wetland had to be used. In the Upper Zambezi today, historic land tenure rights are so strong that wetland use is constrained by these rights, even when the “owners” are absentees and despite development measures to support the use of wetlands (e.g. a Japanese rice project at Sefula, south of Mongu). Technology innovation may also facilitate wetland use, as with the recent introduction of 90-day maize in Ethiopia, and historically with the introduction of dendritic drainage channel technology in the early 1900s.

This discussion points to a growing literature on ‘farmer decision making’ and capability (see for example, Fox, et al, ----, or Dries, 1991). Specifically, in the context of sub-Saharan Africa, an early seminal work by Bernstein (1979) explored the contradictions found in changing terms of trade and the social relations of production that were driving smallholders to make contextually ‘rational’ land management decisions that were environmentally unsustainable and contrary to their long-term interests. Studies such as this demonstrate that poverty, ecological problems and underdevelopment, however localized their specific contours may be, inevitably remain linked to broader national and world systems through political and economic forces. Clearly, rather than seeing the degradation of wetlands as a product of ignorant or irrational local management, the actions of the poor can be seen as ‘rational’ and must be understood in the context of changing economic opportunities, as well as social constraints, and how these are shaped by state policies and external influences.

Recognising this decision-making situation in which rural dwellers live, it can be seen that a specific driver may lead to different pressures, depending on farmers’ choice of action, to drain, irrigate, or raise fish, or to do something else, depending on the returns to
their labour and the risks they face. This in turn affects the state changes depending on whether there is much alteration caused by drainage (depth and extent) or not, or much alteration of flooding by irrigation, etc. Hence, it is always important to explore the responses by actors on the ground at each stage in the model. This is especially so since there are always sets of options and it is the way particular negative or positive impacting responses are made, given the search for sustainable multiple ecosystems functioning, which should be of interest in this work. In the context of this thinking, this Framework Document now moves on to groups of common situations where the actual interaction of the DPSIR elements in reality is considered.
PART II
ISSUE SITUATIONS

CHAPTER 4

Towards an Understanding of Issues and Responses

4.1 Introduction
In this second part of the Framework Document, the focus is on the issues which are found in the case studies. A series of common situations of agriculture / wetlands interactions are explored to improve understanding of the inter-linkage between the different elements of the DPSIR model in reality. This provides a basis for discussing the range of responses found to date and developing some ideas about where guidelines are needed for agriculture - wetland interactions in the third part of the document.

4.2 Towards a Definition of Issues
As a first step, it is necessary to clarify what is meant by an “issue”. Unfortunately, the DPSIR model does not define an issue, so an attempt is made here, based on dictionary definitions, the case study material analysed and practical experience. According to the Oxford English Dictionary, issues can be defined as “points in question”, or matters which are “subject to debate” or are the “cause of a problem”. Issues may also be seen as “real world problems”, or “situations” which need to be better understood. In many cases issues are complex, involving multiple linked problems or phenomena. It must be noted that issues are not necessarily negative in nature.

In the GAWI case, issues must relate to a conceptualisation of what is desirable or not desirable in agriculture - wetland interactions. It is proposed that issues should be identified with reference to the “wise use” concept of Ramsar. As a result, issues are seen as factors, circumstances or processes which encourage or discourage the achievement of the wise use goal, and the sustainable utilisation of wetlands for the benefit of humankind in ways compatible with the maintenance of their ecological character, and within the context of sustainable development.

With respect to the DPSIR model, issues may be individual elements – such as drainage, soil degradation or local institutional development, or alternatively, combinations of elements in a case or situation where they combine to support, or prevent, the achievement of “wise use”. This shows that the dimension of scale and hierarchy need to be recognised when studying issues.

Issues which relate to agriculture - wetland interactions frequently focus around pressures, state changes or impacts, but this is often the most obvious, and sometime rather superficial, presentation. If an issue is to be addressed it is also necessary to understand its origins which are for the most part the underlying forces which lead to
the drivers. Even responses may be included in issues, especially in situation where a response fails or is not successful.

4.3 Scales of Analysis of the DPSIR elements
There are various methods which could be used to identify the issues to be addressed in the second part of this document. One method could involve tabulating all of the individual elements from the case studies – a micro-scale analysis and reporting their frequency – along the lines of the material presented in Chapter 3. The result is a listing of close to 150 individual elements recorded in the five levels of the DPSIR model for the cases analysed. However, analysing such a large number of individual elements is difficult in its own right and does not provide a manageable method for comprehending the overall picture and identifying the most important issues. The other point about this method is that it views the individual elements out of context and this is not helpful when trying to move towards practical guidelines where the linkages between elements and the different stages in the DPSIR model need to be recognised.

Hence, in this part of the document, an attempt is made to identify and analyse issue situations, where a series of elements from the different parts of the DPSIR model link together in a relationship which is similar to a causal chain. Once identified, such issue situations can then be sought in the case studies to identify how frequently they occur – either in total or in part.

While it is difficult to put each case into a particular ‘issue situation’, there are some experiences which are sufficiently common to make this feasible and worthwhile for analysis. This allows the identification of common interaction patterns and processes, and so assists comprehension of the extreme diversity in the cases studies. It should be clear that this is not an attempt to forcefully create a line of best fit for a group of cases, but rather an attempt to draw out common issue experiences which allow for an understanding of diversity. In reality each case is context specific and how the similar DPSI elements interact varies from case to case. Similarly, the choice of best responses cannot be made by copying what has been done in other cases but must involve a specific DPSIR analysis of a case, recognising the specific circumstances and factors which may facilitate or retard the achievement of sustainable agriculture – wetlands interaction.

4.4 Identifying Common Issue Situations – Cluster Analysis
To identify such issue situations the Ward Method of cluster analysis was performed on an early version of the database with the cases entered into an Excel spreadsheet. The data entry in this case was simplified in comparison to the database (used in Chapter 3), with only the presence or absence of a more limited set of elements being used. The Excel-based method provided some evidence of grouping amongst the cases in terms of them having common elements in the different DPSIR levels, but there were a number of associations which appeared anomalous. The reasons for these were thought to be the simplified nature of the data, as well as its incompleteness due to the varying emphases or biases in the material used for creating the case checklists.

As a result of discussions about this amongst the GAWI team members, it was agreed that the clustering analysis should be supported by the practical experience of the GAWI team members. This resulted in an increased emphasis upon wetland type and
development experience, in identifying the issue situations, rather than allowing only the DPSIR experience to dominate in this process as had originally been envisaged. It should also be recognised that the expertise and experience of GAWI team members in these discussions also influenced in part this final selection of issue situations.

Attempts to confirm these choices using the database proved impossible due to the complexity of the cases. This was due to the multiple entries or elements in each DPSIR category which made to complex any analysis of cases to identify similar patterns of DPSIR elements.

4.5 Selected Issue Situations
The outcome of this process was the initial identification of four issue situations from different parts of the world to be analysed using the checklist data for sites which fitted within the general issue situation description. This was seen as an initial attempt to test the DPSIR method and explore to what extent it helped in understanding better the agriculture - wetland interactions. One further issue situation was added in the light of comments about missing experiences.

The five issues situations chosen were:

a) Small inland wetlands in sub-humid tropics (initially in sub-Saharan Africa),

b) Agricultural use in Tropical River Basin and their impact on Aquatic Lagoon and Estuary Ecosystems,

c) Floodplains and river valleys, and

d) Oil Palm development on peat swamp forests.

e) Integrated rice and fish culture/capture systems in South and Southeast Asian tropical river basins

These five issue situations are elaborated in the following chapters in order to explore the generic experience within each, and to recognise the degree of commonality and deviation. Each chapter has a common structure, although the level of detail in each section varies from case to case with the material available and the nature of the agriculture–wetland interactions. In general each chapter explores each section of the DPSIR analysis of the cases as a whole, and concludes with a general discussion of the major areas to be addressed and how to do this given the diversity of the experiences from case to case. As a result each issue situation chapter helps test the validity of the DPSIR framework both on a case by case basis and more generically.
CHAPTER 5
Common Issue Situations 1

Small inland wetlands in sub-humid tropics, subject to population pressures, poverty and food insecurity.
Adrian Wood, Alan Dixon & Roy Maconachie, WA

5.1 Overview of Key Characteristics
A number of the case studies show how drivers such as rural population growth, food insecurity and poverty lead small-scale (upland) farmers to the search for the development of new income / food production opportunities in small inland wetlands. While the cases used in this discussion are drawn from Africa, it is known that similar experiences are found in parts of Asia, although with different production systems.

The main point about this issue situation is that it concerns small- to medium-scale farmers, of diverse socio-economic status, from poor to well-off, who are looking to use particular wetland niches, sometimes new and sometimes traditional ones, mostly for agriculture. They are driven to do this as a result of demographic and environmental pressures on the resources they are currently using for farming. The development of wetland cultivation by these farmers is one of several options available to them, and they may take up several of these options in order to respond to their situation. Certainly wetland use is competing with other alternative enterprise options (wage labour, crafts, micro business), which these farmers could chose from, depending on their resources, in order to diversify their livelihood portfolios and improve their food security or develop their economic well-being.

In some cases this experience involves poor households developing wetlands for agriculture in order to meet home consumption needs, in other words subsistence production. However, in several cases, it involves well-off households responding to local and even distant domestic market opportunities (commercial, market-oriented production) and developing their enterprise portfolio for accumulation. In between these are, possibly, the majority of cases with transitional (subsistence to market) production, partly for domestic use and partly for sale in local markets.

Crops include rice in swampy inland wetlands, maize and groundnuts in drained formerly shallow swamps, and maize, sorghum, millet, and vegetables in seasonal wetlands. Technologies vary from flood water management, drainage, residual moisture use and small-scale, mostly bucket, irrigation, but with some recent use of treadle pumps and drip technology. The combination of crops cultivated and the technologies used, including the level of water control, mean that different degrees of transformation of the wetland occur and different pressures are created on the regulatory ecosystem services.

This issue situation involves the exploration of new farming opportunities and the extension of the agricultural frontier into areas not formerly used for cultivation. This has often led to considerable environmental pressures and state changes, and raised questions about the environmental sustainability of these practices and the nature of the regulatory services which can be provided when such agriculture is practised.
While generally positive impacts occur in terms of provisioning services, both locally and more widely, the sustainability of the production is questionable in many cases, while there are often some negative socio-economic and socio-political impacts upon wetland users in situ, downstream and even upstream. In terms of cultural services there is relatively little change or concern reported.

In terms of ecosystem services, the cases in this common issues situation all show a tendency towards the (over-) exploitation of provisioning services at the expense of regulating services. As a result, the responses that need to be developed to address this situation must generally be geared towards re-balancing the ecosystem services. This may involve actions in situ, within the wetland, but can also involve changes in catchment and upstream agriculture as well as water management.

The nature of the interactions in these types of agriculture-wetlands situations are shown in Figure 5.1

![Figure 5.1: Agriculture-wetland interactions in small inland wetlands in the sub-humid tropics](image)

### 5.2 Case Studies

The case studies used in this issue situation are the shallow permanent swamps in Illubabor Zone of the western highlands of Ethiopia where maize is cultivated, the permanent inland valley swamps (IVS) of Sierra Leone with flood recession rice cultivation, the seasonal valley wetlands (small floodplains) in Simlemba Traditional Authority of north-central Malawi where maize and vegetables are the main crops, and the Nakivumbo wetland on the edge of Kampala where sweet potatoes bananas and vegetables are the most important crops. Other similar cases included here,
although not so closely linked with the previous four cases, are the seasonally flooded stream valleys, or *fadamas*, of northern Nigeria, and two cases of seasonal wetlands in drier areas - the bas-fonds of Burkina Faso and the *wadis* of Kordofan in the Sudan. (There are many other similar types of wetlands which could have been included in this Chapter, including the *dambos* of Southern Africa.)

**5.3 Drivers**

The immediate and typical drivers in these issue situations are food and land shortage which lead to the search for food production and income generating opportunities (survival strategy). This is seen to operate in different ways with poor households looking to overcome yield loss and crop failure due to erratic rains by using wetlands to produce crops during the dry season and so overcome the “hungry” season. In other cases, better-off farmers are responding to market opportunities which may reflect local food shortages, but also urban demands. In such cases, this is likely to be part of an income or enterprise portfolio diversification strategy. In some cases, government policies may act as drivers by encouraging the use of wetlands for food production, both for domestic food security (Ethiopia) and for urban market production (*fadamas*). (Domestic food insecurity and local markets drive similar experience with wetlands in Asia and in South America). Further, modernisation, in the form of an increased need for cash, for purchases, school fees and the like, is often a part of the combination of drivers operating in these situations.

In terms of the driver concept, the experience in terms of the better-off and food insecure farmers might be conceptualised in contrasting ways. It might be correct to say that poorer farmers are pushed or driven to the wetlands as a last resort strategy, while the richer farmers are better seen as being pulled or attracted to wetlands, as an opportunity. In particular, it should be noted that since wetland cultivation is often very hard work, the poor and resource short farmers who move into these areas must have very few other options, while the better-off wetland users often employ labour to take up the considerable labour demands in the use of these areas.

Other immediate drivers may include land tenure reforms, as in Ethiopia when, after the 1975 land reform, wetland parcels were given to farmers who were required to cultivate them in order to retain access.

The deeper drivers of this situation may be seen in failed development policies and the macro development situation which have led to rapid population growth and long-term land degradation, while variable weather patterns (increasingly linked to climate change) lead to the increased incidence of harvest failure.

Disruption of the rural economy as a result of war, with the need for short-term / immediate production of food by the post war rural returnees, is seen in Sierra Leone as a deeper driver, while the collapse of seasonal coffee picking income is thought to have been one short-term stimulus to wetland cultivation in western Ethiopia in order to meet critical cash / food shortages in the early 1970s.

Finally it might be noted that drivers are most effective in leading to wetland agriculture where there are facilitating factors. These vary from case to case, but include improved access to wetlands, technology developments (including new drainage methods and the introduction of short season maize varieties in western...
Ethiopia, and the introduction of floating rice cultivars that grow rapidly with the flood in Sierra Leone), as well as improved roads and hence market access for vegetables (in Northern Nigeria).

5.4 Pressures
The pressures typically faced in wetlands in this issue situation are primarily agricultural expansion and intensification in the wetlands. However, some pressures may derive from the catchment due to poor agricultural practices in those areas which create pressures in the wetlands through changes in hydrology and sediment deposition. The precise pressures faced vary from case to case depending on the environmental conditions – particularly dry season water availability, and the technologies used in these areas, such as drainage, water control or water extraction.

The most frequent pressure in wetlands in this issue situation relates to hydrological alteration, especially drainage and water extraction which lead to severe changes in the wetland state. Lesser pressures are created by flood management and use of aquatic environments for rice cultivation (Sierra Leone). Examples of such experience in this issue situation include drainage through small open drains (Ilubabor, Ethiopia and Nakivumbo, Uganda) and water control management (IVS in Sierra Leone) in the wetter environments, with water extraction using shallow wells or tube wells with watering cans and pumps of various sorts (Simlemba, fadama, wadis and bas fond) in the drier environments. The critical point is the extent to which the intervention alters the natural hydrological regime. In most cases extraction of water is for use in the wetlands but in some cases (Northern Nigeria and Malawi) this may be for agriculture on the interfluves (wheat in Nigeria) and on the edges of the wetland (tobacco nurseries in Simlemba, Malawi).

In some cases the disruption of the normal hydrological regime is increased by catchment degradation when this leads to reduced water storage in these areas. This, when combined with changes in vegetation in the wetland, may lead to higher but shorter wet season flooding and to faster flows of such floods down the wetland as in Simlemba, Malawi. This in turn may lead to reduced infiltration into the wetlands. Bunding around wetlands to control water, as in Sierra Leone may also have unexpected impacts by limiting nutrient deposition in the wetland through overland flow from the uplands.

Another cause of increased water extraction is from the cultivation of water loving plants in wetlands or at their edges. The most common of these are sugar cane, which is found in most of the cases cited here, and eucalyptus trees, which are found in Simlemba (Malawi) and Illubabor (Ethiopia).

Agriculture in wetlands always leads to the clearance of the natural vegetation to make gardens, although this clearance is not always complete because areas of natural vegetation may be kept in some cases for flood control and to limit erosion and down-cutting in wetlands ( e.g. Illubabor in some wetlands). Natural vegetation which remains in wetlands will also be put under pressure by the alterations in the hydrological regime, as well as by the competition for water from planted species, especially sugar cane and eucalyptus.
Cultivation creates pressures through the disturbance of soil and together with the removal of the natural vegetation, this increases risks of erosion unless appropriate activities are undertaken, such as mulching. In some cases cultivation occurs in permanent wetlands and involves trying to permanently alter such areas through drainage – Simlemba, Nakivumbo and Illubabor (some), but in other cases cultivation is adapted to natural conditions and farmers even try to maintain the natural flooding regime or allow regeneration of the natural vegetation to reduce pressures on the soil and maintain soil fertility (Illubabor – some cases; IVS of SL).

