Chapter 3

Assessment of agriculture–wetland interactions across the case database

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

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

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

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

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

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

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

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

FIGURE 5
Distribution of case studies by region and development situation

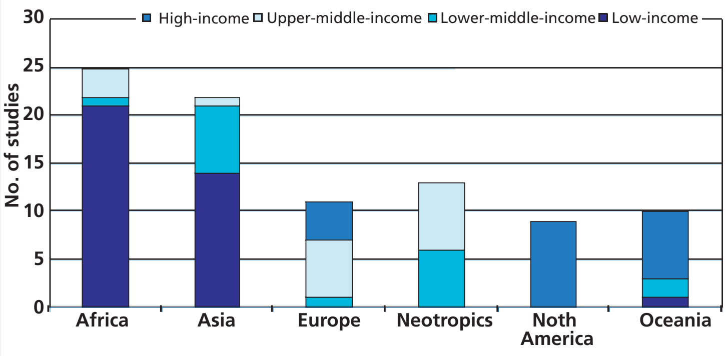


FIGURE 6
Wetland type distribution by region

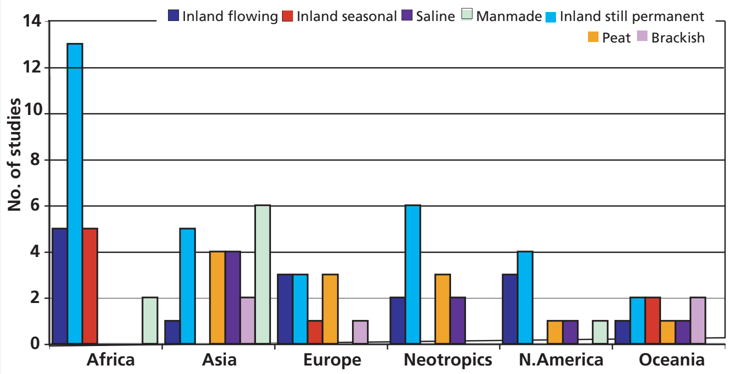
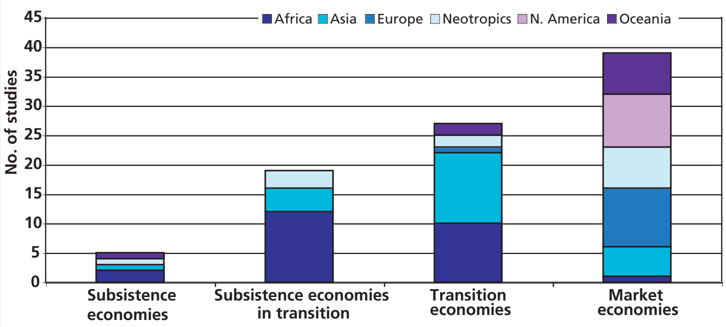


FIGURE 7
Market orientation by region



THE CASE DATABASE

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

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

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

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

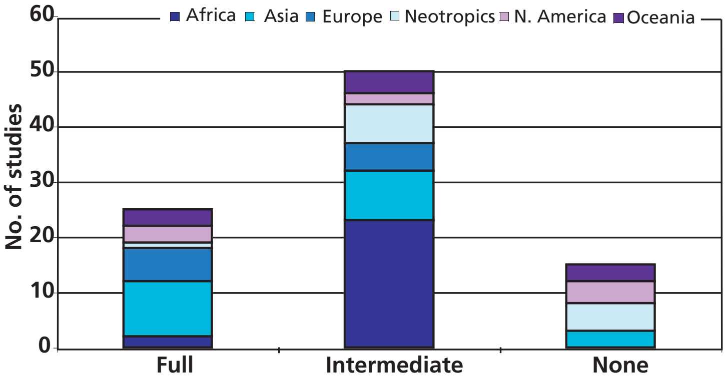
TABLE 5
Global distribution of case studies by Ramsar wetland type

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

In the analysis by agricultural category, the majority of cases are in market-oriented agriculture with full water control, or the transition to market orientation with intermediate levels of water control[5] (Figures 7 and 8).

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

FIGURE 8
Water control by region



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

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

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

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

TABLE 6
Major characteristics of the case database

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

* Relates to Ramsar typologies.

