Section II
Case studies

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

Chapter 4

Small swamp wetlands in southwest Ethiopia

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

BOX 2
Similar cases from other countries

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

DRIVERS

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

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

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BOX 3
Common and diverse drivers of wetland agriculture in Africa

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

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

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

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

Some drivers have operated only at specific periods. These have included the 1975 land reform process, which led to wetland being divided up among the community, with farmers required to cultivate these plots in order to retain access to them. Moreover, in the early 1970s, the collapse of seasonal coffee-picking income (as a result of coffee berry disease) provided a short-term stimulus to wetland cultivation for households needing to replace their coffee-picking income by growing more food during the dry season.

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

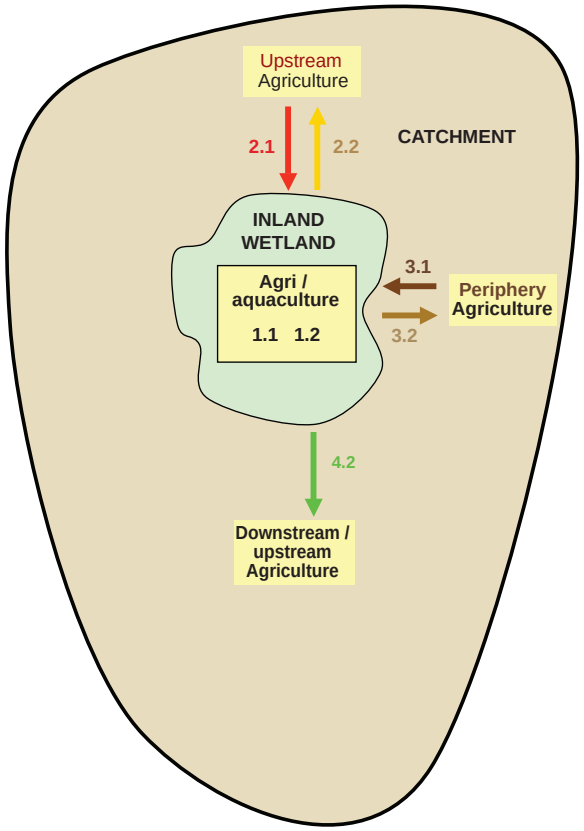
PRESSURES

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

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

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

FIGURE 23
AWIs in Illubabor Zone, southwest Ethiopia



STATE CHANGES

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

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

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

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

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

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

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

BOX 4

Conflicts resulting from wetland agriculture in Africa

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

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

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

IMPACTS

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

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

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

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

RESPONSES

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

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

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

THE VALUE OF THE DPSIR ANALYSIS IN ILLUBABOR

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

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

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

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

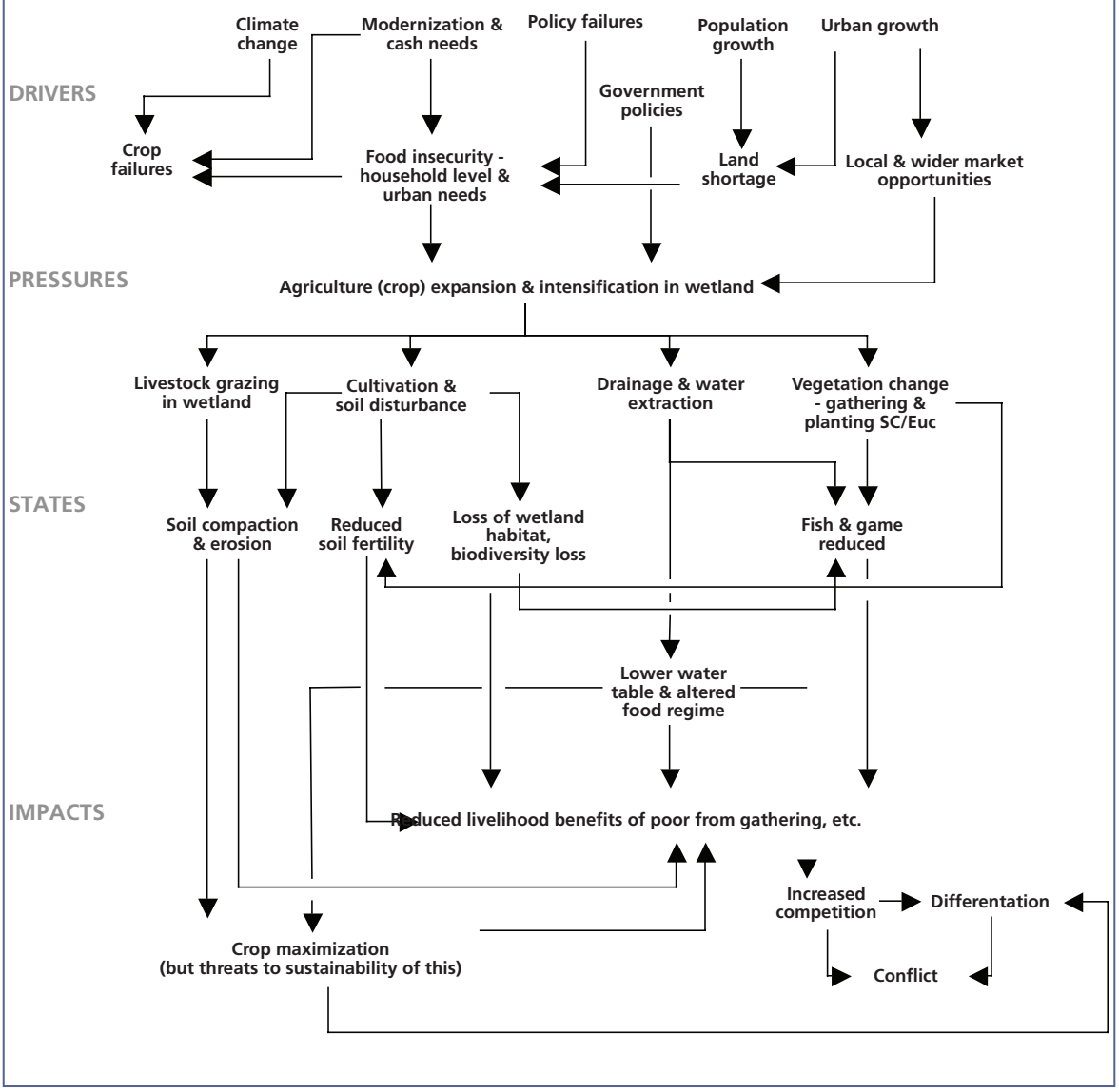
WIDER CONSIDERATIONS

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

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

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

FIGURE 24
DPSI linkages in the swamps of Illubabor Zone, Ethiopia



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

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

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

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

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

CONCLUSIONS

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