Grazing pressures are a serious problem in many wetlands due to the impact of cattle upon both the natural vegetation and the soil. Grazing pressure are greater in the drier areas in Africa due to the presence of cattle (and absence of tsetse flies) and the reduced availability of dry-season grazing (Simlemba, fadama and wadis), although in high altitude areas, such as Ethiopia, cattle may be present even in high rainfall areas (Illubabor)

Human gathering of natural products from wetlands can also create pressures leading to changes in the biodiversity (state changes). Excessive harvesting of sedges can lead to deterioration in the quality of these, although they are quite resilient, even in the face of sustained cattle grazing (Illubabor). Less resilient, are reeds which are used for mat making, and these may disappear through a combination of harvesting, fire and drought (Simlemba). Fire can also have major impacts on other forms of natural vegetation, upon soils – especially where they are high in organic matter, and even upon human health.

Pressures are created in wetlands associated with agriculture both within and outside the wetland considered here. In particular, land degradation as a result of over-grazing or poor cultivation around wetlands may lead to deposition of sediment in wetlands following erosion (wadis, Simlemba and Illubabor). This may lead to state changes in terms of soil fertility and may alter the flooding, in some cases increasing the areas flooded but in some cases both fertility and flood are reduced. The construction of wells in seasonal wetlands in the dry season (Simlemba and wadis) may also be important where they become sources of turbulence and gulley formation. In some cases, non-agricultural activities may lead to extreme alteration, such as through sand or clay mining in wetlands.

5.5 State Changes
The major changes in the state of the wetland environment as a result of in situ agricultural development in the issue situations discussed in this chapter are mainly in the areas of hydrology and biodiversity within the wetland. Overall this leads to poorer regulatory services.

The most common state change in this issue situation is lowered water tables in the dry season due to drainage to permit cultivation – even when this is for rice (as in Sierra Leone), but more obviously when swamp drainage occurs for the cultivation of dryland crops, such as maize (Illubabor) and when water extraction occurs for use within wetlands (Simlemba, wadis, fadama). A lower water table may also lead to both reduced dry season flow and to lower floods, as more water is used to recharge the groundwater resources in the sediments below these wetlands, although this issue of reduced wetland water storage in wetlands is increasingly questioned.
Where wetlands are completely drained there will probably be less groundwater recharge over the year as a whole and this may lead to lower groundwater table levels in adjoining areas.

Agriculture in wetlands, but also in the uplands near to wetlands, may lead to the development of erosion features, especially gullies, in wetlands. This is usually due to increased runoff from the uplands and possibly also in the wetland (due to vegetation clearance), but also through increased turbulence caused around wells in the middle of wetlands where wet season flows are most intense.

The major bio-physical changes, which occur in these wetlands as a result of agriculture, are biodiversity loss or change and the loss of habitat for wildlife (and hence the loss of wildlife). There is often the invasion of dryland species of weeds into wetland areas once they are cultivated (IVS of Sierra Leone and Illubabor), while the changed vegetation often reduces the buffering role of wetlands in slowing floods and extracting pollution.

Cultivation in wetlands often has major impacts upon soils. Although not well documented in the material studied for these cases, there are reports of soil ripening with increased acidity (Illubabor) and iron toxicity (IVS), as well as some evidence of salinity (*fadama*). In many cases there are reports of declining soil fertility as a result of prolonged cultivation and also of reduced organic matter content which reduces dry season water storage when cultivation is taking place. The other major change in wetland soils is compaction which usually results from grazing pressures (Illubabor, Simlemba, *fadama*). This, in turn, may affect water infiltration into wetland sediments and possibly groundwater recharge during the flood season. Wetland soils are also affected in limited areas by sediment deposition from upland erosion, thereby altering soil quality and suitability for cultivation (Illubabor, Simlemba). Conversely, restrictions in run-off from uplands into wetlands are seen in some places (SL) as a cause of declining soil fertility in the wetlands. In the *bas fonds*, intensive cultivation leads to crusting which in turn leads to erosion and loss of the A horizon thereby reducing soil fertility.

### 5.6 Impacts

The major positive socio-economic impacts of the issue situation considered here is an increase in the provisioning benefits generated from these areas as a result of wetland agriculture during the dry season. These impacts of cultivation are mostly in the form of improved food security and increased cash income. The improved food security relates partly to the poor in the rural communities whose farming is mostly for domestic use (in all of these cases this occurs), but also to the better-off farmers whose production from these wetlands is for urban and rural markets, the income from which increases their wealth accumulation (mostly in Simlemba, Illubabor and IVS).

However, there are a number of negative socio-economic impacts related to wetland cultivation in the areas considered here. The most widespread of these is the disruption of other provisioning services by agricultural expansion. In such cases, the expansion of agriculture disrupts other uses of wetlands, for grazing as in the *fadama* and *wadis*, for plant collection in Illubabor and the Bas Fonds, and for fish production
in the *fadama* of northern Nigeria and in the IVS of SL. These may have knock-on impacts in terms of nutrition for at-risk groups, especially children. Loss of springs due to lowering of water table affects the workload of women and so may also impact upon child care and child health, while less clean and reliable water sources may more generally affect health (Wood, 2001).

Sometimes the disruption of non-agricultural provisioning services is such that conflicts can occur between cultivators and, for instance, pastoralists in northern Nigeria. In the case of the *wadis* of Kordofan, the general collapse in the well-being of communities in these areas, which is linked to the decline in small businesses and trading centres, is in part due to agricultural decline following the over-exploitation of these seasonal wetlands and the imbalance between regulatory and provisioning services.

The development of wetland agriculture is often undertaken more by the better-off because they are best endowed with the necessary resources to be successful in this enterprise (Illubabor, Simlemba, IVS in SL, *fadama*). The poor do not have the resources to prepare wetlands, nor the time to wait for such supplementary harvests, and need immediate piece work income to survive. In such situations wetland agriculture may be associated with increased differentiation, with the rich becoming richer and the poor loosing some of their sources of income – e.g. plant collection in wetlands. In extreme cases wetland farming by the better-off with pumps may undermine lower technology wetland farmers when the water table is lowered beyond their reach (*fadama*).

Other negative socio-economic trends may include increased tenure insecurity in wetlands as these areas become valuable, both for agriculture and for urban development.

5.7 Responses

In this issue situation, there is in general limited evidence of responses to the problems raised at different points through the above DPSIR analysis. In particular, in several cases there is continued, or increased, government support for wetland cultivation because of its contribution to food security (Illubabor, IVS, *fadama*) and little or no attention appears to be paid to the problems identified. In the *bass fonds* of Burkina Faso, state measures to intensify production, with the use of permeable stone bunds and various types of dams, were reported to try to improve capturing of rainwater for use in cultivation. Similarly in the *wadis* of Northern Kordofan, there have been small agricultural schemes, although these seem to recognise more their downstream impacts as there is reference to a “river system approach”. The opposite type of approach is seen in Uganda where the Wetlands Inspection Division has developed a strong national wetlands policy and is seeking to protect wetland from agriculture with the motto “from conversion to conservation”.

The major case where there is some evidence of responses to the issues identified in the above DPSIR analysis is in Illubabor where farmers have developed, both in the past and more recently, local community institutions for the management of the wetlands and have experimented to develop their own technologies and by-laws to limit the negative effects of wetland farming and to encourage the use of specific practices. However, even in this small area such positive experience is patchy, and
varies from community to community. Nonetheless, it has been identified by a local NGO which is trying to consolidate the lessons into a set of guidance, support the local dissemination of this good practice for wetland agriculture, and pressure the government to change its policy of demanding unlimited expansion of wetland farming.

This experience shows that for the most part where there are responses they generally focus on reducing the negative state changes in order to maintain the provisioning benefits for the wetlands. These responses involve both technical and institutional measures. This type of focus is primarily driven by the fact that responses are at the community level where it is state changes and impacts which are most amenable to influence. Actions by the state at the policy level would probably be more appropriate for addressing many drivers but there is little evidence of concern for this at the political level in these cases. (It is worth noting that this was not the case in Southern Africa with respect to *dambos* during the colonial period and even into the 21st century, and there is other evidence of new political concern in this area of environmental protection and sustainable water resource management in a number of African countries.)

5.8 Issues, Responses and Future Guidance

Reviewing the above discussion of the experience in the cases in this issue situation, a number of common typical problem chains can be identified where a development at one stage in the DPSIR model leads to further problems at other scales. It is these problem chains which can be seen as issues, rather than the individual problems. (See Figure 5.2 below).

The major issue is the way in which the drivers, such as poverty, food insecurity and population growth, create pressures that lead to changes in the environmental state which in turn threaten the sustainability of provisioning services, as well as reducing the regulatory services. This occurs in various ways, with regulatory services affected most by hydrological alteration and vegetation change, while provisioning services are most affected by changes in soil characteristics, erosion and some aspects of hydrological change. In all cases studied under this common issues situation, there is a tendency for provisioning services to be over-developed to the detriment of regulatory services, with negative developments in the regulatory services affecting provisioning services.

A number of options need to be considered in order to move towards some better balance of provisioning and regulatory services, whilst also maintaining the ability of the wetlands to provide the same level of livelihood support. However, the applicability of these options varies from site to site. Further, it should be noted that there is a need to undertake site specific DPSIR analysis first as a basis for reviewing the relevance of options, while consideration of situational factors which can facilitate or retard specific interventions must also be undertaken.
In the first instance, there is a need to consider changes in crop choice and hence the amount of transformation of the wetlands which is required for 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 eco-agriculture approach. Further steps in this direction might involve the use of natural vegetation fallows, of *Cyperus latifolius* for instance in permanent wetlands. A second option 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. A third area to consider would be to reduce the area of cultivation in a wetland, which, when combined with changes in crops, could bring the level of state change required below the level required for sustainability and resilience, and still meet the provisioning / livelihood needs.
Other areas of local intervention, which could help improve wetland functioning, especially regulatory services, include improved catchment management through soil and water conservation and good agricultural practices. This could increase the water infiltration and storage for dry season flows from those areas and to reduce sedimentation problems in wetlands.

Where there is a reduction in total agricultural output, in order to re-establish a balance between provisioning and regulatory ecological services, there is a need to explore other provisioning services which 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 eco-tourism) 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 which could be developed. This would certainly require consideration of appropriate policies in terms of rural development, population growth and non-farm income opportunities.

Socio-economic elements may also need to be considered with the wetland management changes discussed above, as institutional development may be necessary to address some of the related challenges through the development of different forms of wetland and catchment management groups. Such institutional development may also be able to address some of the conflict and differentiation problems reported in these issue cases, as well as livelihood diversification to reduce pressures on wetlands.

What is clear, given the extent and diversity of this experience, is that legislative and enforcement approaches are of limited relevance. Rather, creating economically attractive and sustainable land-use regimes, both in wetland and catchments, is needed if these wetland situations are to be managed in a manner which will sustain both provisioning and regulatory services in a mutually supportive balance, given the limited intervention capacity of governments in the rural areas today.

**5.9 Conclusions**

In conclusion, the issue experience with small inland wetlands, facing growing pressures from population growth, poverty and food insecurity, shows that raising awareness of the linkage between maintaining regulatory ecosystem services and provisioning ecosystem services is the most essential and critical challenge. At present there is growing pressure on these areas, often with government support, and a high level of neglect of the degradation occurring in the wetlands and the ways this can impact on human well-being, both now and in the immediate future. In some cases there are examples of good practice to achieve the necessary balanced use of these areas and this experience needs to be disseminated. Interventions will involve not only technical activities in specific wetland sites to address pressures and state changes, but more widely at the basin level, as well as policy measures to address drivers nationally, for instance with effective development approaches to reduce rural poverty. Hence, a multi-level approach is needed which will address drivers, pressures, state changes and impacts, through appropriate action at the correct level.
6.1 Introduction
In this chapter the dynamics and interactions that govern the agriculture-wetlands interactions in the river floodplains and valleys in Europe are discussed. The state (changes) of these agro-ecological systems in Europe, and in particular within the European Union (EU), are currently at an interesting stage of re-balancing the ecosystem services with increasing explicit attention being given to revitalizing the regulating, cultural and supporting services vis-à-vis the predominantly agricultural provisioning services. This is strongly influenced by the common policy and regulation context of the EU, which includes the Common Agricultural Policy (CAP), the Water Framework Directive (WFD), the Birds & Habitat Directives (BHD) and Natura 2000. These are increasingly informed by concepts and notions of environmental sustainability, ecosystems and biodiversity. Nevertheless, it is necessary to discuss the cases from a geo-political context separately, as they differ significantly in their economic context and/or ecological settings, and thereby their context specific DPSIR configurations.

6.2 Case Studies
Four cases are discussed in this chapter. Although they are all floodplains in Europe, with EU policy influences, and with many similar DPSIR elements, there are also some major differences and these are explained first. The Dutch flood plain policy (see Box 1 of Chapter 2) and the middle Sava river in Croatia are ecologically similar in that they have seasonal flood plains that have been historically attractive for agriculture but are increasingly valued for their flood protection functions. The cases of the river Drentse Aa (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 Dutch cases represent a setting of high economic wealth wherein agriculture has been shaped by past EU policies and subsidies favouring intensified and consolidated agriculture. The cases of Poland and Croatia, on the other hand, are less affluent settings where agriculture has been shaped by the past central planning of eastern Europe, and is currently subdued to a whole new set of regulations, norms and values around entry into the EU.

The nature of the agriculture-wetland interactions in these wetlands is shown in Figure 6.1.
6.2.1 The common EU policy context
The Common Agriculture Policy (CAP) of the EU has influenced, and continues to encourage the expansion, intensification and extensification of agriculture. In particular, for the Dutch 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 days of EU over-production in the mid 1980s and expansion of the EU into southern and eastern Europe thereafter, the financial and political pressures has been mounting to (gradually) reform the CAP away from direct production subsidies to the wider concerns of rural agro-ecological landscape management. With the introduction of production limits and the first partial reform of the CAP from production- to area-based subsidies and the introduction of limits on the maximum individual CAP support, the incentives for maximized intensive production have been gradually diminishing.

The importance of environmental sustainability and ecological conservation and restoration has been increasingly reflected within the EU policies and regulations at roughly the same time as the shifts in agricultural policies. The conservation and restoration of ecological habitats and the preservation of biodiversity have culminated in directives, such as the Birds and Habitat (BHD) and Natura 2000, and the restoration of the environmental/ecological state of water bodies in the water framework directive (WFD). These have provided additional policy and financial (e.g. subsidy) impulses to re-shape the agro-ecological landscape through active
ecosystems restoration and management thereby increasing regulating, cultural and support services.

These shifts in the policy and regulation framework of the EU have cleared the way for increased recognition of the value of the multi-functionality of these agro-ecological landscapes, and the natural resources therein. A functional approach to highly intensive and productive agriculture is still present and applied to a core segment of the agricultural sector and landscape that is geared towards optimizing their specific provisioning services; but this is increasingly supplemented by a multi-functional 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 re-balancing of ecosystem services is induced on two fronts:

i) by regulating the negative impacts of high production functional agriculture, in particular for basin level interactions (for example the strict nitrate budgets in livestock); and

ii) by providing support and financial incentives for delimitation of in-situ agriculture in support of regulating and supporting service of the agro-ecological landscape (e.g. biodiversity and habitat subsidies).

6.2.2 River floodplains and the revitalization of flood retention capacity

The river floodplains have long been attractive for agriculture due to the seasonal deposition of rich clay soils. Along large tracts, dikes and dams have been built to improve the conditions for agriculture and protect cities and towns from flooding. This has restricted the extent of the flooding in the floodplains during periods of high river discharge to an ever narrowing strip along the river – especially in case of the Dutch floodplains. There are, however, also exception – especially in eastern Europe – like for instance the vast tracts of floodplains along the Middle Sava (Croatia), the Drava (Croatia/Hungary), the Pripyet (Belarus) and the Prut (Moldova) where agriculture (mainly grazing) has been adapted to the seasonal flooding. In the latter a rich and specific fauna and flora is thriving in the agro-ecological landscape of seasonal flooding and pasturing.

The case of the Dutch flood plain policy (see Box 1, Chapter 2) provides an excellent example of rebalancing the ecosystem services of the floodplains around a specific and purposeful hydrological function, namely protection against flooding. This represents a marked turnabout in the floodplain land use strategies of the Netherlands compared to the past decades. The basic principle underlying this marked turnabout was to base the land and resources use planning of the Dutch river floodplains principally on their regulating service for flood protection, instead of their provisioning services for agriculture and urbanization. This was in the Netherlands Government’s financial interest as it averted investment costs. The extreme river peak flows of the spring of 1995, which lead to a serious risk of flooding in Wageningen and polders to south, some of which were even completely evacuated, brought to the forefront the serious limitations of the river dikes. The first and immediate reaction to this crisis was that the river dike system was in dire need of a complete overhaul (i.e. stronger and higher dikes). It was argued that the lapses in the river dike system had
been allowed to creep in, as all the attention and (financial) effort of the sector had been directed towards providing revamped flood protection against the sea after the flood of 1953. With strengthening works underway on the weakest river dike sections and as the national overhaul plans started to emerge, it quickly became apparent the government was facing major investments costs for decades to come – just as with the delta-works against the sea that were nearing their completion by that time.