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

DRIVERS

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

Driver groups

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

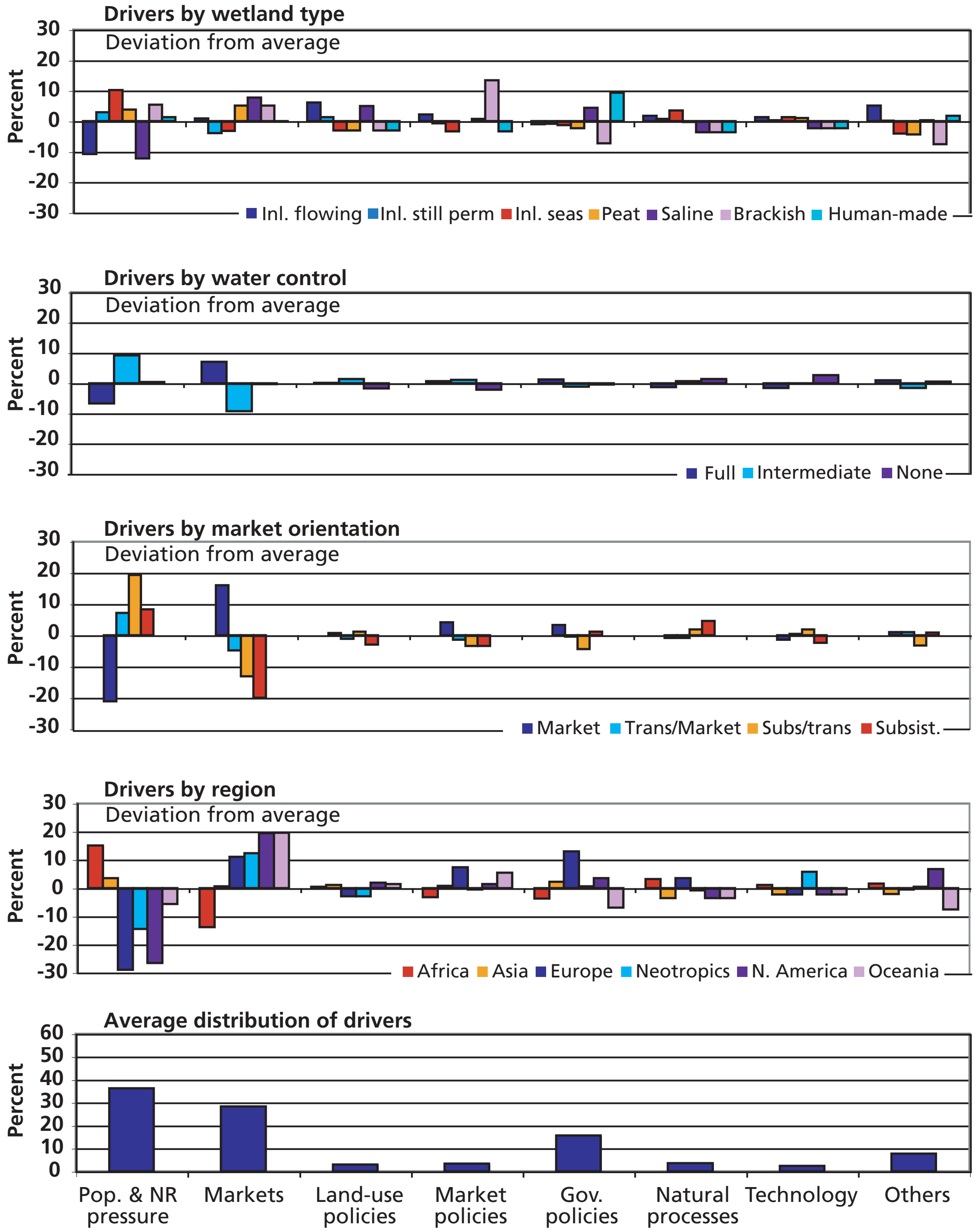
Population and natural resources dynamics

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

Markets

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

FIGURE 9
Distribution of reported drivers by driver group



Government policies

While government policies may be less frequently listed as drivers than those originating from population, natural resources and markets, this does not necessarily mean they are less significant in shaping particular response strategies or shaping present AWIs and the resulting state of ecosystems. On the contrary, government policies are frequently enacted, or acted upon, as a means to regulate the use of natural resources and/or the environmental impacts of agriculture. Illustrative examples of these are provided by Chilika Lagoon – e.g. the driving force of the Montreux Record in shaping the response strategy (Chapter 7) – and the Netherlands floodplain policy (Chapter 5).

