Ramsar
Convention on Wetlands

TECHNICAL NOTE

Global Wetland Outlook: Technical Note on Drivers of Change

The Drivers of Change section of the Global Wetland Outlook (GWO) discusses the three main drivers of wetland change: direct drivers, indirect drivers and global megatrends. Direct drivers create biophysical change in wetlands through, for example, land use and pollution. Indirect drivers are processes in society that create the direct drivers, while global megatrends influence the indirect drivers. Effective wetland conservation and wise use requires a sound understanding of the drivers of wetland change so that the root causes of wetland loss and degradation can be addressed. This Technical Note provides further information on:

- methods used for soliciting expert views on the drivers of change in wetlands;
- additional figures and data sources;
- examples of drivers wetland degradation and destruction;
- references on drivers of change (more comprehensive than the list used in the GWO).

Background
The GWO, which is the Ramsar Convention's flagship publication, reports on the status and trends of the world's wetlands. The Contracting Parties requested the GWO in Ramsar Resolution XII.5, which called upon the Convention's Scientific and Technical Review Panel (STRP) to update and expand upon Ramsar Briefing Note 7, State of the World's Wetlands and their Services to People: A Compilation of Recent Analyses. The Standing Committee subsequently identified this task as among the STRP's highest priorities.

Purpose
These technical notes are complementary to the GWO. They consist of technical information to explain the methodology or analysis supporting findings published in the GWO. They also provide supplemental details and references.

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1. Methods used for soliciting expert views on the drivers of change in wetlands (Tables 3.1 and 3.2)

Tables 3.1 and 3.2 in the GWO were constructed using the hierarchical structure for direct and indirect drivers and their influence on wetland types as distinguished in the Ramsar classification.

Direct drivers were classified using four categories:
- physical regime drivers
- introduction drivers
- extraction drivers
- structural change drivers

Indirect drivers were categorized according to four sectors of economic development:
- water-energy
- food and fibre
- infrastructure
- tourism and recreation

The localised effect of climate change was added as another category of indirect drivers. As a result, Table 3.1 shows the extent of the impact of direct drivers of change on different wetland types, and Table 3.2 shows the impact of indirect drivers of change on the four categories of direct drivers.

A qualitative approach was used to evaluate the significance of these drivers. The “likely extent of impact scores” of the drivers were indicated using color codes with the following interpretation:
- Red: major influence of global distribution/significance
- Orange: significant influence of regional to global distribution/significance
- Tan: other known significant drivers of change, extent local or not known

In Table 3.1, small circles indicate drivers that can lead to the total destruction of these wetlands. Another interpretation could be that these drivers lead to irreversible degradation and so contribute to the eventual destruction of these wetlands. The color differences in the table cells primarily give an indication of the global spread of these effects. They do not express the severity of the impact.

The overall approach was discussed initially with a small group of participants in STRP20 in February 2017, and then the scoring for the various combinations of direct drivers-wetland types (Table 3.1) and indirect-direct drivers (Table 3.2) was done in two sessions with a larger group (appr. 15 participants), also at STRP20. The resulting tables were described, and the emerging patterns were elaborated. Subsequently, the Tables, as part of the review process of the draft report, received comments from STRP National Focal Points (First Order Draft) and from anonymous reviewers (Second Order Draft).

Although the Tables are not a quantitative or an exact measure of the impact of drivers of change on wetlands, they do help in understanding and creating awareness about the relative scale of impact of some drivers and about the influence and importance of some drivers for specific wetland types.