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

The emergence of the new Dutch floodplain policy was the fruit of pairing the turnaround in agricultural policies with the need to provide for an increased flood protection by means of restoring the river flood plains and increasing the peak flow capacity within the outer (or winter) dikes. This could be achieved relatively easily and cheaply (when compared to revamping of dike infrastructure) by actively restoring the flood plains through hydrological landscaping, and limiting and relocating agriculture to non-flood intrusive agricultural practices (i.e. low flow summer agriculture). In addition, the new floodplains were ideal for restoring wetlands, with which the increasing demands for nature and recreation in Dutch society could be met, while also meeting the requirements of the EU’s environmental directives (i.e. WFD, BHD and Natura 2000).

So both from an agriculture interest and flood protection perspective, the reshaping of the floodplains could be initiated, and affected farmers compensated through funds made available from agricultural policy reforms, environmental policies and directives, and averted flood protection investment costs. The result was to encourage them to change their practices towards flood-friendly agriculture.

The floodplains of the Middle Sava, in contrast, have been characterised by a less intensive agricultural development. This was based on extensive and seasonal grazing of livestock on the communal pastures in the floodplains which 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 privatisation 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 Croatian government to designate the middle Sava for flood retention and this has also been beneficial for the protection of biodiversity, with farmers able to continue their traditional communal grazing practices 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 WFD and BHD.

6.2.3 Small river valleys with peat meadows
A slightly 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 hay making and grazing. Due to the specific biodiversity that had developed in these hay meadows, large areas of these river valleys had been nominated as so called Sites of Community Interest under the Birds and Habitats Directives of the European Union. However, with the abandonment of these areas by agriculture, the specific biodiversity also disappears and member state countries are facing problems in meeting their obligations to the European nature conservation legislation.

In case of the Biebrza valley (Poland), the economic transition and accession of Poland to the EU has lead to a significant transition of the rural and agricultural economy, in which the poorer grounds and resources of the peat meadows of the Biebrza are being abandoned by agriculture (as consolidation and intensification is concentrated in more productive areas). The specific response here, has been to designate the Biebrza as a nature and biodiversity reserve under the Birds and Habitats Directives in an attempt to preserve the unique landscape and biodiversity. Since this landscape and biodiversity was shaped by farming, the proposed management of this area consists of copying the traditional agricultural use with the work carried out by farmers or specialised management organisations who are remunerated for the delivery of the biodiversity and landscape attributes from EU and state budgets. In the case of the Biebrza this is achieved primarily through specialised management organizations. Furthermore the Biebrza is increasingly attracting tourists, which can further provide incentives and resources to maintain this specific agro-ecological landscape.

The Drentse Aa valley (Netherlands) faces similar pressures as the Biebrza, in that it is not longer a core agricultural production area, and continued extensification and cessation of agriculture threaten to undermine the agro-ecological system that depends on active grazing. Also in this case, the designation of the valley as a Site of Community Interest under the BHD, provides the means to preserve the agro-ecological peat environment by supporting agricultural uses for the sake of landscape and biodiversity management. In the case of the Drentse Aa this is, however, primarily directed towards compensating still existing farmers for their multi-functional role in landscape and biodiversity management. They can further supplement this income through providing recreational services (e.g. campsites), with the aim of keeping the desired level of in-situ agricultural activities. In-situ agricultural activities are thereby actively supported by the environmental directives, with the aim of topping up lower income levels (as compared to mainstream agriculture) and maintaining specific fauna and flora that depend on active and controlled grazing and landscape management by farmers.
6.3 Drivers
The major drivers in this issue situation include:

- EU Policies which require member states to protect habitats and species of European importance (through the Birds and Habitats Directives) have forced member states to protect semi-natural habitats of which the biodiversity attributes depend on low energy input agriculture. Further, the EU CAP encourages farmers to increase the agricultural area per farm since EU subsidies are area-dependent, rather than being product-dependent. Since the EU also demands to apply “good agricultural practices” for areas that remain in agricultural use (and are eligible for subsidies) farmers have a tendency to “tidy up” farmland which goes on the account of biodiversity. Last but not least, EU market policies encourage farmers to invest in producing crops for the world market instead of for the local market.
- Globalisation and changed market opportunities prevent small farms competing because their products are produced under sub-optimal soil conditions.
- Urbanisation and land reclamation through which the storage and retention capacities in the uplands have significantly decreased has lead to a faster discharge of the precipitation into streams and rivers, causing higher peak discharges and increased flooding.
- Climate change leading to changed discharge patterns of the rivers,
- In the case of the Sava River, Croatian government policy, in the form of land privatisation, jeopardises the traditional use of the Sava floodplains for grazing because the local small farm households cannot afford to purchase the privatised lands.

The diverse ways in which these drivers operate in the different situation has been discussed above and need not be reiterated here.

6.6 Pressures (on the wetland environmental functioning)
The main pressure which is found in these floodplains wetland is changing land use and intensity of use. Specific pressures vary depending on the environmental conditions (big rivers as opposed to small rivers; peat soils as opposed to clay soils), and the level of economic development. In countries with developed economies the regulatory function of floodplain wetlands in terms of flood alleviation is gaining more and more appreciation in policies and plans. This lead to changes in the use of the floodplains, away from agriculture. This leads to a “positive pressure”, whereby agriculture needs to adapt to the newly given primary function of floodplains to store peak flood flows, as opposed to former times where the water dynamics where adapted to the needs of agriculture. This means that agriculture in the floodplains is becoming more seasonal, being abandoned in time when flooding occurs, and that crop production is replaced by cattle grazing.

The pressure observed in the small river valleys, where peat-soils are dominant, is that of the fragile balance between agriculture and nature is being jeopardized because farmers abandon the floodplain meadows. This causes the loss of specific biodiversity (vegetation, birds) that depended on the low energy-input farming.
Land privatisation leads to the cessation of traditional agriculture in the floodplains which were used for pasture, and through which a site-specific vegetation type had developed. The herb rich vegetation, with its specific value for biodiversity, has been replaced by bushes and trees. Cessation of the pasturing activities will, in the long run, result in the loss of this site-specific biodiversity. Apart from the loss of biodiversity, bush and tree encroachment in the floodplains can also hamper the discharge capacity of the floodplain during periods of peak discharges.

Another pressure observed resulting from the privatisation is that the new owners are transforming pasture into arable land leading to the loss of biodiversity (state change).

6.7 State Changes
The major changes in the state of the wetland environment, as a result of changing drivers and pressures discussed in this issue situation are mainly in the areas of hydrological and biodiversity change within the floodplain wetland. Other state changes relate to the landscape features. As a result of agricultural development in the catchment, there are state change in terms of the poorer quality of the surface and ground waters in the floodplains.

In the river valleys with dominant peat-soils the main state change is in the vegetation, caused by the cessation of the grazing and haymaking activities by farmers. In combination with this change in the vegetation, the bird population has also changed and a common feature observed in this scenario is the loss of biodiversity. The major bio-physical changes which occur in the river valleys as a result of the cessation of agriculture is biodiversity loss or change, and the loss of habitat for wildlife (and hence the loss of wildlife).

This process is further amplified by the deteriorating quality of the surface and ground water predominantly caused by catchment agricultural activities. Although it has to be stated that this is not common to all the cases reported here. In well developed economies there is a trend of improving water quality as a result of several national and European policy measures resulting in a reduction of the use of fertilizers and pesticides benefiting biodiversity. In the economies in transition, economic development could well lead to increased use of fertilizers and pesticides which will go on the account of biodiversity.

Measures to store and retain rain water in the upper parts of the valleys in the frame of flood alleviation measures improve ground water recharge and in addition improve the ground water tables in the valley. This improves the conditions for biodiversity.

Pressures from gravel mining, as observed along the major European rivers, destroys the original landscape and vegetation in some sites in the floodplains considered here. However, if well planned, the original attributes in terms of biodiversity and value for tourism and recreation can be replaced by other types of tourism (swimming and fishing) or wildlife typical for (artificial) lakes.

6.7 Impacts
The major positive socio-economic impact of the issue situation considered here along the big European rivers is the increased value attached to the regulating function of the floodplains to provide storage and discharge capacities and increased
safety against floods. This implies that the prime ecosystem service of the floodplains in many areas is now flood prevention – regulation, instead of agriculture - provisioning.

In economies in transition the major socio-economic impact is on the rural communities, where as a result of the declining importance of agriculture people (especially young people) are leaving and the villages are becoming depopulated. Services like shops have closed down because of a lack of income adding to a further decline of the population.

The cessation of agriculture in the peat-soil dominated river valleys has run parallel with increased appreciation of these areas for tourism. This has changed the composition of the traditional population in the villages in the developed economies where the majority of the inhabitants are now employed outside the agricultural sector. This has, to some extent, helped to maintain the viability of the rural economies. The same trend is visible in the economies in transition where an increased value is attached to the cultural historical features of the small-scale landscape of the river valleys, with open pastures, meadows and small forest patches.

Another socio-economic impact is the increasing value that is attached to the biodiversity values of the river valleys and floodplains resulting in an increase in protected areas in this type of landscape. Extensive areas of the river valleys analysed here have been designated under the Birds and Habitats Directives in an attempt to preserve the unique landscape and biodiversity.

The changed attitude to the floodplains, resulting in a higher appreciation of the regulating service (flood retention, nutrient trapping) relative to agriculture, has also had big socio-economic impacts. Farming has become less important, farms have closed down, the rural economy deteriorates and the composition of the rural population changes.

6.8 Responses
The multiple responses observed are all aimed at achieving a new state where the ecosystem services are re-balanced on a more equitable level (i.e. provisioning services brought down through non-obtrusive agriculture; increasing the regulating services, in specific the flood management capacity; revamping the aesthetic (cultural) services by ecosystem restoration and recreation development.) These measures will then presumably result in the resolving of the negative impacts.

In the European Union the responses to the two main drivers, climate change and market development, together with a growing public awareness of the deterioration of the environment, paved the way to searching for a new balance between agriculture and environment. The mixture of environmental concerns and the desire to bring agricultural production in balance with market demands have lead to the design of agri-environment schemes in the European Union through which support is provided for the protection of biodiversity and the diversification of the rural economies. Farmers that adapt to nature oriented agriculture can be compensated for the loss of income while farmers who would like to shift to biological agriculture can receive financial support. This support, however, seems to only slow down the process of land abandonment and cessation of agriculture in sensitive areas with valuable landscape
and biodiversity, but does not stop it completely, possibly because the remuneration the farmers receive is too low for maintaining their farms.

As a response to the loss of biodiversity and the deteriorating quality of surface water new legislation was imposed in all member states. This included the Birds and Habitats Directives demanding member states to designate areas holding habitats and species of European importance as protected areas and carrying out management that secured the protection of these habitats and species. Another major policy response is the adoption and implementation of the EU Water Framework Directive that requires member states to restore the ecological quality of surface waters based on an analysis of the reference situation of these waters.

These policy instruments, together with an increasing awareness about the effect of climate change, supported the designation of vast tracts of floodplain areas for flood retention and nature protection along the Rhine and the Sava, among others, and the designation of vast areas in the valleys of small rivers as nature reserves (e.g. Drentse Aa, Bierbza). The designation of these areas for flood retention and/or nature protection as a response to the drivers mentioned in this scenario, however, have not yet resulted in a situation that has been shown to be beneficial for biodiversity.

Despite the remuneration farms can receive for “nature friendly farming” farms close down in the valleys of the small rivers and the valuable biodiversity that is linked to the farming activities disappears. A new balance has yet to be found and it is uncertain whether agriculture can be maintained as a provisioning service on these floodplain meadows.

At a macro economic level the economic return of the ecosystem services (flood retention, biodiversity and aesthetic attributes) provided by the floodplain wetlands are higher than the value of the agricultural products produced in these wetlands. One of the problems is that there is not yet an overall acceptable method for evaluating the economic value of the ecosystem services provided by farmers through the adapted management. In addition, farmers have “psychological” constraints to being paid as park managers.

The response to this state change is the provision of biodiversity management by specialised nature management organisations funded from national and EU budgets as happens in the Netherlands.

As a response to changed market conditions some farmers shift to the production of agricultural products for specialised markets of nature friendly or biological products. This trend might, in the long run, lead to a new balance between biodiversity and agriculture.

The multiple response of adapting to new market conditions and support through agri-environment schemes to pay for the production of ecosystem services (aesthetic values and biodiversity) seems to be the most promising in this scenario for finding a new balance between agriculture and wetland management.

The process of biodiversity loss is exacerbated by the fact that the responses are not sufficiently catchment-based. The designation of protected areas as a response to the
state change of the river valleys is limited to those areas that possess a high value for nature conservation. The loss of biodiversity, however, is also caused by the pollution of ground and surface water by agriculture in the higher parts of the valleys. The response to this state change is adopting more strict legislation on the use of fertilizers and pesticides so that legislative obligations in the field of nature conservation and water management can be met. These measures however have not yet proven to be sufficient.

Overall there is limited evidence that the responses to the problem of deteriorating biodiversity, identified through the DPSIR analysis, are providing the right answers. However, this is not so for the response to the lack of storage capacities of floodplains as provided by the Dutch policy plan “room for the rivers”, and the designation of vast tracts of the Sava floodplains for the storage of floodwaters. For the Sava floodplains the response to the changed discharge patterns by designating the floodplains for flood retention has proven to also be beneficial for the protection of biodiversity because farmers were able to continue their traditional way of agriculture, adapted to temporal flooding. This way of agriculture (grazing of domestic animals on communal owned pastures in the flood plains) is now coming under pressure because of the land privatisation. No proper response to this pressure, leading to state changes and impacts (cessation of farming activities), has been observed. The management of the nature park tried to have the nature park exempted from the privatisation process.

The experiences show that for the most part, the responses identified focus on addressing the drivers and negative state changes in order to alleviate the increasing threats of flooding and to maintain the provisioning services of the wetlands. The responses involved include legislative, institutional and technical measures.

6.9 Issues, Future Guidance and Responses
The floodplains and river valleys can progress toward a sustainable, use regime through the use of these areas for flood protection and rebalancing regulating and provisioning services. Further, the political will is beginning to exist to compensate farmers adequately for the maintaining regulating and cultural services by protecting and managing biodiversity, maintaining aesthetic landscapes and improving water quality.

There remain challenges in terms of the opening up local and national markets as a result of globalisation and EU policies which force farmers to intensify their productivity with the lowest possible investments, thereby forcing them to abandon areas which are sub optimal for agriculture. Although increased values are attached to the regulatory ecosystem services, such as biodiversity, flood retention and aesthetic landscapes, farmers are still not appropriately compensated for these. Either farm land has to be bought up for flood retention and biodiversity protection (like in the Netherlands), or designated as nature reserve (all over Europe). In all cases agriculture will cease to be the prime function.

The overall positive signal from this issue situation is the increased appreciation of the flood retention capacities of the floodplains which has resulted in new policies aiming to stop the loss of floodplain wetlands and revamping the balance between nature, agriculture and flood retention.
To halt the on-going loss of biodiversity and stop the deterioration of cultural historic landscapes, new sources of income for farmers other than agriculture have to be found. These can be found through promoting forms of agriculture that are balanced with the provisioning of ecosystem services and by adequately compensating farmers for the “production” of ecosystem services like biodiversity and aesthetic landscapes.

The newly adopted legislation on the use of fertilizers and pesticides in the European Union has further helped to improve the quality of surface and ground waters. The hydrological situation in the flood plains and river valleys will further improve if the implementation of this legislation is combined with local interventions to improve to increase the infiltration of water in the upper parts of the valleys and to reduce the run-off of polluted water.

In addition it is recommended that land-use planning takes into account the impact of planning new urbanised areas on the discharge patterns of the streams and rivers. It should be avoided that these new areas further increase the pace with which water is discharged to streams and rivers, further increasing the water levels in the rivers during peak discharges.

6.10 Conclusion
In conclusion it is clear that the economic and environmental policies of the EU are having a major effect as drivers of land use changes and agriculture-wetland interactions in the floodplains of this continent. However, the way in which the policies work out in practice varies with the economic position of the countries and the specific flood plain characteristics. It could be seen that there are a series of stages through which countries will pass as they are increasingly impacted by the policies and their integration into open market conditions, thereby creating the conditions for the sharing of lessons across this experience.
CHAPTER 7
Common Issue Situation 3

Oil Palm estate development in south-east Asia: consequences for peat swamps and livelihoods
Aart Schrevel, WUR

7.1 Overview of Key Characteristics
Elsewhere in this volume the issue situation of small inland wetlands in the humid tropics is described. The pressures and drivers that lead to state changes and subsequently to socio-economic impacts and responses in this issue situation originate from the rural areas (the pressures are population growth, food insecurity, poverty and the search for new income and food production opportunities; see Case Study 1). The issue situation described in this chapter is of a fundamentally different nature. The pressures are globalization, market development and national policies. Although the setting is entirely rural, the forces of chance originate outside the rural areas themselves, in provincial and national capitals, as well as in overseas urban centres.