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

Individual drivers

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

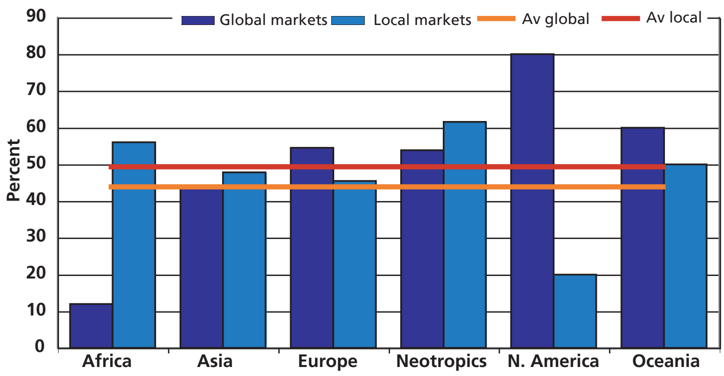
Population, food and natural resources dynamics

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

Global vs local markets

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

FIGURE 10
Global and local market drivers by region



Government policies

At the driver group level (Figure 9), the relevance of drivers stemming from government policies is lower than market and population drivers. However, when considering individual drivers, on average half of all cases report drivers stemming from government policies (Annex 5, Table A5.1). Europe deviates from this in that nearly three-quarters of its cases report government policies as drivers; whereas Oceania and Neotropics list substantially less government policies as drivers, this being in only one-fifth and one-third of their cases, respectively.

Other drivers

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

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

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

PRESSURES

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

Pressure groups

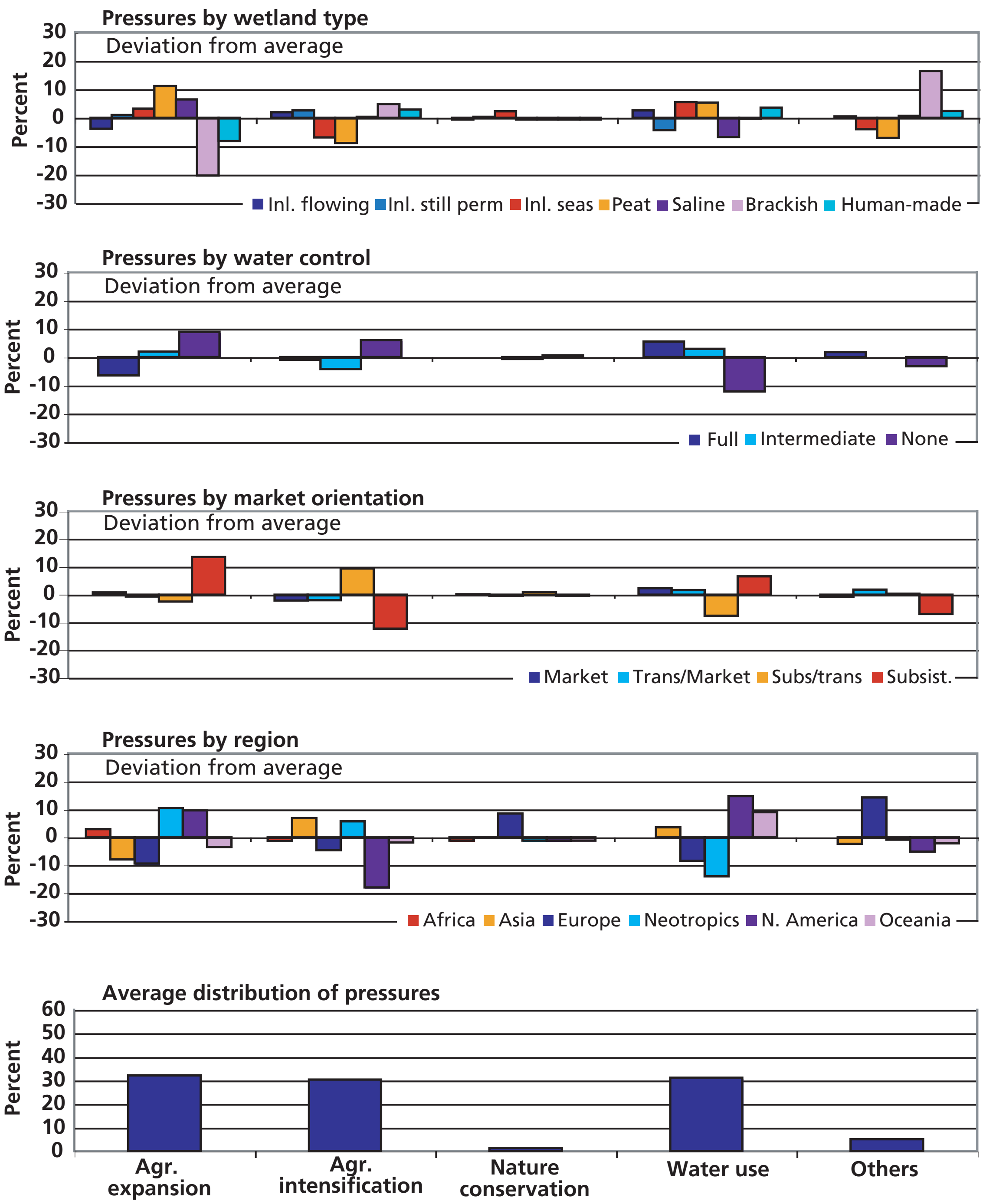
The pressures are distributed approximately evenly over the three major groupings of agricultural expansion, agricultural intensification and water use – where on average each group accounts for roughly one-third of the listed pressures (Figure 11). When set against the different categories of region,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