Photo: A.A. van Dam

2. Additional figures and data sources

2.1. Dam capacity (Dam capacity in km^3 of water potentially held in each of the six Ramsar regions)

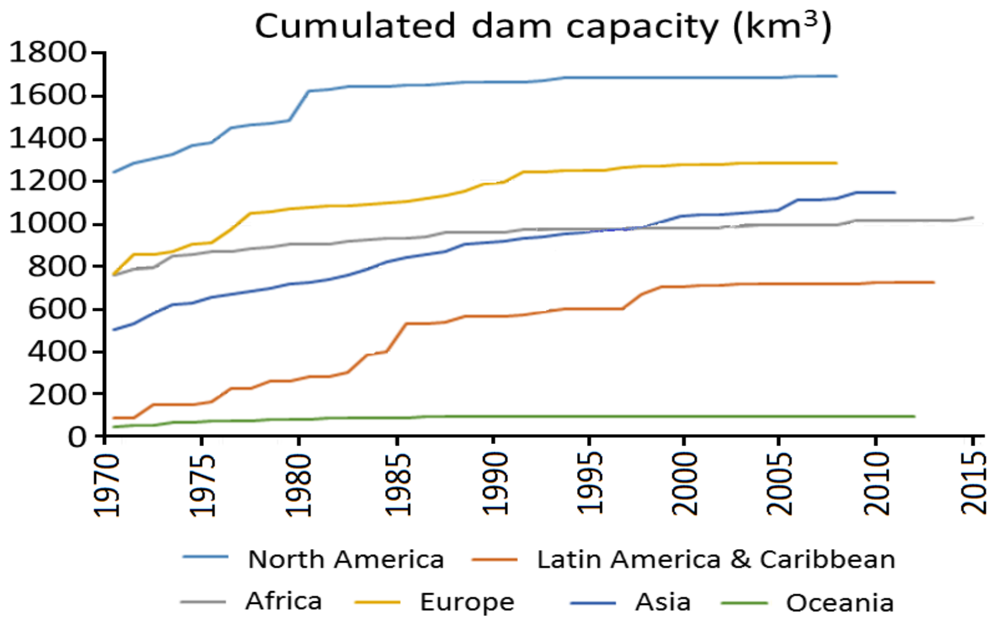

Figure A. Dam capacity (in km^3 of water potentially held) in each of the 6 Ramsar regions. Source: FAO–AquaStat Dams Database. http://www.fao.org/nr/water/aquastat/dams/index.stm

The data for Figure A is from the AquaStat main database, FAO's global water information system (FAO 2014). Data were found under “Water resources”, then “Exploitable water resources and dam capacity”, and then “Total dam capacity”. AquaStat contains data, metadata, reports, country profiles, river basin profiles, regional analyses, maps, tables, spatial data, guidelines, and other tools on water resources, water use, wastewater, irrigation, dams, and water-related institutions, policies and legislation. The time period covered is from around 1960 until present.

Besides the main database, there is more information under the GRanD (Global Reservoirs and Dams database), a database in which more detailed information and data about dams can be found in files organized around continents (Lehner et al. 2011). There are both geo-referenced datasheets and files with notes and references. Information about dams includes for example the administrative unit, river basin and nearest city, dam height, if the dam is used for irrigation, etc.

- FAO. (2014). *Understanding AQUASTAT, FAO’S global water information system*. Information note. Rome: Food and Agriculture Organization of the United Nations. Retrieved from: http://www.fao.org/nr/water/aquastat/About_us/index.stm
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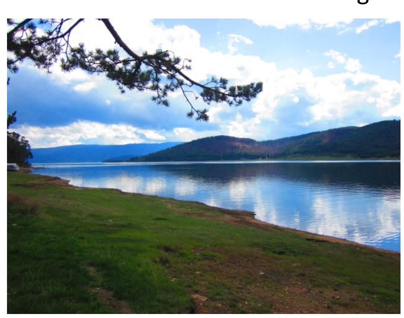