World demand for oil from oil palms has increased substantially over the last decade. The world’s two most important producing countries have reacted to this demand by converting more tropical forest land to oil palm estates. To give just one figure to illustrate this: In the decade from 1995-2005, Indonesia’s output has tripled from 5 million MT to 15 million MT; the figures for Malaysia are 8 million MT and 15 million MT (ref. US Department of Agriculture, 2007). It is predicted that production in the next decade or so will double again. Oil palm estates are established in the peat swamp forests that are found in Kalimantan (Indonesia and Kalimantan) and Sumatra (Indonesia).

A typical peat land forest of south-east Asia before the establishment of an oil palm estate would be hard to access. Not only would the peat layer be thick, sometimes up to 15 meters and more, but the upper layer would consist of branches and other organic material soaked in water. Water tables would be up to grass root level. In the water and up to the top of the trees a great variety of animals would live. Peat swamps support a large and diverse range of plant species, which in turn provide habitats for many birds, mammals, reptiles and insects. Higher spots in the forest area would be the location of small settlements, inhabited by indigenous people, such as the Dayak in Kalimantan. Transport would take place over small rivers and terrestrial paths.

Large areas of peat land forests have since long been given to concession holders who have taken out the valuable species of trees. An oil palm operation starts with digging canals to drain the area. This immediately results in the lowering of the water table and the shrinking of the peat layer by several meters. Often a fire is lit to get rid of the dead branches and leaves. The area becomes accessible and roads can be constructed. The area will be cleared and the oil palm seedlings can be planted. It is important to note that once the water table is below grass root level, a process of oxidation starts and the peat disappears. In the process CO2 is released. The scale at which land clearing takes place is enormous, and so are the amounts of CO2: Indonesia is responsible for 20% of the total amount of CO2 releases in the atmosphere.
Where an oil palm estate is developed, the original wetland ecosystem is replaced by another. The oil palm estate will border to a forest. The key to the survival of the remaining forest is water management. It follows that the site of the oil palm estate must be chosen carefully and that the draining of the site must be done without compromising the water table in the surrounding forested area.

The people that organize the conversion of the natural forests to oil palm estates are without exception people from outside the area itself. They may even be foreigners who are granted concessions. For example, the State Plantation Corporation PT Perkenunan Nusantara (PTPN), Indonesia, plans to develop 1.8 million hectares of oil palm estates and one-third of the area would be developed by companies from PR of China. The local inhabitants may be hired to do the manual work, although also this work is often done by outsiders. In the best of cases, the local people receive compensation for the land, land on which they lived for generations, but in the end they lose access to at least part of the resources they depend upon for their survival. An increase in poverty is the result. Impoverished local people are often involved in illegal logging activities, which are organized by local business men.

This issue situation involves the extension of the agricultural frontier into previously marginally used wetlands. Where estates are established, the natural wetland ecosystem is replaced by a man-made agriculture based ecosystem. The services of the latter are positive for those with access to land, usually large companies, and to the State, who receive revenues for concession holders. Development of the new, agriculture based ecosystem is often done in an unsustainable way, resulting in pressures on the remaining natural environment, state changes that are irreversible, and socio-economic impacts that are largely negative for the local populations.

As was the case with other issue situations described in this volume, this one is also an example of over-exploitation of provisioning services, at the expense of regulating services.

7.2 Case Studies
Case studies used to describe this issue situation come from the three geographic and socio-political environments where oil palm estate development is most extensive: in Central Kalimantan province, Kalimantan, and in Jambi province, Sumatra, Indonesia, and in Sarawak State, Malaysia. Sarawak State is the northern part of Kalimantan.

The case study in Sumatra is Air Hitam Laut River Basin. Air Hitam Laut literally means ‘river that brings black water to the sea’. The black water refers to the colour of the water that drains from the peat. The case involves the Berbak National Park, with an area of 162,000 ha and a Ramsar site since 1991; it is an important bird migration area. The Berbak National Park can serve as an example of the biodiversity that can be met in a peat swamp forest: 224 bird species, including the Kingfisher, Hornbill, and the White Winged Wood Duck, almost 30 mammals, 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 rail road tracks built to export logs from the area to enter the area to produce crops or collect marketable products from the forest.
The case study of Central Kalimantan is the case of the Mega Rice Project, an endeavor started by Suharto, the former president of Indonesia, and that involved the clearing of one million hectares of peat swamps to provide space for rice farms to be exploited by trans-migrant farmers from Java. The rice farms largely failed and the cleared land is now being given out in concessions to start oil palm estates. In the process, valuable trees have been exported from the area.

In Sarawak 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.

Figure 7.1 shows the main agriculture-wetland interactions in this issue situation.

![Figure 7.1 Agriculture-wetland interactions in the peat forests of South-East Asia](image)

7.3 Drivers
The deeper drivers that fuel this issue situation are globalization and market development. Globalization is manifested by Indonesia’s more open economy and the demand from western countries as well as emerging economies for suitable land, investment opportunities and the products of oil palms. Demand and supply meet each other in Indonesia’s national and provincial capitals. The market development is triggered by the increase in demand for oil palm products, and notably the promise that bio fuels become more important in the near future. Palm oil is used in a variety of products, and it is a bio-fuel. Decisions on the demand side that shape the developments are taken in China, Europe, and other countries in the world. The result is that people from other, often far away places, are attracted and see opportunities,
and gain access to the natural resources of the tropical peat forests. National policies are immediate drivers as well in this issue situation. These developments would not be possible if the government would not grant concessions. Through the concessions, the land tenure situation has changed. The government sets rules as well, for example when it rules that environmental impact assessments are obligatory. Unfortunately, the assessments are often not as accurate as they should be. The second immediate driver is poverty. Indigenous people and other people, who lived in the area and from the resources of the forest, have lost access to these resources. They are organized by local business men and engage in illegal logging activities, exerting more pressure on the wetland systems.

A factor facilitating this development is undocumented titles to land and other resources in the case of local inhabitants prior to the moment that concession holders come to open up the land. In Central Kalimantan, indigenous people like the Dayak suffer most from the transition of their environment, as their villages are usually located far into the swamps and their livelihood systems depend totally on the undisturbed state of the peat lands. Relative newcomers, like the Malay or the Buginese, have settled at the edges of the peat lands and depend only partly on them. The indigenous people rarely have formal titles to the resources they depend on, even though they depended on them for generations. It seems that the people who settled in the area later more frequently have formal titles. In both cases, the national government, when agreeing to provincial and other regional development plans that include the establishment of estates, neglects the rights of the people already living in and from the area. The land is drained and cleared and the estates are established. The people that lived in and from the land are left with far less resources to exploit, which are also often further away from their houses.

Globalization and market development, facilitated by national government policies, are powerful drivers that have transformed large areas of previously undisturbed peat forest in Kalimantan and Sumatra into land satisfying economic criteria. The regulating services are sacrificed in favour of the provisioning services. The process started when, worldwide, the demand for hard wood increased and accelerated with the increase in the demand for oil palm products. Poverty is a driver as well, as it is poverty that makes people go into the peat forests to bring out logs, again to satisfy the world demand for tropical wood. In many areas the logging activities, although illegal, are well organized by local business men and take place with the help of the authorities. They are so intense, that again the provisioning services win it from the regulating services, leading to non-sustainable conditions and a general decline of the regulating functions of the wetlands.

7.4 Pressures
Basically, two conditions have to be altered to prepare a peat forest environment to receive oil palms. The hydrological regime has to be changed and the natural forest cover has to be removed. Both interventions have severe effects on the state of the wetlands (see below). Typically, canals are dug to drain the area where the oil palms will be planted. Often areas as large as 5000 ha and more are developed in a single effort. Because of the relatively open and light structure of peat, the effect of draining is not restricted to the area to be converted, but to a much larger area. The extent of the effect depends of course on the topography. The challenge is to choose the area to
be drained carefully and to drain exactly as much water as is required, at the lowest possible speed.

Related pressures come from the road building and rail road track construction that is always associated with logging and oil palm estate development. In the Berbak National Park and in the Maludam National Park before it was a protected area local people use the rail road tracks to travel deep into the forest to collect forest products.

The Maludam case is a peat dome that is still much in its original state (except of course for the logging activities that had a negative effect on the biodiversity of the area). Pressure on the hydrology of the area comes from two sides, one real but not threatening the integrity of the peat dome, the other not existing as yet, but potentially very threatening. A pumping and water purification plant has been developed to provide a settlement nearby with water. The quantities of water extracted are such that the effect is minimal and local in the worst case. The potentially more threatening pressure is the plan to develop oil palm estates at the edges of the (protected) peat dome and partly within the dome. The plans foresee in the construction of a broad buffer to keep distance between the oil palm estate, where water tables need to be lowered, and the peat dome, where water tables should not be affected.

Pressure on the Berbak National Park in Sumatra, Indonesia, comes from land conversion and logging in the upper catchments of the Air Hitam Laut River. The effect is an increased water run-off and a decrease in groundwater level leading to droughts in the peat swamp forest. Dry peat soils are particularly prone to fires. Fires constitute another, very serious, pressure. And not only in the Berbak National Park, of which in 1997 10% of was destroyed by fires, but in all of Sumatra and Kalimantan. As everyone with an interest in this part of the world knows, during the entire dry season, smog from bush fires troubles life in large parts of Indonesia and Malaysia. The smog originates in the peat swamp areas. Additionally, peat swamps are huge carbon sinks that release CO2 in the atmosphere when burnt. This contributes to climate change and global warming. CO2 is also released in the atmosphere when the peat land is drained and the peat is left to oxidise.

Removal of the forest cover is another pressure, as is logging, whether legal or illegal, in still existing forests. Logging occurs in unprotected as well as in protected forests. It occurs in both the Maludam National Park in Malaysia and the Berbak National Park in Sumatra. A further pressure exists in the form of local people entering the forest extracting all kind of forest products. To what extent this latter pressure is negative depends on the extent to which it alters the state of the wetland.

In its fully developed state, the peat forms a dome. Its highest part is several meters above sea level. The dome slopes down to sea level nearer to the coast. Salt intrusion can be a problem, but is much more the result of excessive ground water pumping in the coastal zone.

Pressures in this situation case arise from interfering with the hydrology of the area. Peat layers are extremely sensitive to draining. The other direct pressure comes from removing the forest cover. Both pressures interfere directly with the state of the wetland.
7.5 State Changes
Where a peat land forest is replaced by an oil palm estate the state changes are dramatic. The hydrology of the area is changed so much that the forest cannot survive. The trees are removed anyway, to make place for the palms. The biodiversity in these areas changes completely as well. One set of living organisms is replaced by another; typically the former is much more diverse than the latter. The state changes in neighbouring areas that are not transformed into plantations, but experience pressure from altered hydrological regimes, are more subtle and take place at a lower rate. Ground water tables in peat forests are relatively constant and high. Where areas fall dry or become dryer, water loving species flourish less. In the long run the biodiversity in areas that suffer from lower water tables may change fundamentally, with species used to drier environments replacing those that survived in the wetter environment that is no longer.

Selective logging and harvesting of forest products affects biodiversity. Logging in the Berbak National Park, Sumatra, and in Maludam National Park, Malaysia, is taking place at a faster than regeneration rate. The result is the total disappearance of certain species of trees and of the mammals, amphibians and birds depending on them. An example is the case of the Proboscis monkey (Nasalis larvatus orientalis), which has become nearly extinct in the Maludam National Park.

The change in the peat soils constitutes a major state change. Because of the lower water tables, the peat layer shrinks, and peat exposed to air disappears. Where the effects have been measured, it was found that the peat layer had decreased several meters in thickness. The top layer changes in composition: from a mix of water, dead branches, organic material, water loving plants, and more water again, which is hardly accessible, it becomes a more solid, although far from firm, organic soil.

State changes in the tropical peat lands in south-east Asia result foremost from interfering with the hydrological system. The peat layer dries out, which negatively affects the forest cover and the ecosystem itself. Where the tree cover is removed totally, the state change is total. The original wetland system, with its diverse ecosystem and regulating services for even the global ecosystem, is replaced by a much less, alas more economically productive ecosystem.

7.6 Impacts
As is often the case in these kind of situations, the socio-economic effects, or impacts, are positive and negative. The financial returns of oil palms are benefiting their owners, thus people from outside the area and frequently from other countries. In a way, positive socio-economic impacts are felt by people using oil palm products in faraway countries, e.g. China and Europe, although the question should be asked whether these short term benefits are not bypassed by long term negative benefits, as the CO2 releases that are a by-product contribute to global warming.

Positive socio-economic benefits are also felt by local people who, because of roads and rail road tracks that opened up the area, now have access to forest resources that they did not have before. In Maludam, Malaysia, local labourers coming from resource poor families, benefit from them, although they also have to construct their own temporary roads in order to travel into the forest. Their work is being organized by local business men with strong ties in the nearby State capital.
The negative socio-economic impacts are important. They are most notably where oil palm estates have replaced other forms of land coverage and land use. This is clearly the case in Central Kalimantan, Indonesia, where entire villages and communities have seen their generations-old livelihood systems disintegrating. They are now left with fewer resources to exploit at often increased distances from where they live and generally with less sources of income. The coconut plantations at the mouth of the Air Hitam Laut River are less productive because of lower water tables. The people that live from them have lost out on this source of income. The general situation for all the cases underlying this issue situation is that people migrate out of the areas affected and try to make a living in a nearby urban centre. Especially young people move away.

There are basically two ethnic groups living at the fringe of the Maludam peat dome, Malaysia. The Malay plant coconuts and a few other crops at the fringe of the peat dome and live from whatever they can catch in the sea. They still continue living in this way, as thus far the oil palm estates exist on paper (situation 2004). This situation will change once the estates are reality. The coconut plantations will disappear, for which the people will receive compensation. Fishing will continue, and the Malay people, at least some of them, will find additional employment on the estates and in associated commercial activities. Whether the overall situation must be judged positively or negatively is difficult to say (although experiences from nearby sites may add to our understanding). The other ethnic group is the Dayak people. They typically have their villages inside the borders of the national park and they live from the fruits of the forest. The estates will not affect them, provided that the correct hydrological measures are taken, thus that the peat dome itself is not affected by excessive draining.

Particularly important issues are the impact on land tenure, tenure insecurity, and changed rights of access to resources. They are important because they cut right through the issue situation and the dynamics of the situations that were described above. Typically, the local people in the areas where oil palm estates are developed do not have documented titles to the land that they cultivate, let alone to the forest resources that they exploit or the hunting grounds that they frequent. Whether the outcome would have been different is difficult to say, but the fact that such titles do not exist makes it relatively easy for project developers and the authorities to go ahead. In the face of such developments, it is proper to say that tenure and title insecurity constitute main issues. Often some form of compensation is granted, but it is probably safe to say that the compensation is never enough to start other livelihood systems elsewhere. This must be an important response issue: sustainable socio-economic development implies secure titles to other land resources.

The socio-economic impacts of the state changes are both positive and negative. They are positive where people get economic benefits that they would not have otherwise. Both outsiders and people from within the system gain economic benefits. Negative impacts are suffered by indigenous people who are cut off from the resources that they depended on. They do not have strong formal titles that can be defended in court, which makes them vulnerable. They have only traditional rights. Data from Indonesia suggests that the state neglects these traditional rights.
7.7 Responses
Responses included setting conditions for proper water management, thus to control ground water levels. The situation is different for the Maludam area, Malaysia, as opposed to the situation in Central Kalimantan, Indonesia. (Information from the Air Hitam project on this aspect is not available).

The Maludam peat dome was declared a natural park and shortly after that it was found that the southeast corner of the dome had not been included in the park. This could lead to the undesirable situation that this part of the dome would be developed and drained, and that the entire dome, or a large part of it, would experience negative effects. The authorities corrected the mistake. Even so, there are plans to develop oil palm estates at the fringes of the park. Consultants have advised a buffer zone between the park and the estate. The plans have not been turned into reality yet and it is too early to say what will happen.

The authorities in Central Kalimantan are placing emphasis on measures to prevent forest fires occurring in the dry season. There seems to be less attention for hydrological measures, even though this kind of interference could help to curtail the fires. A further response is research on ways to keep water as long as possible in land that has already been drained and cleared, the provision of guidelines on proper water management in peat lands, and the development of a curriculum on the same subject. These latter responses are funded by the EU.

The authorities have also responded with institutional measures. In Malaysia, Park Management Commissions are established. Members of these commissions include local representatives and representatives of relevant government departments. They can make a difference, although the important question with these institutions concerns the power that they have to issue and secure implementation of rules. Other responses included experiments to establish proper land use techniques (Air Hitam Laut Project). Also, community development initiatives must be mentioned. Community based approaches to peat swamp management, wild life management and management of non-timber resources and fish resources were strengthened in each of the cases that underlay this issue situation.

A response also manifested itself at the other end of the market, earlier this year. In the Netherlands the press carried the message that Indonesian palm oil produced unsustainably was used by one of the larger 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 WWF to establish sustainability criteria for palm oil.