Individual pressures

Agricultural expansion

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

FIGURE 11
Distribution of pressures by pressure group



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

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

FIGURE 12
Agricultural expansion by region

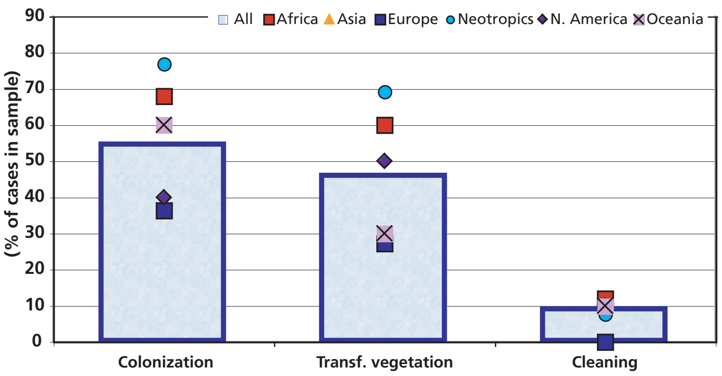
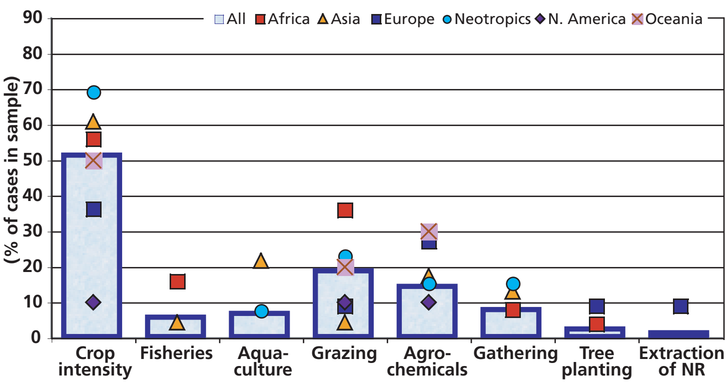


FIGURE 13
Agricultural intensification by region



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

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

When analysed by level of water control, agricultural expansion is more pronounced under conditions of no water control and less so under conditions of full water control (Figure 11). This is what one would expect, as water control enables agricultural intensification.[7] The trend for water use, with higher listings for full water control to fewer listings for no water control, conforms to expectations.

