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3 Demands on monitoring

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Introduction

This chapter is about the policies and legislation governing much of the demand for monitoring and, by default, it leans heavily towards mandated monitoring. Many times, however, the concern about an environmental issue leading to the creation of a policy was first initiated by question-driven monitoring. In a sort of mutual development, results from mandated monitoring can trigger new and revised demands.

An advantage of policies, directives, and legislation is that they are documents open for everyone to read, and the actual concern for any of the issues becomes transparent. Anyone can follow the development over time, when issues were added or discarded, which constitutes a good explanation of what was expected to come out of these directives. By knowing what lies behind the laws or policies, we can understand the questions we need monitoring to answer.

The demands on monitoring are also shaped by the evolution of data, including the increasing availability of new types of digital data (several data portals providing both satellite data and already-analyzed high-resolution layers for Europe or other parts of the world, laser data providing models of the surface and moisture regime). This availability and the subsequent creation of data portals are also changing the demands on reporting and simultaneously forcing and enabling harmonization processes nationally and internationally. The large-scale monitoring in oceans covers both national and international territory, where monitoring has long been organized in large communities across several countries and has been at the forefront of these harmonization efforts. An example is shown later in the chapter.

In this way, the demands on monitoring can roughly be divided into three types: legislation and policy, the evolution of data, and requirements for harmonization so that data from different areas can be combined and compared. It is important to be aware of these influences on how monitoring should be conducted. There are a vast number of directives, and we give a short introduction to some of them in relation to biodiversity monitoring and within the scope of this book.

Demands on monitoring

As mentioned in chapter 2, biodiversity monitoring is needed to benefit society by helping to maintain what the European Union (EU) summarizes as public goods or ecosystem services. By that they mean to map, assess, and achieve good condition of ecosystems so they can deliver benefits such as climate regulation, water regulation, soil

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health, and pollination and disaster prevention and protection (European Commission [EC] 2022b). This is driven by the recognition of unwanted and damaging environmental change from pressures on land use, the exploitation of resources, pollution, and climate change (United Nations, Economic Commission for Europe 2016). If we want to understand how much of a certain biodiversity resource (for humans or for the intrinsic value as a part of the whole environment) we have, whether that resource is diminishing, or what is happening to the environment, we need information. Environmental concerns may also be about perceived trends that, in future, might pose some threat to resources, whether due to changed land use or abandonment, reduced fish catches, or farmland being lost to sprawling towns and housing.

As authorities realize, perhaps from research results, that some vital resource for biodiversity or for the ecosystem that provides us with its services is likely to be lost, policies are a good way to enforce the preservation or restoration of that resource. Policies can steer the work efforts of the region of interest at local, regional, national, or international scales. Examples are preservation of biodiverse areas in wetlands, of water bodies, or on land or taking action against significant losses, such as restoring wetlands by filling in old ditches or creating new pastures on abandoned grasslands to increase biodiversity.

For example, at the EU level, The Biodiversity Strategy 2030 (EC 2022b) called on Member States to map and assess the state of ecosystems and their services in their national territory with the assistance of the European Commission. In 2020, this was expanded to assessments of the economic value of such services and integration of these values into accounting and reporting systems at both EU and national levels (Maes et al. 2018, 2020).

This means that the data collected by monitoring must be able to answer new questions that arise and show the extent of chosen classes of ecosystems according to how these are defined and understood. The data must be able to show whether ecosystems are in good health and whether a potential problem in an ecosystem is detectable and when, meaning as it develops or only when deterioration has gone too far. Data must also be able to say whether ecosystems can provide the services associated with them (Maes et al. 2020).

The social component

There is also much value in being able to assess both habitats or ecosystems and the social structures creating them from one region or country to the next to predict future shortages of habitats or other consequences of accelerating climate changes. These aspects, which follow on from both agreed-upon policies and local demand, are a core theme through the Agenda 2030 described later in this chapter (EC 2022h). Other work, for example, is directed at monitoring land use and changes in land use, like the land use, land use change, and forestry (LULCF) work stream, intended to mitigate climate change in areas of agriculture and forestry, as human activities affect changes in carbon exchange between the terrestrial ecosystem and the atmosphere (EC 2022f).