2.2. Inland fisheries (Inland fish catch 1950-2015, excluding reptiles and mammals)

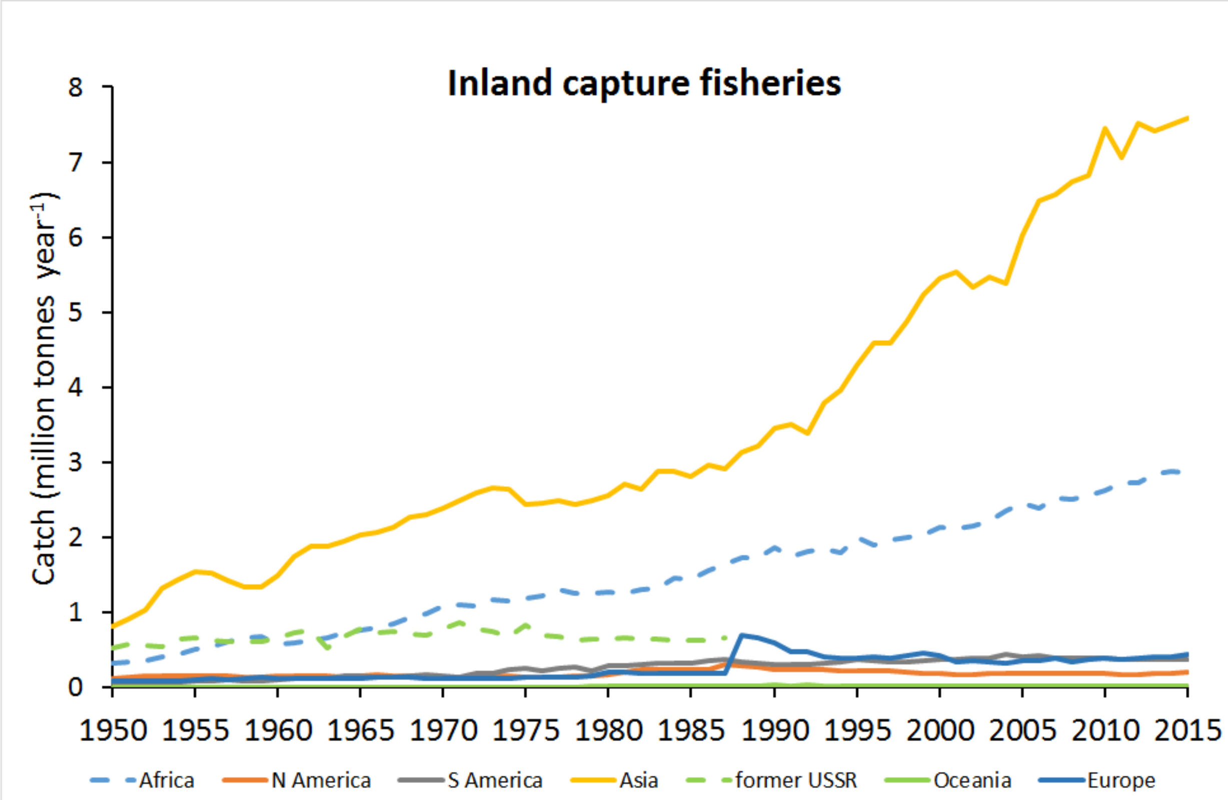


Figure B. Inland fish catch 1950–2015, excluding reptiles and mammals. Source: FAO Fishstat database. http://www.fao.org/fishery/statistics/global-capture-production/en.

The data reported in the database are "nominal catches", which are landings converted to a live weight basis. Often these are the same as the landings, but in some fisheries the landings are processed on board (e.g., gutted or filleted), and therefore the landings need to be corrected to represent the actual catch. For more details on the origin of the data, see the FAO website.

After entering the URL http://www.fao.org/fishery/statistics/global-capture-production/en, the following procedure was used. Under "Available Formats & Information Products", the following were selected:

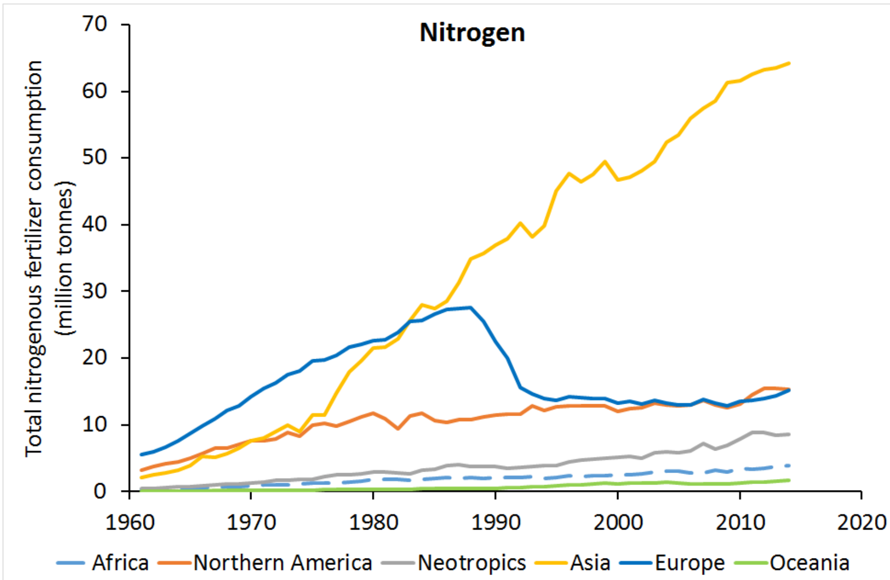
Dataset, Global Capture Production (online query)
Tab "Fishing Area"
Under "inland waters", one region was selected at a time
Submit
Export (this creates a csv-file with the capture data)

The resulting csv-files were imported into an Excel sheet and organized for the production of the graph. This procedure was repeated for each region.