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

Agricultural intensification

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

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

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

Water use

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

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

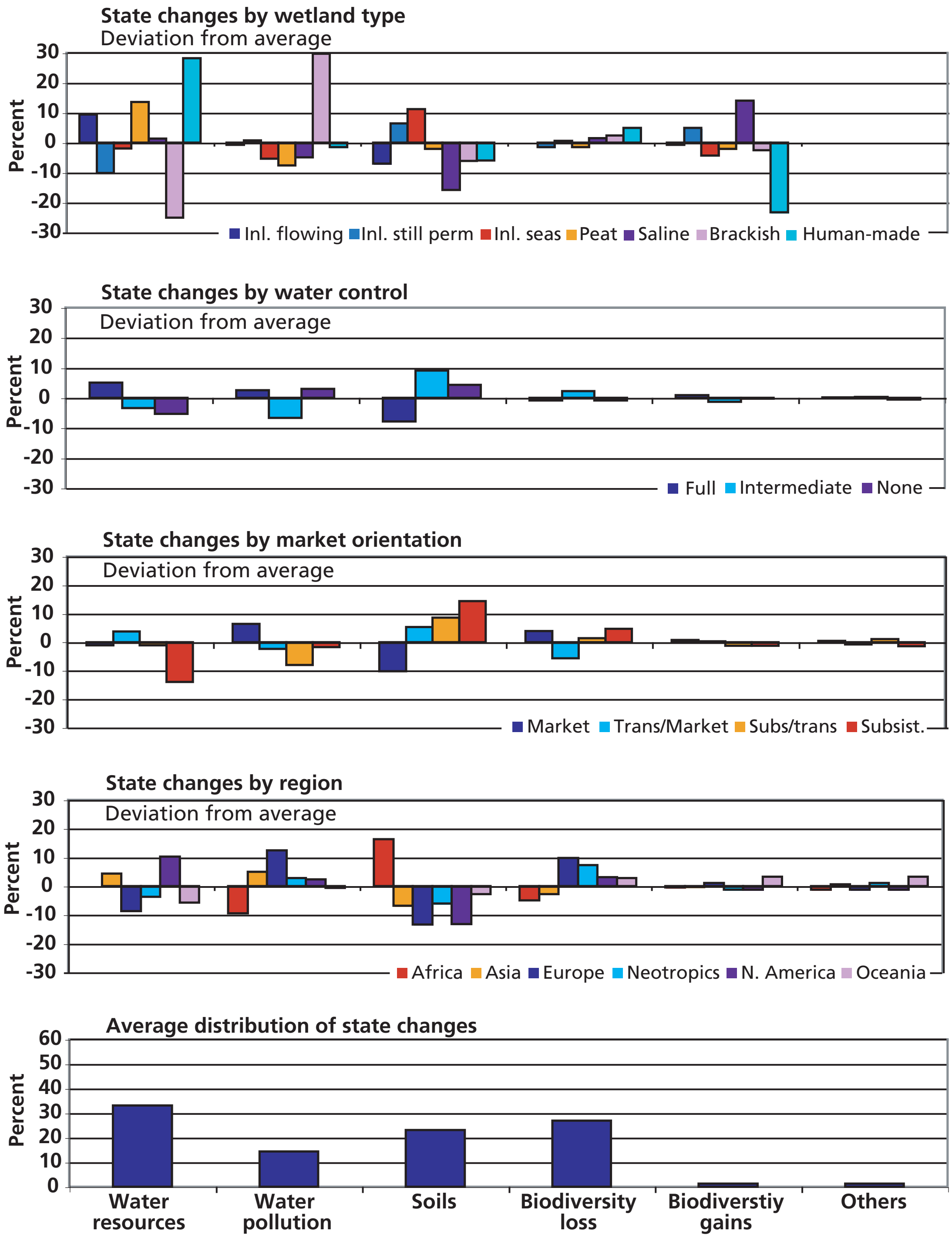
STATE CHANGES

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

State change groups

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

FIGURE 14
Distribution of state changes by state change group



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

Individual state changes

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

Water resources base

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

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

Water quality/pollution

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

In view of the diverse aspects of water quality/pollution, there is a need to discuss this at the individual state-change level in order to capture these phenomena. Figure 15 presents the occurrence of three[9] individual state changes on water quality/pollution by region, as well as their average occurrence[10] in the overall database sample of

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

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

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

FIGURE 15
Water quality state changes by region

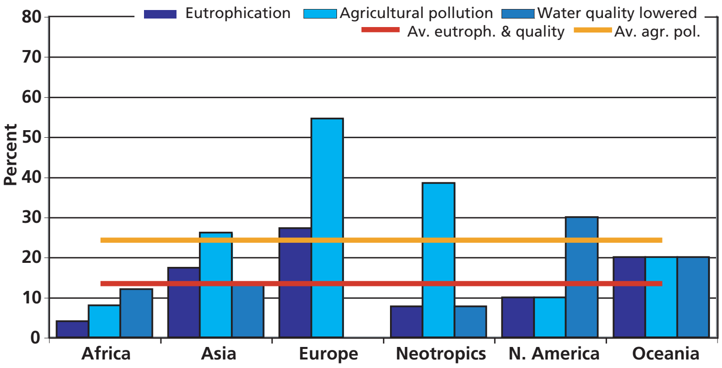
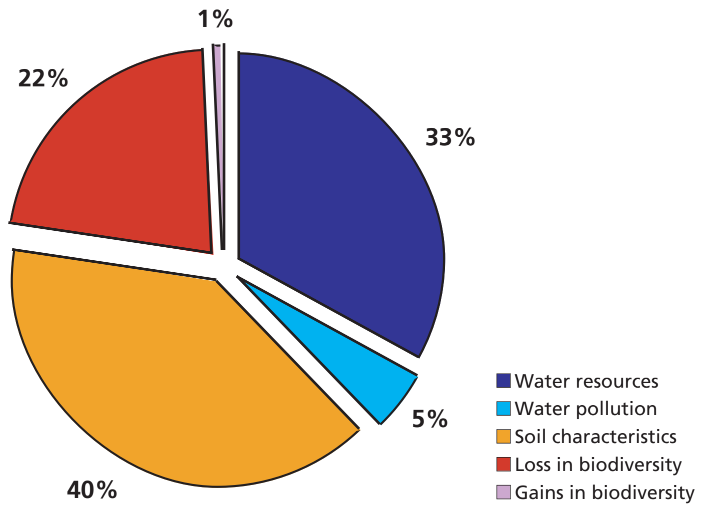