Long-term data versus new content of classes

There is a complexity in the duality of wanting to have data that fit into other classification systems or data that actually say anything about our local site. Both are important when seen from different perspectives. On one hand, long-term monitoring using specially developed classes and/or variables that best fit nature conservation sites within the national range of habitat types and species, mainly for the purpose of management decisions, creates strong local time series of biodiversity data. These series, going backwards in time, constitute a wealth of expert knowledge and observed changes, which can often be linked to changes in both cultural understanding, including policies, and with changes in the physical world, such as climate variations or chemical pollutants. Keeping a special legacy like that is, of course, important. On the other hand, these specialized datasets can be hard to combine with datasets from other countries, an important issue that has driven the recent funding to create ready-made layers of data across Europe (for example) provided by data portals. An example is Copernicus Services, which includes data layers based on monitoring data collected, analyzed, and reported to a common standard from all EU Member States; chapter 15 discusses this further.

Two directives are driving the issue towards harmonization. The EU INSPIRE Directive (EU 2022) was created to establish a pan-European spatial data infrastructure, to be able to receive data that are compatible and usable in a context of community (groups of countries) and across the borders of the different nations or states. To achieve the INSPIRE Directive, each Member State is required to annually report on how they are implementing this harmonization. Much work has been laid down over decades to create harmonized data collection to enable compilation of data across borders (e.g. EC 1999; Copernicus Services 2022). The Open Data Directive is not directly aimed at harmonization but focuses on reusing all public sector information (or governmental data), harmonized in a European data portal. In the EU, the public sector is one of the most data-intensive sectors. Public sector bodies produce, collect, and pay for vast amounts of data. Examples include geographical information, statistics, weather data, data from publicly funded research projects, and digitized books from libraries. *Open* means that public data can be readily and widely accessed and reused, sometimes under non-restrictive conditions (EC 2019). Both of these are important for the EU to provide web services for viewing and downloading data (EC 2019; Minghini et al. 2020). In this context, a monitoring scheme needs to be flexible and able to cope with new questions asked or new rules of data collection and analysis being issued from the policy side.

Tools to help compilation of data across borders

There are a number of different data portals providing the collected and compiled data as services for policymakers and researchers and for use in planning the environment on a regional, national, or international scale. Data painstakingly gathered, analyzed, and reported come back as easily accessible web services with maps and catalogues of various products with compiled information; see chapter 7. Many countries, states, and political unions worldwide have their own data portals with open data to support policy, including the European Copernicus Services catalogue (Programme of the European Union 2022b), the U.S. Government's open data (Data.Gov 2022), and the UK Data Service in the United Kingdom (UK Data Service 2022).

Aside from the already analyzed products, the free and available resource of remotely sensed data is bringing about a revolution in the possibilities for monitoring, as multi-spectral images or radar and sometimes laser point clouds are obtainable from all over the world, downloadable from server halls where they are archived (see list in chapter 7). This is in stark contrast to recent times, when they were expensive enough to hinder most from acquiring satellite data and the analysis of public data rarely was open for all to use.

By contrast, with the diversity of in situ field methods, satellite instruments make exactly the same observations wherever they are in the world, giving results that – after performing pre-processing and calibration – are comparable with common standards of recording and metadata. It is possible to order analysis-ready images, but due to resampling and simplification, they can contain subpixel registration differences, which are hidden to the user, and analysis-ready images are not recommended. In addition, companies are providing "downstream" services, such as the Google Earth Engine, where researchers and companies can access data along with data handling and visualization tools and a library of algorithms, in R-scripts or other types. The library provides help both in choosing algorithms (new ones are constantly being developed, for different purposes) and in applying the same algorithms to data from other providers for change detection (Google Earth Engine 2022).

Collection and assessment – the importance of geographical scale

Collection of monitoring data is a scale-dependent process. This means that monitoring takes place at a chosen set of spatial scales that limit and focus what is observed. Demands for monitoring from government institutions typically also focus on certain spatial scales of particular relevance to policy, planning, or regulation, whereas processes manifesting at other scales may go unrecorded and/or unmanaged.

This means that within monitoring research, scale choices are important. The same research conducted at different scales may lead to several equally valid monitoring results (Henle et al. 2014). For example, a project focusing on tree health in forest landscapes could take, as its point of departure:

- Monitoring individual trees, allowing researchers an opportunity to analyze variations in tree density and health within stands and between individual organisms.
- The primary unit of observation could instead be patches of tree vegetation, which would support analysis focusing, for example, on connectivity between patches, ecosystem size, spatial variability, and distribution of habitats within forests, etc.
- Scaling further out would allow monitoring of whole forest landscapes, supporting research into how forests are distributed, affected by geomorphological conditions, and connected through flows of genetic information, energy, and matter (Forman and Godron 1986; With 2019).