7.8 Issues, Responses and Future Guidance
When reviewing the above experience, a number of common typical problem chains can be identified where a development at one stage in the DPSIR model leads to further problems at other scales. It is these problem chains which can be seen as issues, rather than the individual problems. (See Figure 7.2 below).
The issue at stake here is an increasing demand for a product in one part of the globe and the transformation of a wetland system in another part in order to satisfy this demand. In the process the sustainability of many peat land systems in south-east Asia is threatened and ultimately peat lands are destroyed; the rights of indigenous people and other local people living from the area are neglected; and of a different order, the integrity of the global ecosystem is compromised. It is these three issues that require attention. The responses should focus on sound hydrology 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.
CHAPTER 8
Common Issues Situation 4

Agricultural use in Tropical River Basin and their impact on Aquatic Lagoon and Estuary Ecosystems – A trade-off between agriculture and aquatic provisioning services?

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8.1 Overview of Key Characteristics

Tropical river basins contain both dry-land and aquatic ecosystems that provide a rich environment and habitat for biodiversity, fresh and salt water fish and marine life, as well forests and agricultural crop production, and to a lesser extent livestock. These rich environments 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 river and lagoon ecology state;
- In-situ and periphery exploitation of aquatic ecosystems and natural resources that directly infringe upon 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 a substantial amount of government investment and support to provide for the necessary water storage and conveyance infrastructure. As a result, large tracts in the river basin have been converted to irrigated rice cultivation, especially in the cases of Vietnam and Sri Lanka. These irrigated rice systems affect the aquatic ecosystems in the basin through resulting changes in water quantity (both negative in the river flow, and positive in storage and lagoon drainage discharge), and water quality (negative through pollutants and through diminishing salinity levels in coastal ecosystems).

Dry-land agriculture and forestry management/exploitation in the upper catchments of the basin may substantially impact upon the catchment run-off and water retention capacity, and affect the coastal aquatic ecosystems through sedimentation of eroded topsoil. In general these transformations lead to changes in the flow regime of both the river and the lagoon.

Over 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 impacts directly upon 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 which may compete for ecological niches with native species or be agents of disease and parasites.

The combined effects of both agriculture and aquaculture systems often lead to severe transformations and degradations of the coastal aquatic ecosystems, especially through water quality changes.

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 fish and lagoon species);
- in the refreshment rate, with which aquaculture waste (pharmaceutical and solid) and agricultural waste (agro-chemical) can be washed out;
- oxidation/eutrophication rates.

Also affected – in some locations and some times positively, and others negatively – is the fishery sector of both riverine and marine fish. 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 generally conflicting interests with regard to management of water resources (in quantity, timing and quality). These conflicts are played out both in-situ (in particular at the periphery of the coastal aquatic ecosystem), as in the basin level, where upstream practices impact upon downstream uses. Figure 8.1 shows the main agriculture-wetland interactions in this issue situation.

Figure 8.1 Agriculture-wetland interactions in tropical rivers with rice, fish, aquaculture and lagoon ecosystems
8.2 Case Studies
The case studies that were used in this issue situation are those of:

i. the Kirindi Oya Irrigation and Settlement Project in Sri Lanka, where irrigation development for paddy cultivation has taken precedence over other developments. On the one hand this created fish and aquatic ecosystem habitats through the creation of freshwater reservoirs and tanks; while on the other hand it affected the salinity and marine species stocks in the coastal lagoon by increased freshwater drainage.

ii. the Chilika Lagoon and coastal wetland, a designated RAMSAR site, in India, that has been severely degraded due to the combined impact of upland agriculture, deforestation and lagoon fishery.

iii. the Huong River Basin and Tam-Giang Cau Hai Lagoon in Vietnam, which are characterised by priority development of irrigated paddy and a recent boom in shrimp cultivation in the lagoon which has led to a severe degradation of the aquatic ecosystem in the lagoon and serious problems of salt intrusion that even affect the fresh water 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 in particular in Asia – e.g. Mekong Delta, river basins and catchments in Cambodia and Laos and coastal Bangladesh.

Of these three cases, Vietnam and Sri Lanka have strong similarities in that they share a strong history of purposefully supported irrigated paddy development. The case of Chilika is slightly diverging, in that it does not share this strong support for irrigated infrastructure development, and is characterised by the impact of subsistence upland agriculture and forestry exploitation.

8.3 Drivers
The most commonly shared and general driver is that of a steadfast increasing population pressure 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 ever increasing need for food security and sustenance of economic livelihoods.

In the cases of the Huong River and Kirinda Oya, the respective governments have actively responded to this general pressure by investing in the development of irrigation infrastructure (both storage and conveyance) for paddy cultivation in accordance with the “Green Revolution” agricultural development paradigm. This in turn has led to more specific drivers such as agricultural intensification, agricultural colonization (in the case of Sri Lanka actively supported by settlement policy) and the general priority use of available water resources for paddy cultivation.

In both Huong and Kirinda Oya, but especially pronounced in the Huong case, the global market for and increasing demand for shrimps and other marine species has become an important driver behind the recent boom in aquaculture in these coastal lagoons. In the case of the Huong, this is furthermore actively supported by government policy directed towards accession of Vietnam to the WTO that should further facilitate and support the access of Vietnamese aquaculture products (and
others) to the world market. It should be noted, however, that 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 GAP (Good Agriculture/Aquaculture Practices) and the norms for food hygiene, may in turn provide pressure towards a transformation of aquaculture towards more sustainable and less environmentally damaging practices.

Inland fisheries, and traditionally also coastal fisheries, are primarily driven by livelihood pressures for subsistence and/or complementing household food and nutrition security. Especially in Kirinda Oya and Chilika, these are primary food and livelihood support strategies deployed by the landless and often poorer class of society. These livelihood strategies tend to be enabled (driven) by local markets for fish (products) rather than the international export markets that drive aquaculture.

In Chilika the agriculture in the catchment of the lagoon is primarily driven by livelihood support and food security strategy of the population living in the area (0.8 million in the catchment and 0.2 million around the lagoon). Contrary to Kirinda Oya and Huong, agricultural development in Chilika does not seem to have benefited from any active government support and investments for its development and expansion – most probably as a result of its designation as a RAMSAR site in 1981, from which time onwards the primary focus has been on conservation and restoration, rather than development. Nonetheless, agricultural development has taken place, primarily in two forms in the catchment of the lagoon:

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

The two principal drivers that lead to the possibly unsustainable use of forest resources in Chilika are: (i) the cashew market that leads to pressures of deforestation for cashew plantations; (ii) the consumption of fuelwood by households living in the catchment.

In the case of Chilika lagoon, the comprehensive restoration and conservation program that has been initiated in response to the drivers, pressures and state changes operative in the lagoon and its catchment, has in itself been driven to a large extent by the inclusion of Chilika lagoon on the “Montreux Record” of endangered RAMSAR wetlands, and the political and financial support to take Chilika off this list.

8.4 Pressures

In both Huong and Kirinda Oya the expansion and intensification of irrigated paddy rice constitute some of the major pressures on the river basin and coastal aquatic ecosystems that lead to significant state changes, of both the river and the lagoon. The associated water storage and conveyance infrastructure of irrigated rice, leads to the specific pressures of water abstraction, conveyancing and the consumptive and non-consumptive use by irrigated rice of the fresh water resources in the river. The historic and current priority allocation and objective for rice cultivation, and the increasing population growth, is leading in both cases to specific pressures on the available water resources in the river basin to further increase the water storage and –management capacity to further enhance the intensification of rice (both in terms of increased
cropping intensities and higher yields). In the case of the Huong river, this is leading to the further expansion of surface storage facilities through construction of new dams. In contract, in the case of Kirinda 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) for the intensification of paddy in the dry season. The pressure to intensify rice cultivation is thus in both cases leading to significant alteration of the freshwater flow regimes.

In the case of Huong, the expanding city of Hue and its concomitant increasing demand for water supply and sanitation is further increasing the pressure on the limited available fresh water resources during the dry season. Hue city, situated 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.

The exponential growth in shrimp and aquaculture in the Huong river lagoon is leading to intensified pressures on the available land and water resources – the requirements of which for aquaculture are in direct competition with those of irrigated paddy. The agricultural polders at the fringe of the lagoon are increasingly 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 lead to high incidences of disease and yield failure in aquaculture, which in turn increases the pressure on the lagoon ecosystem as aquaculture expands further and encroaches into the lagoon in search of better water quality.

In the cases of Kirinda Oya and Chilika, the coastal fisheries and aquaculture pressures on the aquatic lagoon ecosystems have primarily become an issue as a result of the state changes of the ecosystems, and its diminishing carrying capacity of fish stock, that is sought out by an ever increasing human population.

The 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 forestry resources base for traditional homestead fuel consumption to dwindle, thus further 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 sustain the food and livelihood requirements of the population.

8.5 State Changes
In both Huong and Chilika the state changes are most pronounced in the state of the aquatic lagoon ecosystems that have undergone severe degradation and shifted into a seemingly vicious cycle of diminishing resilience and further degradation. The critical aspect in both cases is a pronounced change in the hydrological balance and dynamics of the lagoons, with typical symptoms such as: (i) reduction of water circulation within the lagoon and outflow/inflow into the open sea; (ii) resulting changes in water quality – in terms of salinity (increased salinity in Huong, decreased salinity in
Chilika), and pollution (especially in Huong in terms of agricultural chemicals and aquaculture antibiotics and waste).

The direct cause-effect relations, however, differ in both cases as they stem from differing agricultural practices and agro-ecological systems:

- State changes in Chilika lagoon are primarily a result of excessive silt deposition in the lagoon that stem from erosion due to agricultural and forestry management practices in the upper catchment. The effect of siltation on decreasing water circulation and refreshment is further exacerbated by nature as it leads to a boom in aquatic weeds. Siltation, weed infestation and diminishing water circulation and salinity levels in turn lead to dwindling fish stocks and transformations of ecological habitats (sweetening of brackish environments) and species. The situation was further compounded by the effects of long-shore drift which further limited the outlet of Chilika to the sea.

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

In both cases these pronounced state – and even ecological -- changes of the lagoons lead to loss of aquatic habitat and species.

In the case of Kirinda Oya, the state changes are quite diverse and primarily two-fold:

1. The expansion and intensification of irrigated paddy has led to an increase of diffused drainage of fresh water 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.

2. In the initial stages of Kirinda Oya the newly build reservoir and tanks actually created new aquatic fresh water habitats where fish stocks and aquatic species and biodiversity could and did thrive in these so called “manmade wetlands”. However, in the present stage of further intensification of irrigated rice these freshwater habitats are threatened by excessive draw down during the dry season. This may not only threaten fish stocks and other aquatic species numbers, but undermine the resilience of the system if water is excessively drawn down, thereby no longer providing sufficient water or conditions for aquatic species to survive the dry season.

8.6 Impacts
The impacts tend to be quite diverse and context specific, in that they result from the specific bio-physical interrelations that lead to state changes and how they affect the specific agro-ecological domains on which specific sections of the population depend for their economic and provisioning needs and exploitation of natural resources. In addition, the strategies and responses that are deployed by different sectors and segments of society are often structured by their historic experiences. Nevertheless some commonalities in impact can be discerned in the situations of agriculture and aquatic resource exploitation in tropical rivers and coastal aquatic ecosystems.
Shrimp cultivation and aquaculture, as the relative “new kids on the block”, 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 to 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. This is further exacerbated by water management and governance structures that are traditionally centred around and supportive of irrigated agriculture. Whereas shrimp culture and aquaculture, though causing high impacts on water management in both quantity and quality (i.e. management of desired brackishness), tend to be individual entrepreneurial activities that impact upon and free-ride the water management arrangements of agriculture. Early adopters of shrimp culture and aquaculture are generally economic boomers that quickly form a new economic wealthy class, which enables them to further increase their individual enterprises.

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

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, who are most dependent on these provisioning services of inland and coastal waters, are thereby the hardest affected by a substantial loss in food security and livelihood provisioning. This trait is particularly evident in Chilika and Kirinda Oya, but also a common feature of agriculture-aquaculture intensification in Bangladesh, the Philippines and other coastal tropical rice areas.

In Chilika the general subsistence and semi-market (transition) agriculture is affected by high risks of yield reduction and 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 the agricultural practices as they no longer possess the means to invest in good agricultural practices. 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 fuel for household consumption.

8.7 Responses
Of the three cases used in this issue situation, Chilika lagoon is the furthest advanced in formulating and implementing a comprehensive multiple response strategy. It is important to note here, that the political will and financial support to take Chilika off the Montreaux record has been an important driver for the response to, and restoration of, Chilika lagoon. The multiple response strategy is directed towards different
elements of the drivers, pressures, state and impacts that have been governing Chilika lagoon, its catchment and its population. This strategy includes:

- 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 of the brackishness of the water, reduction in weed infestation, and rise of fish and marine stock (and subsequent fish landings by fisher-folk).
- Community based catchment development and management plans. This is directed towards: (i) sustainable agriculture and forestry management practices that reduce erosion and siltation; (ii) food and income generation for subsistence agriculture and cashew growing;
- Reforestation and forest management.
- Development and dissemination of fuel efficient stoves that reduce the demand for fuel wood.
- Food processing and natural products processing and marketing programs that enhance the livelihood means and opportunities of the agriculture and fisheries communities.
- Development of ecotourism as a supplementary economic opportunity of the aquatic ecosystem.
- Development and implementation of a Chilika Development Authority that provides integration and regulation to the common pool management strategies and support and training to the community-based natural resources use and management.

The immediate response in the Huong river case is still 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 the water circulation in the lagoon. The integration of water management for agriculture, ecosystems and aquaculture is still in its infancy, and primarily directed towards establishing governance and regulation structures. The former, is achieved by creating a cross-sectoral and inter-departmental Huong River Management Board. The latter, is sought by attempting to regulate the further expansion of aquaculture into the lagoon. Future responses may however 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 impact upon the lagoon water quality and hydrology and conforms to the high quality and environmental standards of the GAP.

In Kirinda Oya a first step has been set towards an integrated and participatory approach to devise a water management strategy that is explicitly serving 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 during the dry season, that are still 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 the water use efficiency and productivity within the irrigated rice
scheme, and that may further reduce the drainage outflow of excess freshwater into the lagoon.

8.8 Issues, Responses and Future Guidance
When reviewing the above experience, a number of common typical problem chains can be identified where a development at one stage in the DPSIR model leads to further problems at other scales. It is these problem chains which can be seen as issues, rather than the individual problems. (See Figure 8.2 below).

Figure 8.2 DPSIR linkages in tropical rivers with rice, fish, aquaculture and lagoon ecosystems

8.9 Conclusions
These three cases show the way in which catchment, or upstream activities interact with coastal aquaculture. The physical environments are similar in some broad elements, but not in details and the socio-economic conditions are diverse in many ways. As a result the agriculture-wetland interactions vary, as do the potential responses proposed to date to address these issues situations. Some lessons may be learned by one case from the other cases, but the specific circumstances make it imperative that understanding of the situation specific is achieved before proposals
are made. Hence for each of the cases, separate DPSIR analysis and diagrams (like Figure 8.2) need to be developed as the start of a process of identifying the relevant parts of the system most appropriate for action and the measures which are environmentally and socio-economically appropriate.
CHAPTER 9
Common Issues Situation 5

Integrated rice and fish culture / capture systems in South and Southeast Asian tropical river basins
David Blake, Wetland Action

9.1 Overview of Key Characteristics
The lowland societies of Southeast Asia have been described as being “rice-fish cultures”, such is the importance and inter-connection of these two basic food sources (Gregory and Guttmann, 2002). Raising fish in rice fields has been a tradition for over 2,000 years in some parts of tropical Southeast Asia. Rice-fish cultivation may be practised in rain-fed or irrigated rice fields, and both upland terraced and lowland rice fields. While certain favourable areas of lowland mainland Southeast Asia have been converted to wet rice cultivation for many centuries and have been, more or less continually, cultivated over that period, far greater areas are more marginal land which have only been converted to rice paddy during the demographic and economic boom period of the late 20th century.

It is recognised in Common Issues Situation 4 that irrigated rice systems affect aquatic ecosystems through resultant changes to water quantity (both negative from changes in flow and positive from changes in storage capacity and lagoon drainage discharge) and water quality (negative through pollutants and diminishing salinity levels in coastal ecosystems). However, irrigation systems only cover a relatively small area of the total agricultural area devoted to rice cultivation in most Southeast Asian countries.

In large parts of Northeast Thailand, Cambodia and Lao PDR, the land is typified as “complex, diverse and risk-prone” (or CDR lands) and relies on rainfall, rather than irrigation for water supply. Thus the main rice crop is a single crop during the rainy season and early part of the dry season for harvest (i.e. May – November/December period), with relatively few farmers having access to reliable irrigation water for a dry season crop. This is even the case in a relatively water-rich and high annual precipitation (1,200 – 2,100 mm) river basin, like the Songkhram in northeast Thailand, where even best estimates only show that about 4 % of the entire Basin is irrigated (Blake and Pitakthepsombut, 2006). In most lowland parts of the Lower Mekong Basin and Bangladesh, seasonal floods are as much a feature of the annual hydrological conditions as a prolonged period of low flows and water scarcity.

According to Edwards (1999), rice-fish culture has never been widespread and fish are cultured in only about 1 % of rice fields globally, and even in China, it reportedly occurs in less than 5 % of the total area of wetland rice. The line between capture and culture fisheries is blurred, as there is a wide spectrum of instances, involving different levels of management intervention and system modification, and often these low management systems have escaped attention of aquaculturists and agriculturists alike. Where significant quantities of wild fish occur, as in floodplains areas of northeast Thailand, southeast Cambodia, and southeast Vietnam, farmers are unwilling and/or unable to stock cultured fish, but prefer wild fish populations to enter
the rice fields. The fields are often modified to accommodate the entry and harvest of these wild species, which are usually considered common resources.