FIGURE 16
Distribution of state changes in Africa



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

Soils

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

The individual state changes related to soil conditions are more informative (Annex 5, Table A5.4). Overall, the most frequently reported state change is that of increased sediment deposition in wetlands, as reported in half of the cases from Oceania, one-third of those from Africa, and one-quarter of those from Asia and the Neotropics. The other frequently reported soil changes, which are specifically reported in Africa, are: loss in soil fertility (one-third), reduced infiltration, erosion and physical deterioration (one-quarter each). For Europe, state changes in soils are limited to soil subsidence, which is reported in more than one-third of the cases. This is due to the fact that the cases from Europe are predominantly peatlands. For the African cases, the yield and (water) resources losses associated with these soil state changes may form important negative feedback loops to the drivers and pressures that encourage rural communities to expand their agricultural frontiers, especially through the exploitation of prime land and water resources of wetlands, thus increasing their further contraction and conversion.

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

Loss in biodiversity

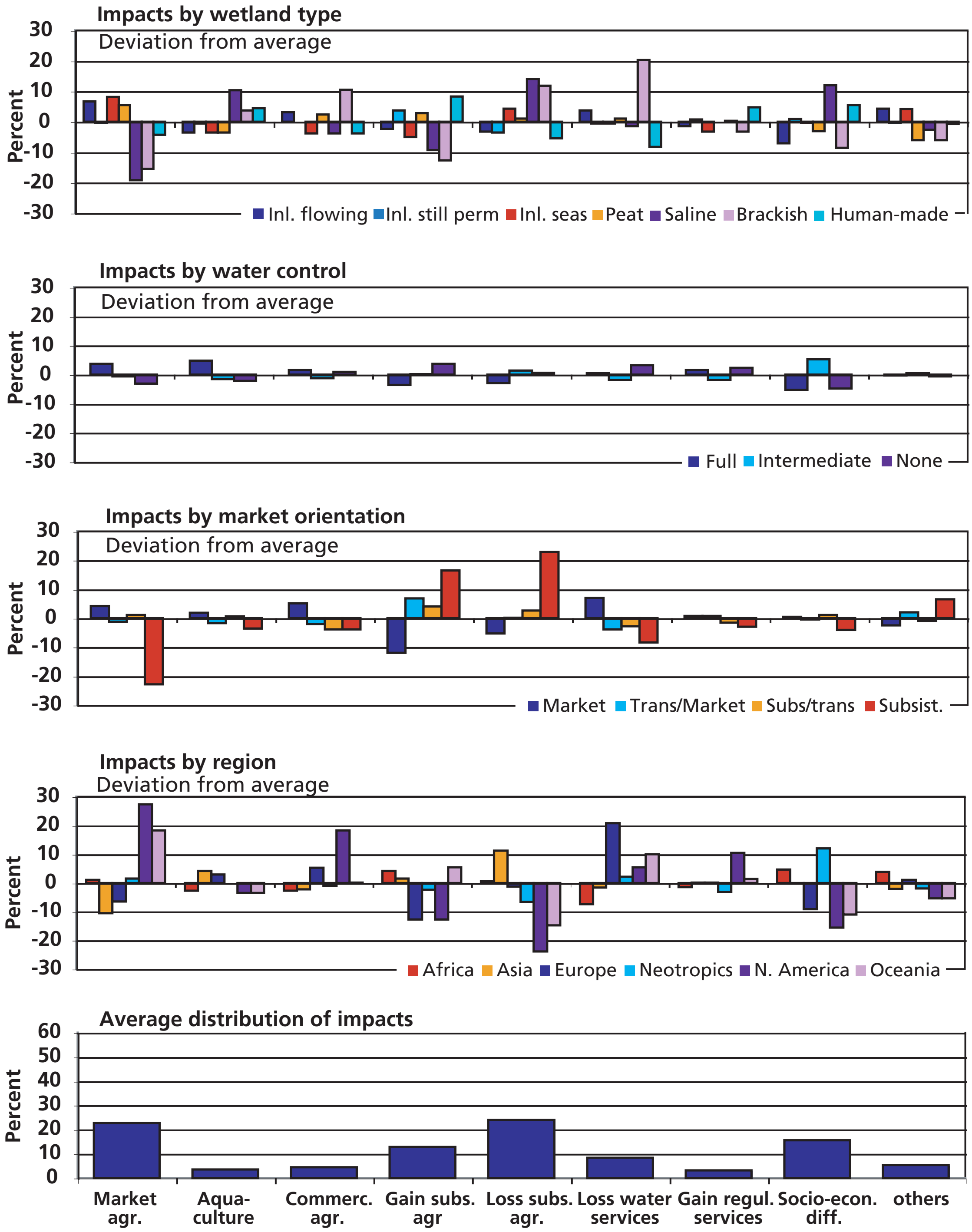
Loss in biodiversity comprises five individual state changes. This is the second-most frequent reported state change after changes in the water resources base. The most frequent individual state change (Annex 5, Table A5.5) is that of decreased vegetation, biodiversity and groundcover, which is reported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