Inland fisheries are often small-scale or recreational and part of household activities, and the catch is mostly consumed locally. Unlike in marine fisheries, there is little by-catch or discards. Because of the wide variety of inland aquatic systems (rivers and streams, lakes, reservoirs, wetlands) and aquatic species, inland fisheries are very diverse. They represent an important contribution to livelihoods, protein nutrition and food security, particularly of lower-income groups (Meusch et al. 2003). A lot of the catch is not recorded properly because of the small-scale nature of the fisheries and because a large part of the catch is directly sold or consumed locally (Welcomme et al. 2010). FAO acknowledges that the inland fisheries capture statistics are likely underestimations of the real catch, by as much as 50% (FAO 2016).

- FAO. (2016). *The State of World Fisheries and Aquaculture 2016: Contributing to food security and nutrition for all*. Rome: Food and Agriculture Organization of the United Nations.
- Meusch, E., Yhoung-Aree, J., Friend, R. & Funge-Smith, S. (2003). The role and nutritional value of aquatic resources in the livelihoods of rural people: A participatory assessment in Attapeu Province, Lao PDR.
- Welcomme, R.L., Cowx, I.G., Coates, D., Béné, C., Funge-Smith, S., et al. (2010). Inland capture fisheries. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *365*(1554), 2881-2896.

2.3. Fertilizer use (Trends in mineral fertilizer (nitrogen and phosphorus) use from 1961 to 2014).



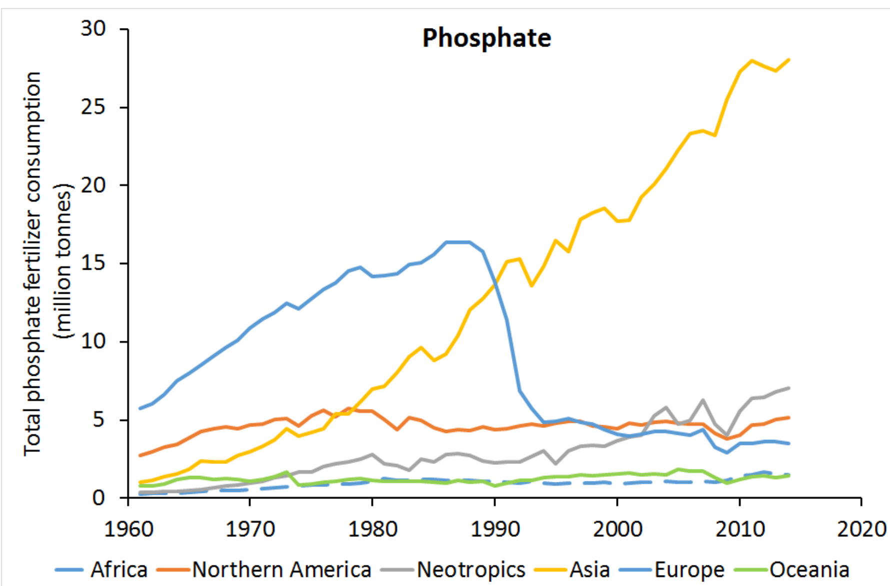


Figure C. Trends in mineral fertilizer (nitrogen and phosphorus) use from 1961 to 2014. Figure based on combined data on agricultural inputs (Fertilizers 2002-2014 and Fertilizers Archive 1961-2001) from FAOSTAT (http://www.fao.org/faostat/en/#data).

The Figure is based on combined data on agricultural inputs (Fertilizers 2002-2014 and Fertilizers Archive 1961-2001) from FAOSTAT (http://www.fao.org/faostat/en/#data/RFN).