### 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 far more than just rice from rice fields, even where rice is the only 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, which usually migrate upstream into the rice field, and use the aquatic habitat as a temporary spawning, nursing or feeding refuge. Over 20 species of fish have been found in rice field systems in southern Lao PDR, 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 mollusks, 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; Meusch et al, 2003).

A rice field ecosystem, by definition is a simplified version of the more complex and diverse natural wetland ecosystem that preceded it, where 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 modernisation of rice cultivation focusing on maximum rice crop yield, exemplified by the ‘Green Revolution’ technologies, has tended to further simplify and compromise the multi-benefit functions and services of the modified wetland ecosystem. This has frequently come at a heavy cost to the environment and societies involved. Attempts to integrate fish cultivation can serve to increase the diversity and complexity of the original ecosystem, by creating a number of new habitats which favour greater aquatic biodiversity and can restore some wetland functions and services.

### 9.2 Case Studies

The case studies used for this common issues situation were:

i. Rain-fed and irrigated rice farming in southern Lao PDR, where three main types of small-medium scale irrigation technology can be found (weir, dam and reservoir, and pumped irrigation). These water resources were assessed in a study to find the impacts of irrigation and aquaculture development on aquatic resources, important in the livelihoods of local people, and the villagers’ perceptions of any impacts (Lorenzen et al, 2000). 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, which contribute to local diets (Meusch et al, 2003).

ii. Rain-fed and irrigated rice farming in the Lower Songkhram River Basin (LSRB) of northeast Thailand, forms part of an extensive wetland area largely converted to agricultural uses, but with significant remaining areas of natural
vegetation cover remaining, such as seasonally flooded forest, which is recognised by local people and fishery scientists to provide valuable spawning, nursing and feeding habitat for a wide range of migratory fish, not easily adapted to monoculture rice fields. Nevertheless, large quantities of fish are harvested from rice fields, both in the dry and wet seasons, but little deliberate stocking of cultured species occurs. Government policy has hitherto tended to only recognise the agricultural potential of the area, at the expense of the rich wetland resources and fisheries sector (Blake, 2006; Blake and Pitakthepsombut, 2006).

iii. Bangladesh contains extensive river floodplains and deltaic lowlands, with floods lasting several months of the year, rendering the land unsuitable for crop production. The freshwater wetlands of Bangladesh are comprised of the ecologically distinct “haor” (backswamp between levees) and floodplain areas each subject to a different management regime by local people (Ahmed et al, 2004). Integration of fish culture allows an opportunity for farmers to increase overall production in the flood-prone ecosystem. Concurrent rice-fish culture in the shallower flooded areas and 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 9.1 Agriculture-wetland interactions in integrated rice and fish culture / capture systems in South and South-East Asian tropical river basins

It will be noted that the first two case studies are floodplain locations within the Mekong Basin, while the third location in Bangladesh has similarities in that the region is flood-prone but fertile and rich in natural resources. It is therefore subject to the same kind of risks and rewards for resource users, but has a somewhat different demographic and socio-economic profile. However, similar issues tend to emerge in all three sites, as they have undergone transformation from natural wetlands to largely
human-impacted wetlands, while, because of extensive seasonal flooding, many of the aquatic resources still remain under common property regimes; unlike farm land.

9.3 Drivers
While population dynamics, economic development and competition for resources within and between sectors are generally blamed for the expansion of the agricultural frontier into natural wetland habitats across the Southeast Asian region, the local drivers for further modification of the wetland system to intensify the rice component or diversify into rice-fish cultivation are more complex. In the case of the LSRB, the population has been steadily growing over the last four decades as a result of natural growth and in-migration from other provinces, although the rate of increase in Northeast Thailand has considerably slowed in recent years due to a successful state birth control programme. By comparison in southern Lao PDR, many years of war, internal disruption and severe economic poverty meant that there was significant population decline until the mid-1980’s, when population growth picked up again and new pressures were placed on natural resources and available agricultural land. Bangladesh has experienced rapid population growth over the last five decades, rated one of the highest in the world during the 1960’s and 70’s, and estimated to be 3.09 % p.a. in 2006, while the high population densities inevitably drive acute pressure on land and wetland resources.

Although Thailand, and to a lesser extent Bangladesh, have been closely integrated into the regional and global economies for decades, Lao PDR has only rather recently opened up its borders to regional trade and aid. This regional integration has led to growing pressures on all its natural resources, especially forests (for timber, wildlife, agricultural land and pulpwood plantations) and water (for irrigation and hydropower), only ameliorated slightly by its remoteness and relatively low population densities. The Lao government has stressed the importance of “modernisation” of rice farming, leading to interventions in wetland ecosystems from irrigation system expansion and intensification of inputs. Fish raising is mostly promoted for subsistence purposes, unlike Thailand, where there is a more developed market and opportunities for reaching a wide domestic and export market have long existed for capture and cultured fish. The wild capture fisheries of the Songkhram Basin were first opened up to large-scale commercial fishing in the 1970’s and only recently has aquaculture started to become popular.

Land use and market policies have been drivers of wetland change in the case of the LSRB, but details are more limited for Lao PDR and Bangladesh. While Thai state policy has essentially encouraged the privatisation of resources, land conversion, agricultural intensification and a strong emphasis on irrigated rice, with large subsidies made available for irrigation infrastructure and agribusiness expansion; fisheries and wetland management have more or less been ignored. Limited funds have been made available for aquaculture promotion, but this has mostly focused on intensive cage aquaculture, rather than rice-fish culture or other semi-intensive technologies. Additionally, a lack of appropriate wetland policies and poor enforcement of the existing regulations were identified as key drivers of wetland destruction in the Bangladeshi case. In all cases, the natural flood-drought cycle is both a facilitator and regulator of the agro-ecosystem, limiting to a large extent the local resource user’s choices and responses.
9.4 Pressures
Farmers will adapt or modify the rice field system to accommodate fish culture or permit entry and capture/harvest of wild fish from surrounding water bodies. 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 flood retention time. The construction of irrigation infrastructure may unintentionally create new aquatic habitats favourable for fish, such as roads and canals altering drainage patterns and ponds created by borrow pits, or the construction of dams, weirs and reservoirs creating new perennial water resources that are often rapidly colonised by aquatic organisms and utilised 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 some species tend to be disadvantaged by habitat modification for rice cultivation, although the Lao case study suggests that overall biodiversity is not affected by small-scale irrigation schemes.

In Bangladesh, the farmers do not try to radically alter the environment to suit the crop, but tend to work within the natural flood-drought cycle by practising either, (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 during the flood season in an enclosed area, such as a fish pen. Thus, the natural hydrological cycle is maintained. In LSRB and Lao PDR, the state tends far more to view the flood-drought cycle as an impediment to development, and seeks to alter it through engineering interventions to even out the flow, and supply more water for rice in the dry season and ameliorate the impacts of floods in the wet season. Crop irrigation and intensification is 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 to date), while in southern Lao PDR the same policy pressures have only been evident over the last 10 – 15 years. Thus the extent of failed irrigation infrastructure is not as obvious as in northeast Thailand, where much of it lies abandoned or under-utilized. Despite this, there are new attempts to promote large scale, trans-boundary water transfer from southern Laos (seen as water rich) to northeast Thailand (seen as water deficient) for basin-wide irrigation coverage projects, including the Songkhram Basin (Blake, 2006).

9.5 State Changes
Inevitably, the conversion of natural, seasonal wetlands to 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. The areal and volumetric expansion of water sources over baseline conditions, is more critical in Songkhram and Lao PDR, while it is implied in the Bangladesh case that stresses on water resources and biodiversity come from over-abstraction for dry season irrigation of natural perennial water bodies called “beel”, suggesting a possible nett seasonal decline in overall lacustrine aquatic habitat (Ahmed et al, 2004). 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 not clearly stated in any of the cases, but is generally implied that where rice cultivation has intensified under
“Green Revolution” principles of greater external inputs, there has been a concurrent decline in water quality manifested by occasional pollution incidents, fish kills and anecdotal observations by local people that the water less fit for consumption than in former times (Blake and Pitakthepsombut, 2006).

While water is essential for fish survival, this is not the case with lowland rice which although technically a “wetland plant”, can survive periods of drying. Hence, especially with rain-fed, rice-only systems there are periods of rice field water scarcity and sometimes drought which wipe out all but the hardiest of aquatic organisms. Adoption of rice-fish culture by farmers would tend to favour the creation of new aquatic habitats, whether through digging trenches, ponds, raising bund heights, and facilitating entry of migratory species from adjacent natural waters through addition of various devices and management techniques. Ironically, rice cultivation is seen by some as a heavy consumptive use of water, but fish rearing as a non-consumptive component, affecting only quality and not quantity of water (Halwart and Gupta, 2004). This may not necessarily bear scrutiny, as fish need water constantly and by implication, more fish need more water. Thus, as fish raising systems intensify and stocking densities increase, greater water volumes and flows will be required to support the increase.

According to Lorenzen et al. (2000), wetland biodiversity may be encouraged and maintained by the adoption of rice-fish culture, with no major observed effect on natural aquatic resources in the case of the southern Laos study. However, it was observed in Thailand that pressures to increase the area of irrigated rice were directly leading to loss of habitat and biodiversity of native flooded forest vegetation, itself a vital habitat for Mekong fish species (some IUCN Red List species) to feed and complete 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 fish culture over capture fisheries.

Riverine and floodplain habitat diversity are changing at the LSRB and Lao PDR sites, 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 increasingly being replaced by lacustrine habitats, and downstream areas are becoming drier at some locations, as water is abstracted for agricultural uses. In the case of Bangladesh, large-scale conversion of wetland habitat has been blamed as the main cause of biodiversity loss and decline (Ahmed et al, 2004). This suggests that the aquatic environment maybe becoming more stressed and less able to cope with shocks.

Clearance and conversion of seasonally flooded forest habitat to agriculture in LSRB has led to soil degradation, including declining soil fertility, salinisation, increased erosion, etc. Groundwater levels have been raised and soil salts mobilised by reservoirs and irrigation schemes. Intensification of rice cultivation has encouraged greater use of chemical fertilizers, pesticides and non-native varieties of rice, causing localised pollution and further soil degradation in some instances. 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. The Lao and the
Songkhram experiences would tend to contradict one another on this point, perhaps due to differences in research approach and design. In the Bangladesh case, the point is made that rice-fish farming reduces the need to use chemicals for pest control, thus preserving a diverse rice field biota. It argues that “the presence of fish makes the rice field ecosystem more balanced and stable”, by such services as weed and insect pest consumption (Halwart and Gupta, 2004).

The potential impacts of climate change, including global warming, sea-level rises, increased ultra-violet radiation and water availability are briefly considered to be risk factors for future sustainability of rice farming in the Bangladesh case study, but in the LSRB case, although acknowledged, it is argued that there are far more immediate pressures and risks to the wetlands ecosystem of greater importance.

9.6 Impacts
Rice-fish culture, where adopted in Southeast Asia, has been widely credited with improvements in the income status, household nutrition, public health and general social well-being of communities, although solid data proving these benefits tends to be lacking. In Bangladesh, studies have shown that the net returns from the rice-fish culture were over 50 % greater than that from rice monoculture (Halwart and Gupta, 2004). By contrast, figures from Thailand indicated that profitability in the rice-fish fields was only 80 % that of rice monoculture, which was attributed to high initial investment costs in rice-fish culture. 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. The study by Meusch et al. (2003) in Attapeu Province of southern Lao PDR was an exception, providing solid evidence of the links between small-scale aquatic resources and nutritional security for rural people. Gregory and Guttman (2002) argued that it is a gross over-simplification to promote aquaculture as a means to fill the gap between declining (wild) fish production and increasing demands from growing populations, and suggested that sustainable management of the rice field fishery might provide better returns for the Lower Mekong Basin countries. 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 integrated pest management practices reducing use of chemical pesticides in the process with direct benefits to environmental and public health.

In the Lao PDR case, it was found that irrigation development caused reductions in fish abundance (but not biodiversity) in natural wetland areas (e.g. marshes and swamps) and catches declined downstream of weirs and dams. However, new opportunities for fishing were created by reservoirs and fish catches tended to increase, while reductions in seasonal scarcity of fish were noted (Lorenzen et al, 2000). Where wetland areas dried up downstream of water infrastructure, people were obliged to travel further to access fish and aquatic resources. Similarly in LSRB, it was found that villagers with more land and resources were better able to take advantage of new opportunities presented in fisheries and aquaculture, than resource poor and landless households. 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 the 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. The Lao and Bangladeshi cases do not document conflicts *per se*, but in the case of the LSRB, they are relatively well documented and may happen at the intra-community, inter-community, state - resource user and resource user - private business levels (Blake, 2006). Villagers using small non-commercial fishing gears are frequently in dispute with those using large, commercial or “destructive” gears, seen as harming the interests of the community as a whole. On the other hand, the auction of fishing rights to use these gears or claim exclusive rights to a particular floodplain lake, can provide income for the benefit of the community as whole. At the same time, there have been long and on-going disputes between fishers using technically illegal, but locally accepted fishing gears (e.g. stationary trawls) and the Fishery Department, charged with enforcing national fishery laws and regulations. A new and growing threat in Songkhram and southern Lao PDR relates to disputes between powerful private eucalyptus growing interests (tied to trans-national companies) and loss of common resources, whether capture fisheries, wetlands foraging rights or livestock grazing.

All three case studies make the point that it is local communities that are the key 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 at the regional or national levels. It has either involved tokenism or has only rather recently been recognised by state institutions as being worthwhile or valid form of governance. 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 a large rice farmer turns to fish culture or intensifies rice farming, he/she is in a way enclosing a former common pool resource and privatising it, where previously the aquatic resources were often shared between many users.

### 9.7 Responses

Responses can be considered at several different levels, depending on the actor involved and perceptions towards the wetland or farming system in question. There are both commonalities and differences between the case studies. Governments on the whole tend to be relatively unresponsive to the needs of diverse livelihood wetland users and the unique characteristics and economic potential of wetlands ecosystems. They vary in their recognition of and responses to the wetlands, often with stark differences of opinion between ministries and departments. This is highlighted by such instances as the Songkhram Basin, where the Office of Natural Resources and Environmental Policy and Planning (ONREPP) wants to propose the LSRB as a future Ramsar Site, while the Department of Water Resources, under the same Ministry of Natural Resources and Environment has been actively pushing for a massive trans-boundary water transfer scheme to bring water from Lao PDR into the Songkhram and other river basins of NE Thailand. These differences expose fault lines between more traditional dominant sectoral developmental paradigms, with more contextual and pluralistic approaches, that are steadily getting better recognition in Thailand.
In southern Lao PDR, the government has apparently recognised the results on irrigation impacts from the 18 month study 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 Lao provinces. This helped coordinate research and development efforts between provincial agencies, with a strong link to the Department of Livestock and Fisheries at the national level. A follow-up research project funded by DFID 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 Lao PDR and the wider region.

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. Halwart and Gupta (2004) contend that “Bangladesh is one of the few countries actively promoting rice-fish farming and pursuing a vigorous research and development programme.” NGO’s would appear to be at the forefront of efforts to extend rice-fish culture, such as 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 Songkhram case, numerous initiatives were undertaken to coordinate research, unite common interests between diverse state and non-state institutions, build capacity and promote awareness of wetlands ecosystem management and biodiversity value, through the LSRB Demonstration Site of the Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme (MWBP), between 2003 and 2007. The MWBP was able to effectively coordinate between local, provincial, national and regional bodies, leading to a much greater recognition of LSRB wetlands in planning, including the proposal to include it as a possible future Ramsar Site. Other key activities included the community-led Tai Baan Research for understanding and addressing fisheries and NRM issues; an Intermediate Environmental Flows Assessment and various youth and school conservation activities, centred around wetlands.

**9.8 Issues, Responses and Future Guidance**

When reviewing the above experience, a number of common typical problem chains can be identified where a development at one stage in the DPSIR model leads to further problems at other scales. It is these problem chains which can be seen as issues, rather than the individual problems. (See Figure 9.2 below).
9.9 Conclusions
Rice and fish are fundamental components of farming systems and diets in many South and Southeast Asian nations, including those of the three case studies considered. They create a system of wetland use which is sustainable and strikes a balance in terms of provisioning and regulatory 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 rain fed, deepwater and irrigated systems, which provide suitable environments for fish and other aquatic organisms. The real and potential impact of rice-fish cultivation and general utilisation of living aquatic resources from a rice field in terms of improved income and nutrition is significant but generally underestimated and undervalued. Yet despite the potential,
the uptake of more management-intensive forms of rice-fish cultivation has generally been low in most countries, although 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 play an important role in providing certain other ecosystem functions and services, including (but not limited to) 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 over the natural, pre-agricultural state wetland is uncertain. However, the key socio-cultural role of both rice and fish cultivation and consumption to the lowland societies of the region should not be overlooked.