IMPACTS

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

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

FIGURE 17
Distribution of impacts by impact group



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

Impacts groups

Gains and losses in provisioning services

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

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

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

Individual impacts

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

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

FIGURE 18
Market and commercial agriculture by region

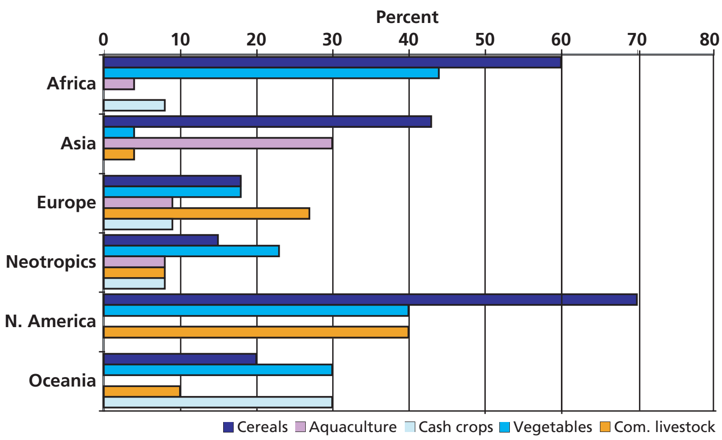


FIGURE 19
Changes in subsistence agriculture

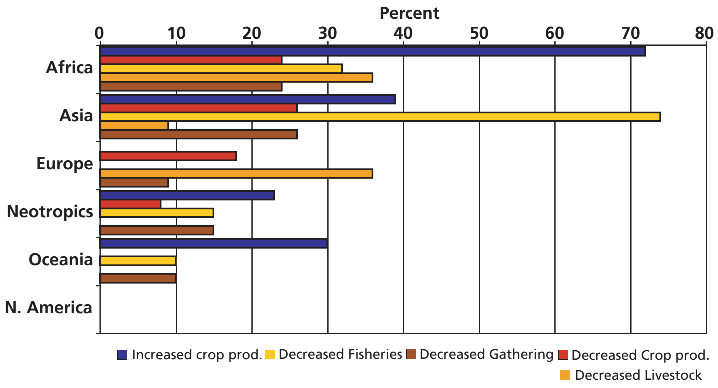
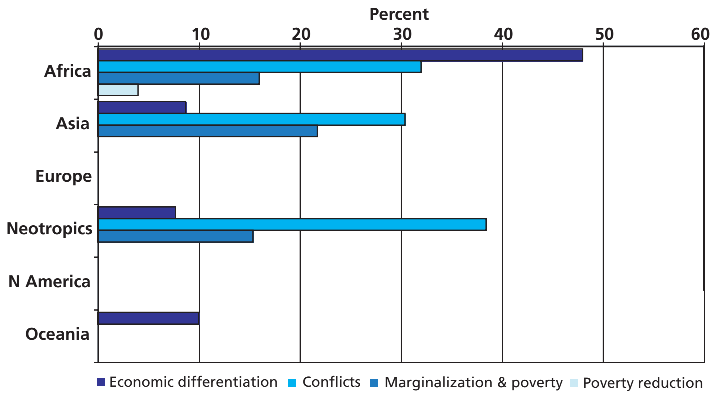


FIGURE 20
Socio-economic impacts by region



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

As gains in market-oriented or commercial agriculture represent shifts and transformations in resources utilization, any gains need to be viewed against potential trade-offs or offsets elsewhere. Within the provisioning services such trade-offs are evident within the reported impacts in terms of gains and losses in subsistence agriculture (Figure 19). Gains in subsistence agriculture are limited to reported increases in subsistence crop production – in particular in Africa (from two-thirds to three-quarters of cases) and Asia (two-fifths of cases). Such gains are generally the direct result of the agricultural expansion that has taken place. On the other hand, the reported losses or decreases in subsistence agriculture are substantive in terms of the frequency with which they are reported. The most prominent of these is the reported loss in fisheries, which seems structural for Asia (three-quarters of cases) and significant for Africa (one-third of cases). However, these declines in fisheries may be a result of transitions to market-oriented/commercial agriculture and/or expansion of subsistence agriculture. Moreover, as in the case of livestock in Africa, decreases in derived socio-economic benefits from fisheries often tend to signify a deprivation of an entire livelihood. Decrease in livestock, in particular owing to loss of grazing lands, is prominent in Africa (more than one-third of cases). Decreased subsistence crop production (e.g. rainfed) is common in both Africa and Asia (one-quarter of cases), as is the reported decrease in gathering (one-quarter of cases in each of the two regions). For Africa, the decrease in subsistence crop production is linked to the reported state changes in soil characteristics (especially erosion and loss of fertility). The reported losses in subsistence agriculture in Europe are misleading – decrease in livestock and crop production are primarily indicators of switching from intensive agriculture to low-intensity agriculture as a means of agro-ecological landscape management. Thus, they are as much a nature conservation response and impact as that they are an agricultural impact (see Chapter 5).