3. Additional examples of drivers of wetland destruction or degradation

3.1. Climate change as a driver of change in wetlands (with an example of saltwater intrusion into coastal areas)

In the context of drivers of change in wetlands, climate change presents considerable challenges conceptually, as well as in terms of identification and evaluation. Wetlands are particularly vulnerable to climate change because it directly affects some of the main physical determinants of wetland ecosystems (temperature, water) and because climate change leads to extreme events that affect wetlands (e.g., droughts, floods, fires) (Finlayson 2017; Finlayson et al. 2017; Moomaw et al. 2018). In the conceptual scheme used in the GWO drivers chapter, climate change fits in every category of drivers: direct, indirect and megatrend. Climate variability is generally seen as a natural driver of change, whereas climate change is considered a human-induced driver (MEA 2005). Increases in temperature and changes in precipitation patterns as a result of climate change are direct drivers of change that affect the processes and species in wetlands. Indirectly, decision-making in response to climate change also creates impacts to wetlands, e.g., when construction of hard infrastructure in a river basin to reduce flood risk interferes with water flows to wetlands. At the megatrend level, climate change also influences wetlands, e.g., when in attempts to reduce carbon emissions from fossil fuels, countries increase their investments in hydropower and dam construction (which can affect water flows to wetlands) or biofuel production (which can lead to conversion of wetlands).

Saltwater intrusion (displacement of the fresh-salt interface in coastal aquifers towards the land) can serve as an example of the complex problems resulting from climate change. Many coastal wetlands suffer from increasing saltwater intrusion, in the form of saltwater penetration into estuaries. The drivers of this process are multiple: it can happen through natural causes such as storm surges, hurricanes, and land subsidence, but there are also anthropogenic causes such as land drainage, water abstraction for cities or agriculture, and changes in river discharge (e.g., from dam construction or upstream water abstraction). All these drivers are working on different spatial and temporal scales, and can interact with, and reinforce each other (Herbert et al. 2015; White & Kaplan 2017).

Climate change has an impact on almost all of these drivers, whether natural or anthropogenic. It leads to more extreme events (storms, hurricanes) and to sea level rise. Many areas will experience drought, which will reduce river discharge and allow more saltwater intrusion. Sediment accretion is affected strongly by all these processes and may lead to some coastal wetland types (particularly wet forests) not being able to keep up with sea level rise. Human activities in the coastal zone and in the river basin often lead to reduced freshwater supply to the coastal wetlands, further exacerbating the problem of saltwater intrusion. Behind the water and land use changes is a network of indirect drivers (actors, policies, institutions and decision-making processes) that needs to be understood and become part of the search for sustainable restoration solutions. To address the problem, a thorough analysis of the underlying processes is needed for every specific case. When coastal aquifers are transboundary, international cooperation is needed.

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3.2. Food security policy and agricultural development as drivers of degradation in African wetlands

Riverine and lacustrine wetlands throughout eastern and southern Africa are used for seasonal agriculture. Many of these are papyrus wetlands (dominated by the sedge *Cyperus papyrus*), but other vegetation types also occur. Generally these wetlands are under considerable pressure from economic and agricultural development and urbanization (van Dam et al. 2014; Beuel et al. 2016; Kipkemboi & van Dam 2018). These wetlands are a common part of the landscape for many people in eastern and southern Africa, suggesting that they do not need protection. However, because of their range of ecosystem services they are of high ecological and economic importance, and their widespread degradation and destruction are a concern. Traditionally, agriculture in the seasonally flooded zones of these wetlands would support riparian communities and be part of a mixed livelihood strategy that, next to wetland agriculture, consisted of several activities including fishing, vegetation harvesting, and other types of formal and informal employment (Kipkemboi et al. 2007). In this seasonal system, agriculture takes place in the dry season, during which the aboveground vegetation is removed and other crops are planted (e.g., maize, arrowroots or vegetables). During the rainy season these areas flood again, and fast-growing natural vegetation can regenerate from the rhizomes and roots that remained intact during the cropping season. This relatively low-intensity, seasonal cropping system would allow the wetland vegetation and its biodiversity and ecosystem services to remain intact (van Dam et al. 2014).

With growing populations, the need for higher food production increases. This leads to more permanent drainage measures, which allow for year-round culture in these wetlands. As a result, some wetlands see a continuous decline in the area covered by original wetland vegetation (e.g., Namatala wetland Uganda; Namaalwa et al. 2013). Traditionally, the annual cycle of dry and wet conditions played a large role in the seasonal use of wetlands because during the dry season wetlands are accessible and more vulnerable to exploitation. When flooded, human activity declines, and the natural ecosystem can recover. In many places, permanent changes to the seasonal wetlands are made to prevent flooding and enhance drainage. This allows for more permanent and more intensive cultivation. Consequently, these drained wetlands can lose their wetland character as they are cut off from the annual cycle of flooding and drying. In the long run, this has consequences for the supply of nutrients and sediment to these wetlands, and farmers often observe a decline in yields. Where in the traditional system the use of fertilizers was rare, in these drained wetlands there is a need for external nutrient input to maintain yields (Namaalwa et al. 2013; Uwimana et al. 2018).