As such, choosing a scale of monitoring is important for how ecosystems can be described, and often this choice depends directly on demands for monitoring. This is because demands for monitoring reflect scales of human decision making, policy, and practice, making them equally scale dependent. Therefore, precise and policy-relevant monitoring research often depends on finding a scale of observation and analysis that makes sense both ecologically (by capturing key variation in ecosystems) and socially (by matching the scale needed for decision making; Hägerstrand 2001). It is not always possible to reconcile social and ecological units of analysis if these do not match each other spatially (Liu et al. 2008). When demands for monitoring require certain scales taken into account to ensure relevance for subsequent formulating and evaluation of policies and regulation, it can be particularly challenging to match the scales.

Example of mismatching scales: farmland monitoring in Denmark

An example of mismatching scales is the case of nitrate pollution stemming from agricultural land use in Denmark, where leaching and emission of nitrate from fertilized agricultural fields to coastal waters, aquifers, and freshwater recipients represent a major ecological problem. Therefore, various kinds of general regulation have been imposed, limiting the use of fertilizer. This kind of blanket regulation has historically been a very efficient way of lowering nitrogen loading to recipient water bodies. However, further lowering of nitrogen emissions from agriculture while maintaining high levels of productivity in agriculture will depend on more targeted, differentiated measures that focus on those fields that emit the most nitrogen due to their location, soil, and hydrology (Dalgaard et al. 2014). This means shifting the scale of observation from whole watersheds (based on water quality measurements made continuously where streams meet the sea) to individual fields (either based on numerous measurements made in drain pipe exits or based on modelled emission estimates tuned to watershed totals). Experiments with this kind of monitoring and associated regulation show promising results, because it is at the scale of individual agricultural fields where emissions of nitrogen originate. There is, in other words, a match between the social and ecological processes interacting at the field/patch scale, making it possible to trace downstream environmental impacts back to particular practices and land units (Christensen et al. 2019).

The demands for monitoring coming from political and administrative interests instead emphasize farm businesses as the preferred unit for regulating nitrogen emissions and request monitoring matching that scale. Farm businesses, though, typically consist of many fields, which change ownership through time and may be located in several watersheds. This makes it exceedingly difficult to progress with monitoring and associated policymaking, because data reflecting ecological realities do not match political demands and ambitions for policy intervention (Christensen et al. 2021).

What is at stake here is generally referred to as a lack of "fit" between social, ecological, and administrative/political systems, including the spatial units and scales that they operate within (Epstein et al. 2015). Monitoring in general depends on researchers being able to fit such demands on monitoring together, creating and maintaining monitoring frameworks that match a range of different and often contradicting demands and concerns regarding scales of observation, analysis, and reporting of results.

When policy falls short: the High Nature Value farmland indicator

This example underlines the importance of having a clearly defined objective and precise methodological framework for the successful development of monitoring, and the results coming from different countries need to be compatible. It also shows why policies need revision.

The European Commission set up a new indicator for regular reporting from Member States in 2007, as a part of the Common Agricultural Policy (CAP) of the EU (EC 2022c). The term *High Nature Value (HNV) farmland* refers to types of farmland that are important for biodiversity, and the indicator was intended to show how much of the total agricultural area had high biodiversity and track changes in the area over time.

Each Member State should mainly use existing monitoring data to do this, but the EU forgot to define exactly what was meant by three classes (Table 3.1). They also did not show how different results, stemming from different monitoring schemes, should be used

Table 3.1 Indicator types with High Nature Value in farmland

Type	*Class*
1	Farmland with a high proportion of semi-natural vegetation
2	Farmland with a mosaic of habitats and/or land uses
3	Farmland supporting rare species or a high proportion of European or world populations

by the member country, leading to a variety of methodologies for identifying the three classes; see Table 3.2. In addition, when trying to complete missing data to fulfil the obligation, the vague guidelines led to differences in what area types were perceived as important or what scale should be used for the monitoring (van Doorn and Elbersen 2012).

A number of Member States tried to follow the guidelines that did exist (Andersen et al. 2003) but had to back down (e.g. Zomeni et al. 2018). It was quite obvious that mismatching occurred on several levels when Paracchini et al. (2008) made an overlay analysis to estimate the distribution patterns of High Nature Value farmland in Europe based on reported biodiversity data and land cover. The European Commission will remove the indicator from the common indicator set from 2023 and onwards, due to the lack of comparability.