Socio-economic differentiation

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

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

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

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

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

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

RESPONSES

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

DPSIR level of responses

Of the responses identified in the database, the majority are directed towards state changes (Figure 21), with responses directed towards the interactions between agriculture–water–ecosystems at wetland sites. For the cases from Asia and Oceania, state changes account for about half of all responses; for Africa and Europe about two-fifths, and for the Neotropics and North America one-third to one-quarter. Pressures are the second-most frequently addressed category of responses – less so for the cases from Africa and Asia, where pressures account for one-fifth of responses compared with about one-third for all other regions. Drivers are the least addressed but still account for a significant proportion of the responses of the cases from North America

FIGURE 21
Responses to DPSI element

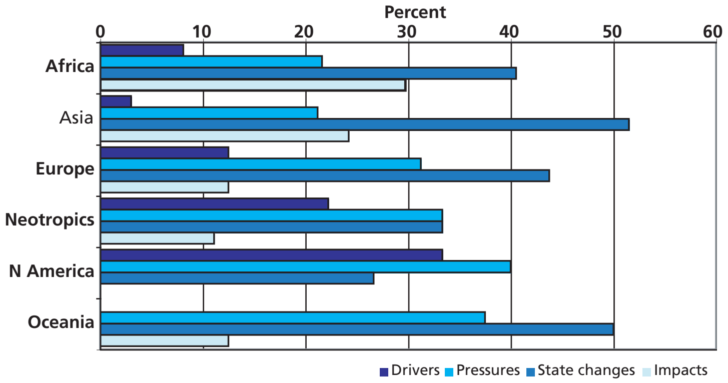
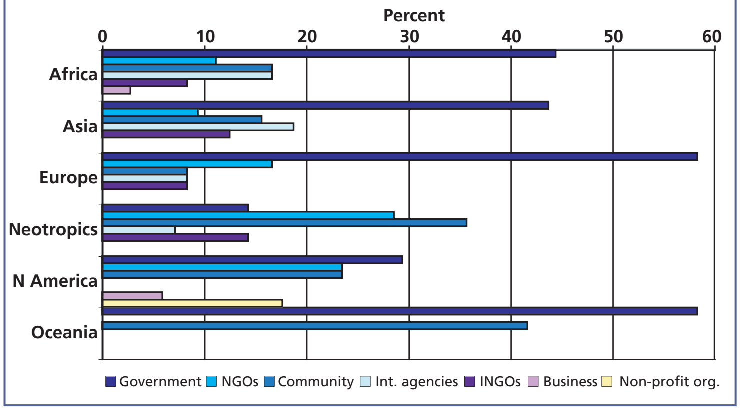


FIGURE 22
Actors responding



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

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

Actors responding

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

Type of responses

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

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

TABLE 7
Type of response as percentage of total responses

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

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

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

DISCUSSION

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

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

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

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

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

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

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

Related to the above is the issue of assessing and valuing the biodiversity of ecosystems. As previously mentioned, the cases in the database provide only a general assessment of biodiversity loss, which is not sufficient to guide adequate response strategies. That the loss of biodiversity tends to be a general trade-off as a result of increases in agriculture (through expansion or intensification) is more of a general truism rather than an insight, especially when considered over longer time spans. Although better qualifications can be made of different degrees of biodiversity loss and their role and function in sustaining supporting, cultural and regulating ecosystem services, such specialized and complex assessments are not captured in this dataset. However, there is a clear need for more precise assessments and diagnosis of the role of biodiversity in sustaining ecosystem services and in defining the ecological character of the ecosystems. In particular, as the drivers and pressures for provisioning services are set to continue to increase, rather than decrease, there is a need to qualify the role of biodiversity in sustaining the ecological character and functioning of ecosystem services, and in specifically identifying the thresholds. This is so that inevitable trade-offs in interactions at the landscape/catchment level between provisioning services and other services can be assessed and dealt with adequately. However, this goes beyond the scope of the present report.

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

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