The three case studies considered provide some similarities, but as many differences in the drivers, pressures, state, impacts and responses existing at each locality (as broad as they are), and it is somewhat difficult to typify based on the limited references. While Thai state agencies traditionally have tended to attempt to adapt the environment to the crop (whether plant or animal), there is some evidence to suggest that in Bangladesh there is a more sympathetic view towards adapting the plant or fish to the local environment by state agencies involved, avoiding some of the more serious impacts happening in other countries. Such variations emphasise the importance of understanding the policy environment and sensitivity of government before any discourse about wetland use systems is begun and response proposals made.

Typically in the past with single sector agencies (usually irrigation oriented) dominating state-led water management interventions in developing countries of the region, there has been little role for more multi-disciplinary and holistic approaches to water management that would recognise the importance of living aquatic resources in the livelihoods of small-holder farmers. There is evidence that this situation is starting to change in all three cases considered, where state agencies are starting to take an interest in the role of living aquatic resources in the livelihoods of the poor; create new implementing and research institutions (such as RDC in Lao PDR) which cross traditional governance barriers to be more farmer-focused; and rice fields are being recognised as being more than single-product environments. Multi-product outputs of rice-fish systems, providing services and valuable ecosystem functions throughout the year even in non-irrigated, rain fed paddies are being recognised, allowing more flexible strategies to water management which can provide win-win situations to the resource users, product consumers, communities and wider environment.
CHAPTER 10
Response Scenarios

10.1 Introduction
Chapter 3 provided an initial review of the DPSIR data concerning responses (R). The data used in Chapter 3 was aggregated from the database, with most individual cases having multiple actors and multiple responses, and with one or more DPSI elements being addressed in each case. In this chapter, an attempt is made to take a more holistic approach to responses, recognising that they have these three constituent parts – actors, response mechanism and DPSI element addressed, and that these interact with each other. Hence, it is better to conceptualise a response as being a combination of parts or a scenario. Further, response scenarios are situation or context specific, with particular facilitating or retarding circumstances. Having a favourable context, as well as involving the actors and addressing the relevant DPSI elements appropriately, is vital for response success.

The focus in this Chapter is on trying to identify types of response scenarios that have been implemented and which 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 as the data is limited. Nonetheless, this chapter provides an exploration of responses which have been used in different situations and so provides some ideas to be developed in the next stage of the GAWI work.

10.2 Responses in the Context of the DPSIR Analysis
The DPSIR model has shown links between:
- Drivers of change,
- Pressures which lead to state changes,
- State changes which can undermine regulatory and provisioning services, and
- Impacts of various socio-economic dimensions, including provisioning services and conflicts.

In addition there are numerous feedback mechanisms which often reinforce changes.

This understanding points to the potential need for response scenarios to operate on several DPSI elements. The reality, as shown in Chapter 3, is that there are often responses to more than one element in a case, but the bulk of these responses are on State Change and then on Impacts and Pressures identified by the DPSIR analysis. This tends to suggest that for the most part the responses are coping mechanisms, trying to address the symptoms of the situation rather than the underlying drivers which are creating the agriculture-wetland interaction (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 international terms of trade, or government policies, or poverty
which have been driving the use of wetlands for agricultural purposes. Hence, an initial point to make for this response discussion is that there is a need to pay more attention to addressing the drivers of change and seeking to redirect drivers to produce more beneficial agriculture-wetlands interactions where the balancing between provisioning and regulating services is achieved.

However, it is also important that the response scenarios consider all of the elements in the AWI situation, as shown by the DPSIR analysis, so that the results from the drivers in terms of pressures, state changes and impacts, and the feedback mechanisms which they set up can be addressed. Given that there is often a need to address the situation quickly, it is important to address the pressures and state changes, and ameliorate negative aspects of these rather than waiting for work at the policy level to address drivers feeds through.

In particular, 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 issues are being addressed. Agriculture cannot just be displaced or greatly reduced without consideration of alternative incomes or livelihoods. Further, the conflicts which can be created between interest groups through agricultural development in wetlands, especially in less developed countries where marginalisation may occur, also need to be addressed to ensure sustainability.

Further, given that all DPSIR elements need to be considered, it is important to involve all stakeholders, as they may have different roles to play with respect to different elements. An open and participatory approach could help address this, giving different stakeholders a say in decisions, and ownership over measures, being applied.

### 10.3 Characteristics of Response Scenarios

In order to make the response scenario analysis proposed above, all 91 cases were studied separately. This showed that 62.6% of the cases had responses of some sort attempting to address the AWI situation. Of the others, 6.6% showed some evidence of an established sustainable use regime, usually because of a low intensity and subsistence forms of agricultural use. In contrast, there was evidence of on-going and increasing agricultural exploitation in a similar 6.6% of the cases, without any explicit reference to consideration of the AWI situation.

#### Table 10.1: Reaction to AWI Situations by Ramsar Region

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>Europe</th>
<th>Oceania</th>
<th>N. Am.</th>
<th>Neotropics</th>
<th>Asia</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responses</strong></td>
<td>57</td>
<td>10 (90.9%)</td>
<td>7 (70%)</td>
<td>10 (90.9%)</td>
<td>5 (45.5%)</td>
<td>12</td>
<td>13 (52%)</td>
</tr>
<tr>
<td><strong>Existing Sustainable Use System</strong></td>
<td>6 (6.6%)</td>
<td>2 (20%)</td>
<td>3 (27.3%)</td>
<td>1 (4%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>More Agric Devt</strong></td>
<td>6 (6.6%)</td>
<td>6 (24%)</td>
<td>1 (10%)</td>
<td>1 (9.1%)</td>
<td>3 (27.3%)</td>
<td>22</td>
<td>11 (47.8%)</td>
</tr>
<tr>
<td><strong>No Resp/No Info/Proposals</strong></td>
<td>22 (24.2%)</td>
<td>1 (9.1%)</td>
<td>1 (10%)</td>
<td>1 (9.1%)</td>
<td>3 (27.3%)</td>
<td>11</td>
<td>5 (20%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>91</td>
<td>11</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>23</td>
<td>25</td>
</tr>
</tbody>
</table>
For the remaining 24.2% of the cases there was no information about responses or else there were only proposals made for action, rather than any report of practical or policy measures being taken (see Table 10.2). (These types of proposals were all similar to the ones covered in the 62.6% of cases with responses.)

The regional nature of this 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 and to a lesser degree Africa and Asia. This is partly a function of the cases which were found, and the degree of reporting on responses, but it is also a reflection of the different levels of awareness of AWI situations and prioritization of these issues relative to other national issues – such as poverty and economic growth, and the differences in the resources available to address them. The relatively recent development of pressures on wetlands in Africa is reflected in the fact that this is the only Ramsar region with cases which show increased agricultural development of wetlands, irrespective of sustainability and environmental issues. Existing sustainable wetland use systems refer to systems which are of long standing and where no pressures are reported to exist. These are mostly found in the less developed countries, including Papua New Guinea and Micronesia for the cases from Oceania.

Where there were responses, these were analysed along with the initial DPSIR analysis presented in Chapter 3 and additional information on the checklists. These were then grouped into four categories which had some commonality of approach, focusing on conservation, water resource management, balancing of conservation and sustainable livelihood development, and market / financial mechanisms. For each of these types some generic characteristics can be identified as is given below, although it must be recognised that there are considerable variations within the groups. In addition, there are some elements of several approaches in one case and overlaps between the groups in the cases where responses from different groups were applied together.

**Table 10.2: Response Scenarios by Ramsar Region**

<table>
<thead>
<tr>
<th>Category</th>
<th>TOTAL</th>
<th>Europe</th>
<th>Oceania</th>
<th>N. Am.</th>
<th>Neotropics</th>
<th>Asia</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation</td>
<td>19</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>33.3%</td>
<td>90%</td>
<td>28.6%</td>
<td>20%</td>
<td>20%</td>
<td>33.3%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Livelihood Devt &amp; Cons</td>
<td>19</td>
<td>1</td>
<td>1.8%</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>33.3%</td>
<td>5.7%</td>
<td>14.3%</td>
<td>40%</td>
<td>60%</td>
<td>25%</td>
<td>61.5%</td>
</tr>
<tr>
<td>Water Res. / River Basin Planning</td>
<td>15</td>
<td>4</td>
<td>57.1%</td>
<td>3</td>
<td>30%</td>
<td>33.3%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>26.3%</td>
<td>26.3%</td>
<td>40.6%</td>
<td>30.0%</td>
<td>30%</td>
<td>33.3%</td>
<td>4</td>
</tr>
<tr>
<td>PES / Mkt / Financial</td>
<td>3</td>
<td>1</td>
<td>1.8%</td>
<td>1</td>
<td>10%</td>
<td>1</td>
<td>8.3%</td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>20%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>1</td>
<td>8.3%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.8%</td>
<td></td>
<td></td>
<td>1</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Responses</td>
<td>57</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>
Table 10.2 shows that there are two leading response groups Conservation and Livelihood Development and Conservation. The Conservation group (33.3%) includes various cases where protecting or enhancing the natural state of the wetlands, or the human created biodiversity or landscape created in a wetland is sought (as with fen meadows and inland fish ponds in the latter two cases). In most cases, such action is led by the state, with or without some degree of involvement of local or international NGOs and with varying degree of community engagement. Some of these cases include the development of ecotourism to create new economic drivers, but this is not explicitly stated in the majority of these cases. The majority of these cases involve the creation of new drivers, such as subsidies on 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 which had encouraged wetlands cultivation and drainage. In some cases there are incentives through increased benefits from ecotourism, or harvesting / fishing / shooting benefits, although the latter three benefits are more common in the next group. 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 group (33.3%) 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 other words a balance is sought in wetland land use in terms of the ecosystem services and sometimes in terms of the distribution of benefits amongst stakeholders. This group includes five cases (8.8%) which explicitly try to address wetlands and their catchments in an integrated manner to improve the hydrological functioning of the system and hence the sustainability of agricultural land use in the catchments and in the wetlands. This produces a better functioning landscape without the alienation of wetlands from the community for conservation use alone, and 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. In these cases there are often specific technical measures to address state changes caused by management practices in the wetlands and catchments, as well as to support income generation benefits from semi-conserved wetlands, such as fishing, reed-based crafts, and duck shooting. In some cases these initiatives may involve clarification of community rights to wetlands to reduce excessive exploitation caused by open access and to encourage communities to better manage wetland resources.

The third group is Water Resource and River Basin Planning (26.3%). This involves a focus on the hydrological systems, usually a river basin, and so focuses more on the larger spatial units, rather than individual wetland sites (and catchment) with in situ management – which is often the focus in the above two response groups. The water resources approach attempts to introduce innovations to manage a river basin in a way which recognises 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 re-balancing 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 group usually includes legislative and institutional development measures to establish management organisations, as well as water allocation arrangements to achieve a more balanced use of water, often with financial incentives to encourage the more efficient use of water. Technical measures are often applied in these cases with respect to water use.

**Payment for Environmental Services / Financial / Market Mechanisms** (5.3%) is the last specific group. It includes three cases where there are a range of financial mechanisms – charges, markets and subsidies, which act as new drivers to influence land use and water management in wetlands and their catchments. The experience is difficult to generalise about but seems to suggest that there is a need for some agreement amongst stakeholders of the need for ecosystem regulating and support services related to wetlands to be better valued or valued in new ways and payments made for these to achieve improved management. To date there is only one case of payment for environmental services – for catchment management, one case of tradable water rights and one case of subsidies 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 Ramsar region, with the dominant approaches being 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 with conservation and water resource management each accounting for a third of responses, and livelihood development and conservation accounting for 25%.

These variations in responses are partly due to socio-economic conditions with the richer countries of Europe, and New Zealand being able to afford to pay for wetland conservation, or use financial mechanisms to achieve wetland land use change, while in many of the cases from Africa, the Neotropics and Asia there is a need to focus on livelihood development to address poverty issues. The case of sustainable livelihood development and conservation in North America is due to the linkages between the duck lobby and farmers to create wetland conditions which can give increased benefits for both ducks and farmers. Other important regional patterns are the importance of financial mechanisms in Europe (20%) and North America (10%), conservation in Asia (33.3%) and Oceania (28.6%), and Water Resource Management in North America, Asia and Africa (all over 30%).

**10.4 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 which facilitate or constrain them, a number of cases of each type of response are elaborated in this section.

**10.4.1 Conservation**

**Lake Kolleru, India**

This appears to be an extreme case of removal by government agencies of non-conservation land uses, namely 31,000 acres of fish ponds, from the lake and its wetlands to encourage the return of migratory bird species after 17 years of absence. Some alternative land has been made available for a small percentage of the people
removed from the lake, while others have been given training opportunities for non-farming/non-fishing enterprises.

Uganda Wetlands Policy
Uganda has a strong wetland policy which seeks to move the country from wetland conversion to wetland conservation. This goal has come about as the result of major destructive uses in wetlands, associated with rice cultivation and grazing, amongst other agricultural activities. It is interesting that in the two cases from Uganda, while both recognise the national wetland policy and the search for wetland conservation, one recognises the limits of the policy given the intensive agricultural use of wetlands and shows how response interventions have to include livelihood development, with wetland conservation measures being applied in limited areas mainly to prevent extreme degradation due to bankside cultivation.

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

Te Waihora / 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 – Ngai Tahu. There has also been a decline in the local fish stocks and potentially negative implication for tourism (for fishing and duck hunting). Recognising these negative development and their implications a Trust was set up to articulate local stakeholders views and to develop, with the Department of Conservation, a Joint Management Plan.

10.4.2 Livelihood Development and Conservation
USA Wetlands for Ducks
Initiatives from the NGO Ducks Unlimited (DU) in North America has sought to combine the interests of farmers and the duck conservation / shooting lobby in innovative ways. With respect to rice cultivation in the USA, DU is working with the Rice Growers Federation to develop hydrological regimes which suit the ducks - stable winter water levels, and which 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, where a change to the water management regime and the hay harvesting practices has allowed more hay to be obtained while also there have been higher water levels in parts of the marsh to allow ducks to breed. Other wetland maintenance and rehabilitation activities in the USA has been facilitated through a combination of government policies such as the Clean Water Act – which prevents the filling in of wetlands, and the Food Security Act which withholds subsidies 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 organisations, usually NGOs, are working with communities to improve the livelihood benefits they can obtain from wetlands in a sustainable way and also
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 South African government’s Working for Wetlands Programme which is trying to re-establish wetlands which have been lost so as to improve the functioning of the national hydrological system. Another case of note is how in Ethiopia another local NGO is involved in supporting communities to resist government policies which encourage complete wetland transformation, and instead are trying to generate a better balance of catchment and wetland farming which can maximise benefits from the overall natural resource base.

**Esmeraldas Province, Ecuador**

In response to extensive destruction of mangroves caused by immigrants engaged in fishpond production of shrimps and the negative impacts which this had upon the “indigenous” population’s gathering economy based on cockles, crabs and fishing, a mangrove reserve was created. This has given clear rights to the “indigenous” population and reduced the pressures upon 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, NGO’s, 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 with more bottom-up development approaches. Tanguar haor and Sundarbans have been declared as Ramsar sites. IUCN Bangladesh Country Office, in collaboration with Ministry of Environment and Forests and UNDP, plus three national NGO’s has implemented a “Community-based Haor and Floodplain Resource Management Project” in five degraded areas. Responses have focused on both capture and culture fisheries. More attention is being paid recently to developing rice-fish culture systems that are in tune with the flood-drought cycle, and don’t seek to alter the environment, yet improve household livelihoods, e.g WorldFish initiatives with local partners and Care-Bangladesh promoting rice-fish farming as an integral part of its IPM strategy.

10.4.3 Water Resources and River Basin Planning

**Environmental Flows in Australia**

As a result of increased environmental awareness in Australia, and especially the government’s adoption of Ecologically Sustainable Development as a guiding principle in ----, there has been increased awareness of the damage to wetlands as a result of irrigation water off-take 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 to allow the retention of sufficient water for environmental flows which 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 interests, and continued resistance from the irrigation industry.
Jewel Project, Haejia-Nguru Wetlands, Nigeria
Basin water resource planning and management was originally introduced, more than 20 years ago, in order to improve irrigation development in the area. However, poor design and maintenance led to sedimentation and weed build up in channels. This is now being addressed through a more participatory approach and is trying to create a hydrological system which also addresses the need for environmental flows to maintain wetlands.

Canadian River Projects
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 which include wider participation and include the needs of the environment and through that recreational interests in the generation of water resource / river basin planning.

10.4.4 Market, PES and Financial Mechanisms
USA, Deschutes River
Due 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 they created a system of water rights which could be transferred or leased, allowing holders of water rights to be compensated for not using their full allocation. They also developed target flows for habitat restoration and wildlife 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 NGO working with the local government to fund catchment rehabilitation through voluntary contributions from the tourism industry which will benefit from improvements to lake and wetland ecology.

10.5 Response Scenarios and Facilitating Circumstances
The overall picture which emerges from studying the individual response scenarios is that in most cases there are a combination of country or site specific factors which have made particular responses feasible or led to responses being implemented. These multiple factors may relate to public awareness and support, community motivation and local organisation, government policies, national or higher level legislation, resources available for actions with respect to wetlands, and interest from international agencies, INGOs, and national or local NGOs or interest groups.