Summarizing, a number of interacting drivers operating at different scale levels can be observed in this example (van Dam et al. 2013). Population growth and the need to produce food and support livelihoods drive the intensification of agriculture, sometimes helped by infrastructural developments for flood prevention and government policies for food security and agricultural development. This intensification leads to the year-round cultivation of wetlands, which causes a disruption of the natural inflow of nutrients that supported agriculture. The ensuing import of nutrients in the form of artificial fertilizers leads to more nutrient export from wetlands, which increases the risk of eutrophication in downstream water bodies. Other ecosystem services of the wetlands, which used to be (at least partly) restored during the wet season, are also lost.

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- Kipkemboi, J., van Dam, A.A.,Ikiara, M.M. & Denny, P. (2007). Integration of smallholder wetland aquaculture-agriculture systems (Fingerponds) into riparian farming systems at the shores of Lake Victoria, Kenya: socio-economics and livelihoods. *The Geographical Journal 173*, 257–272.
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- Uwimana, A., van Dam, A.A., Gettel, G.M. & Irvine, K. (2018). Effects of agricultural land use on sediment and nutrient retention in valley-bottom wetlands of Migina catchment, southern Rwanda. *Journal of Environmental Management*, https://doi.org/10.1016/j.envman.2018.04.094 (accepted).
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3.3. The complexity and interactions of indirect drivers of degradation of a protected freshwater lake (Burdur Lake, Turkey)

Burdur Lake is a Ramsar site in the Mediterranean region of Turkey. This 20,000 ha tectonic lake is a major wintering site for the endangered white-headed duck (*Oxyura leucocephala*). It is located in a closed basin and receives water from a number of rivers and underground water sources. Due to water abstraction in the basin for irrigation and drinking water and dam construction in the rivers, the water level in the lake has been declining since the 1970s, leading to increased salinity in the lake. In addition, eutrophication is a problem as a result of the discharge of untreated municipal and industrial wastewater and the use of fertilizers in the lake basin.
In an analysis of the causes of ecosystem degradation in Burdur Lake, based on a study involving stakeholder interviews and focus group discussions, Adaman et al. (2009) list a number of interrelated causes. It is easy to understand the direct drivers of change: the modifications of water supply to the lake and the pollution with agricultural runoff and wastewater. However, the indirect drivers underlying these direct causes are more difficult to identify and understand. In this case, the protected status of the lake (besides being a Ramsar site since 1994, the lake also has designations as 'Wetland Birds and Wildlife Protection Area' and 'Protected Area of First Degree Importance', and the basin is a 'Wildlife Development Zone') does not guarantee adequate management and protection.

A number of reasons for the disconnection between protected status and observed trends are explored by Adaman et al. (2009).

At the national level, the 'modernist' approach of the national government emphasizes economic development (e.g., in the form of dam construction and industrialization) with marginal attention paid to the environmental effects of development projects. Despite the existence of environmental agencies and legislation, a strong patron -client dynamic was identified in the relationships between state and lower levels of government, which led to one-sided attention for particular interests. This resulted in, for example, construction of a large number of illegal wells in the basin. In general, local implementation of the international and national legislation was not effective owing to cumbersome bureaucratic procedures and inertia and alienation among the local population. Direct dependence on the lake among the communities diminished over time, and this was reinforced by the on-going degradation of the lake. There was a lack of organisation among conservationists, while the business community was more effective in advocating its own interests. The strong 'hard-park' policy of the government created resistance among sectors such as farmers and entrepreneurs, who felt that restrictions on farming or business development were too strong.

This example illustrates the complex, multi-scale nature of the indirect drivers and their many interactions, and the importance of good governance. Besides the more obvious cause-effect relationships between human action and impact on the ecosystem, it involves (power) relationships between people and their organizations, learning and knowledge of obvious and less obvious ecosystem services, different perceptions of reality, and the willingness among different groups of stakeholders to develop an understanding for each other's interests and values. Addressing these underlying causes requires long-term, concerted efforts at different levels of governance.

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4. Additional references (used to inform the GWO; organized by driver category).

Physical regime (water, sediment, salinity, temperature)

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Extraction (water, biota, soil and peat)

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