The dominance of the “Conservation” responses in Europe is very much influenced European Union legislation, especially in the cases from the new EU members. However, this builds upon national interest and legislation in many countries, with public concerns and national lobbies interested in wetland, biodiversity and bird conservation. Ecotourism is mentioned in many of these cases as ways of generating additional funds to meet the opportunity costs of land use change in wetlands 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, subsidies to
farmers or other ways in which the drivers for wetland transformation and exploitation through agriculture are redirected towards more conservationist uses and technical measures applied to achieve conservation goals.

Conservation in other high income countries, such as New Zealand and North America, is also the result of similar state, community and interest group actions with subsidies and state funding important. In the cases of conservation in lower income continents there is more involvement in support of the state or even local communities from INGOs or local NGOs, although the Indian government and state governments are reportedly funding directly some quite “rigorous” conservation measures in lake wetland due to the ecological importance of these areas.

In Africa, and other lower income continents, the major responses are “Livelihood Development and Conservation” due to the considerable and diverse uses made of wetland by communities for provisioning services and the inability of displacing large populations without political implications or major costs. In these cases there is often a combination of local or international NGOs working with community initiatives with varying degrees of government involvement. Several cases in North America show the conservation and recreation lobby Ducks Unlimited working with farmer groups to try to create win-win situations, where farmer and interest group benefits coincide, and with government policies and subsidies often contributing to these initiatives.

Water resource and river basin planning usually involves government leadership but this may have different sources of stimulation. In Australia, the government policy of ecologically sustainable development, local wetland / conservation interest groups and concerns about water management in the drought affected areas have created conditions where discussions about re-establishing environmental flows was easily taken up. The same is true in some respects in Canada, but community interests, especially recreational concerns have also been important there. In Asia and Africa water resource 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 “Market, PES and Financial” are very diverse being found in the USA, the Netherlands and India. They appear to be the result of very different stimulating circumstances – water shortages and farm income pressures, flooding and EU agricultural policy changes, and sedimentation / pollution respectively, and different responses initiators, these being communities, the state and an INGO. These represent new initiatives which 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 links between community groups and an INGO, and in the USA a combination of pressures which could not be met in traditional ways.

10.6 Conclusions
In order to achieve sustainable agriculture – wetland interactions, a better balance between provisioning and regulating services in wetlands is needed. This can be achieved by a rebalancing of the drivers, as well as by interventions with other of the elements identified by the DPSI analysis to ameliorate pressures, reduce state changes and address socio-economic conflicts and marginalisation.
The Conservation group of responses seeks to completely displace agriculture and return to more natural conditions, or to specific biodiversity and landscape conditions associated with low intensity use of the wetlands. Such changes have to be financed either by government or other agencies, or through the generation of new incomes such as ecotourism or wise use gathering activities. Otherwise the costs fall heavily upon people who are displaced and whose livelihoods are destroyed.

The three other groups of responses are more concerned with achieving the better balance in use of eco-system services in wetlands and sustainable agriculture – wetland interactions. One way of looking at these is to focus on the approach rather than the activity, with these being community development in the case of Livelihood Development and Conservation, planning in the case of Water Resource Management, and payment for previously unpaid environmental services in the case of the Financial ones.

While these four response groups have different characteristics, they all include similar elements with institutional development and organisation management central to all – be this at different scales, technical measures applied on the ground – but for different aspects of water, wetlands and agricultural management, and with leadership and awareness raising a pre-requisite for these actions. For these responses to be successful, they need to be sensitive to the wider circumstances they are operating in, be this poverty and food insecurity, market pressures, environmental lobbies and interest groups, water shortages, income diversification needs, and the like. Hence, when considering responses to AWI situations, while lessons may be learned from study of global experience, the choice of specific measures has to be case specific.

Hence successful response scenarios are likely to need to have five characteristics:

• they must be multi-element, addressing several or all elements of the DPSI analysis in an AWI situation, including feedback mechanisms;
• they must seek to redirect drivers to reduce the negative results which occur, especially through reducing the prominence of use of one ecosystem service or activity,
• they should involve stakeholders in an open and inclusive process, so that the skills and contributions of the different groups, organisations and individuals can be utilised,
• they should address both in situ or site issues and basin level issues, and
• they must be suited to the situation – responding to facilitating factors or overcoming bottlenecks.

Overall they must achieve a more sustainable balance between socio-economic / poverty reduction and ecological needs in wetlands which allows sustainable use of wetlands for multiple ecosystem services for the benefit of society.
CHAPTER 11

Ways Ahead

11.1 The Aims of the Guidelines
The goal of the GAWI initiative is to support the development of “sustainable agriculture-wetlands interactions” that effectively manage and reduce the negative impacts associated with the use of provisioning ecosystem services in wetlands and thereby ensure the maintenance of the regulatory and support services in these ecosystems. This is vital at the present point in time as the CA points out the potential growing demand for food and the increasing demands for water with which to provide this. Indeed the drivers of change – population and economic growth, are likely to remain for several decades and the demands for increased economic output and food production are set to continue to grow substantially for the next thirty years with the expectation that more wetlands will be impacted upon negatively.

These predictions, along with the analysis in this volume, confirm that the key issue is the over-exploitation of the provisioning services at the expense of the regulatory and support services. This imbalance has implications for the medium and long-term sustainability of the wetland agriculture and aquaculture, and in the short-term for the regulatory and support ecosystem services of wetlands. The analysis suggests that the way ahead has to involve a rebalancing of the way the ecosystem services are being used. This must ensure that the provisioning services are not exploited to the state where the regulatory and support ecosystem services are undermined with negative in situ and downstream consequences in terms of flood control and hydrological system functioning. Further, these regulatory and support ecosystem services need to remain functioning in order to maintain the provisioning services.

11.2 Conceptualising Ways Towards Sustainability
To restore the balance between the different ecosystem services, and progress towards the objective of sustainability in agriculture-wetland interactions, rather than seeking solely wetland conservation, it is necessary to undertake activities at different scales, in situ - within a wetland site, and basin wide - including catchments and wetlands.

11.2.1 In situ Ways Ahead
Within a wetland, where agriculture is present, a better balance of ecosystem services, can be obtained by using some or several of the following set of options:
   a) limit or reduce the “over-drive” provisioning service to permissible “ecologically” sustainable levels;
   b) diversify into other provisioning services that the wetland ecosystem can provide so as to reduce the pressures created by one use being excessively dominant – often agriculture / aquaculture;
   c) restore regulating, supporting and cultural services in wetlands, and exploit their economic benefits; and
   d) some combination of the above.
a) Reducing Provisioning Over-Drive

In this case the aim is to reduce the demands on the wetland from provisioning services so that the alterations / damage to regulatory and support services are reduced to a level where they can function satisfactorily. This is effectively a “trade off” between one set of ecosystem services and another, and may be seen in the changing spatial pattern of use in the wetland - with areas reverting to more natural conditions to sustain wetland regulatory services. In terms of human welfare this could lead to a reduction in the total livelihood benefits, unless there are changes in the provisioning use in parts of the wetland which lead to higher productivity and higher value production, without damaging regulatory and support services as a whole.

This sort of response is typical of some of the Livelihood Development and Conservation response scenarios outlined in Chapter 10. Assuming that the correct balance can be found, this response can lead to a sustainable utilisation regime and the continuation of provisioning, regulatory and support ecosystem services. If improvements cannot be achieved within the provisioning services this might require people and economic activities to be relocated to allow more conservation within the wetland to maintain regulatory services.

b) Diversify into Other Provisioning Services

This is effectively another type of trade off, which in practice is often linked with the previous one. As mentioned earlier, problems in wetlands are often caused when one use, usually cultivation, becomes dominant at the expense of others, such as capture fishing, gathering or grazing. Rather than just reducing the one dominant provisioning activity, as is proposed in (a), an alternative is to develop a new pattern of livelihood uses, with a number of provisioning services, which are more ecologically suitable and can help maintain regulatory and support services with a different, but hopefully higher total value of provisioning output. Such multiple use regimes are often found in “traditional” sustainable use wetland management regimes, although the level of income which they can support in those situations is usually low. A further concern is that such more ecologically suitable provisioning services are rather limited – fishing, gathering, natural material crafts activities etc, and they have limited markets and income potential. In addition, there are major issues of regulation arrangements for such common pool resources.

One other point to address here, is that there may be socio-economic impacts from these option proposed in a) and b). This is because the limitation and diversification of provisioning services equates, in most cases, to a reallocation of the benefits from natural resource use between different sectors and users (e.g. crop – fish – livestock) and may well involve tensions and conflicts, especially where overall livelihood benefits are reduced.

c) Exploiting Economic Value of Regulatory, Support or Cultural Services

In this case there is an attempt to increase non-provisioning benefits from wetlands as a way of compensating for reduced provisioning activities. Rather than diversifying within the provisioning service sources of income, this approach looks for new non-provisioning sources of income, with payments for wetland environmental services, such as flood attenuation, ecotourism, or recreation. These, it is proposed, can replace the income from provisioning sources. In addition, income can be obtained by actively and explicitly valuing and rewarding other beneficial ecosystem services that
have traditionally not been valued and rewarded in the production and food economy, such as water regulation and purification, biodiversity and carbon sequestration. (There are major practicalities in such proposals and these are discussed below in 11.3).

11.2.2 Basin Level
At the catchment and basin scale, specific trade-offs between provisioning and regulatory services will also be needed, along with overall water resource and land management and planning. Sustainability at the basin level can be increased by explicitly managing the up- and down-stream interactions between production systems and wetland ecosystems, concentrating on minimizing negative impacts and mitigating strategies. This can involve a number of measures.

a) Strategic and Functional Choice
A strategic approach at the basin level could involve allocating parts of a basin for provisioning services and other parts for regulatory, or other non-provisioning, services. This is effectively a basin scale land use strategic plan which is based upon an understanding of the hydrological and ecological functioning of the basin. This provides a basis against which provisioning services can be developed in ways which are most sustainable and cause least damage to ecosystem functioning and regulatory services especially. The issue of practicalities enters very much at this step, as it does in most of the other measures proposed here as there are in most basins pre-existing land and ecosystem uses which are not located in the most appropriate location, while in some basins the level of development is such that there is no room for re-establishing natural areas to support non-provisioning regulatory services.

As a result, re-balancing ecosystem services, especially at the basin level, therefore inevitably entails a re-balancing and re-allocation (i.e. transfer) of ecosystem services benefits (i.e. value) between sectors, and between users (i.e. stakeholders). This requires difficult political choices, guidance, and where possible economic regulation and compensation between beneficiaries and ‘losers’ across sectors and across ecosystem services – whether these are represented as groups in society at large or as individual economic enterprises. No straightforward guidance can be provided in these matters, as they represent difficult society specific choices and negotiations that need to be conducted.

b) Minimised Better Management of Production Systems
Pressures upon wetlands can be reduced if agricultural production systems both within the wetland and elsewhere in the basin are improved using good agricultural practices (GAP). These will reduce the negative impacts on wetlands and still allow for production maximisation. Key goals here are to reduce the negative consequence for regulatory services in wetlands from cultivation and the minimisation of negative impacts in wetland from upslope cultivation through sediment deposition and accelerated runoff. In some cases there may be a need to consider whether crop combinations, and especially specialisation, should be reduced.

c) Revitalisation of Regulatory Capacity of Agricultural and Natural Ecosystems
GAP can help improve water storage in catchment, water infiltration and improved hydrological functioning in the catchment and which can in turn benefit wetlands.
Revitalising the regulatory capacity of the catchments can have positive effects on the operation of the wetlands.

d) Exploiting Non-Provisioning Ecosystem Services
To assist in the process of shifting the balance in ecosystem services within a basin, it will help if non-provisioning ecosystem services can be developed and systems of charging for these to reward those who provide them. These include measures such as flood control and water purification, but they can include nature conservation and ecotourism which can generate payments.

e) Supplementing Wetland Incomes from Off-wetland Activities
A basin approach directs attention for income generation outside the wetland. Rather than seeking increased or alternative incomes from the wetland, farmers there may be able to reduce their demands upon the wetland if they are able to obtain supplementary income from elsewhere in the catchment or river basin. Indeed it may be possible to divert both poor and better off households from seeing wetland conversion as their preferred option to address their survival and accumulation livelihood strategies.

These basin level measures should be seen as trying to improve the functionality of the river basin as a whole in terms of total productivity and income generation, whilst maintaining regulatory and support ecosystem services.

11.2.3 Combining and Prioritizing
Both in situ management and basin level management need to be used as response measures. However, the precise combination of measures will depend upon the specific situation, facilitating and limiting factors and the findings of the DPSIR analysis undertaken. A key element in the analysis to identify the appropriate combination will be the relative importance of the different ecosystem services in that specific case. Inevitably there will be a need for trade-offs between wetland transformation and loss of ecosystem services to meet livelihood needs. For instance at the basin level it can involve identifying which wetlands are essential for maintaining the hydrological functioning of the basin and which can be transformed in part or completely. At the site specific, in situ, level this can explore the balance between wetland cultivation and non-conversion uses which are needed to sustain ecosystem services.

11.3 DPSI Changes for Rebalancing Ecosystem Services
All these options try to maintain income from wetlands for farmers, but do this in different ways in order to facilitate increased regulatory or support services from wetlands. In exploring how to implement these options it is necessary to look at the drivers, other PSI elements, and facilitating factors which need to be altered if successful change is to be achieved.

a) Changed Provisioning Services
Responses in terms of changed provisioning services (in 11.1a & b) will require investment at policy level (to agree necessary payments) and technical support to make them attractive. They should include incentives for converting agricultural uses into good agricultural practices (GAP) and ecological capacity practices. Increased productivity, within the permissible exploitation level, will require investment in
technical measures such as more efficient water use, and higher value crops and their marketing.

**b) Multiple Use Lessons**
In order to achieve greater benefits while ensuring wetland use stays with the resilience level of the ecosystem and ensures that ecosystem services are maintained, it is thought that multiple, rather than single, use is more appropriate. Specific better management practices which can be found from existing cases of wetland use may include:

- Farming practices, aquaculture practices,
- Crop choice, fish species choice,
- Increased water use efficiency, and
- Positive enterprise combinations, such as fish and rice, or rice and ducks.

c) **Redressing and Re-allocating Provisioning Services**
Policy responses are also needed in order to redress and re-allocate provisioning services (take away perverse incentives for overdrive), provide new incentives for diversification, institute limits on wetland use and design and apply regulations.

d) **Payment for Environmental Services**
The “new economy” of valuing and introducing monetary compensation for non-provisioning ecosystem services (11.2d) is still in its infancy and most successful cases of PES are based on the principle of cost avoidance – e.g. revitalizing regulating services of ecosystems is cheaper than the technological alternatives of water purification or refurbishing the dykes. The challenge is to get the ecosystem services compensation (d) actually accrued at the local state level, compensating local users and managers for their sustainable use and management, as well as compensating losers in the restriction of the overdrive provisioning service, and as a means of financing redress and rebalance of economic use.

11.4 Beyond – national policy and international principles
However, it is increasingly clear that achieving the sustainable use of wetlands needs more than site specific technical fixes, or basin level planning and management. It is clear that there is a need for a wider understanding of wetlands within the development process, within the market transformations in Eastern Europe and beyond, and within the post-development processes of the west, which include the rehabilitation of wetlands for water management purposes. Hence, there is also the need for nation level analysis of policies which seek to address poverty and development issues in ways which meet people’s needs and aspirations without driving the poor, or encouraging the rich, to convert wetlands to the extent that these areas loose their ability to provide ecosystem services. It has to be recognised that the wetland “losses” reported in the MA are often driven by the failure of development, by the approach to, and nature of, development and by socio-economic and political processes in the countries concerned. Drivers in this area include population growth, local urban markets and global markets. These socio-economic, economic and political areas need to be engaged with and addressed to ensure the future of wetlands in diverse situations and the maintenance of wetland ecosystem services.
11.5 Ways Ahead for GAWI

To conclude this Framework Document, it is clear that the DPSIR tool has provided a new and informative conceptual approach to the analysis of agriculture-wetland interactions. Combined with the eco-systems services concept from the MA this has helped interrogate a range of diverse cases and clarify where changes in the broad nature of the interactions are needed. However, the experience with responses, especially in terms of their effectiveness remains weak and further exploration of this are needed along with the discussions of in situ and basin level opportunities discussed in the first part of this chapter.

Overall it is appropriate to conclude this volume by re-iterating the following key points:

- The diversity of wetland experience shown by the DPSIR analysis, means that guidance and responses must be based on case by case DPSIR analysis, rather than any prescriptive copying of lessons;
- There is a need to address the real driving forces in the AWIs, rather than the symptoms, and this action will be more effective if there are interventions at multiple levels based on the use of the DPSIR analysis to identify key elements at the different levels;
- It is important to recognise the socio-economic and socio-political elements in sustainability, both at the driver and the impact levels.
- There is a need to determine where guidance is already available, and where it is not for such multiple level and multi-actor response measures, so that GAWI can focus on developing only that guidance which needs to be developed.