One of the few that did succeed was Germany, where the 16 Federal States of Germany decided to cooperate by developing a common approach to create harmonized data. The various data sources already existing in the German states were analyzed to grasp to what extent they were compatible in relevance to the three indicator classes, including biotope mapping programmes, Farm Accountancy Data Network (FADN; EC 2022a), remote sensing data, grassland monitoring, Natura 2000 monitoring, etc. The result mirrored the internal inconsistencies that other EU members had encountered, such as:

- Extensive heterogeneity existed between the relevant mapping programmes of the individual Federal States concerning spatial and temporal resolution.
- There was a limited extent and selectivity of monitoring programmes, not matching the total utilized agricultural area.
- Resampling of data was often not secured or had extended time gaps that did not fit the mandatory reporting cycle.
- Enormous costs of obtaining the high-resolution remote sensing data needed to focus on detailed biodiversity.
- Natura 2000 monitoring was done within a small random sample, not matching the total utilized agricultural area and not matching all relevant categories.
- Data availability was restricted from the FADN due to data privacy regulations.

The best solution instead proved to be the implementation of a new, strictly targeted and cost-effective monitoring programme, which was in fact more cost-effective than expanding and adapting the whole list of already running programmes. A random sampling approach was developed and biodiversity data on the common agricultural landscape were collected on a national level and in a systematic manner in Germany (Benzler and Fuchs 2016). So, finally this example illustrates how important it is to have iterative developments of both the requirements as well as the methodology used for the actual monitoring.

Table 3.2 Methods used in different EU Member States to identify High Nature Value farmland and effectiveness in identifying the three types of High Nature Value farmland

Method	*IRENA/ EEA*	*Land cover*	*Soil/ altitude*	*Management schemes*	*Farming systems*	*Species data*	*EU designated areas*	*National designated areas*	*Other habitat identification*	*Site sampling*	*IACS/ LPIS*	*HNV type 1*	*HNV type 2*	*HNV type 3*
Case	*Methods used (x=used)*											*Effectiveness in identification*		
1				x							x	xx	x	
2							x		x			xx		
3							x	x						xx
4		x					x		x		x	xx		xx
5							x	x	x			x		xx
6	x											xx	x	
7										x		xx	xx	xx
8		x					x					xx		
9		x	x			x	x	x	x			xx	xx	xx
10							x	x				x		xx
11							x	x				x		xx
12		x			x							xx	xx	
13							x		x			x		xx
14		x			x		x		x			xx		xx
15		x		x			x		x			xx	x	xx
16	x												xx	
17	x											xx	x	
18		x										xx		
19		x		x	x		x	x			x	xx	x	xx
20		x		x	x	x					x	xx	x	x
21		x			x	x						xx	x	xx
22		x										xx	x	
23		x			x	x						xx	x	xx
24		x			x						x	xx		
Total	**3**	**13**	**1**	**4**	**7**	**4**	**12**	**6**	**7**	**1**	**5**	**18 + 4**	**4 + 9**	**13 + 1**

Source: Modified from Peppiette (2011).

XX means the indicator was effectively identified; a single X indicates partial identification.

Abbreviations: IRENA/EEA = Indicator reporting on the integration of environmental concerns into agricultural policy, a project run by European Environment Agency; IACS = The Integrated Administration and Control System (which consists of computerized databases of the subsystems); LPIS = Land Parcel Identification System; HNV = High Nature Value (HNV) farmland describes the link between extensive farming systems and their use of semi-natural land and the conservation of high biodiversity in agricultural landscapes).

Conventions and agreements for the environment on land, water, and semi-aquatic areas

Environmental monitoring may be initiated for several different reasons. One important reason is that countries need to start monitoring programmes as a direct or indirect response to international environmental agreements. Parties, usually countries, agree upon conventions as a means for promoting collaboration and developing international law and action towards specific goals that cannot be reached independently. As part of the agreements, some conventions prescribe detailed monitoring and reporting of progress, whereas others are vague and leave it to the parties to decide upon appropriate measures.

The directives are also constantly revised and added to as the Member States report on difficulties or how something was meant to be monitored but the agreed-upon methods just did not function for all states (e.g. Minghini et al. 2020). Some of the important conventions and directives are listed in Table 3.3.

In recent years there has been a change in demands from the EU, especially in the questions asked of monitoring. The enquiries have been changed into whether there are enough resources, habitats, or food supply for species or groups of species, making the analysis trend towards being more ecosystem based (accounts for ecosystem extent and condition). Another new demand is to measure the socioeconomic part of the natural capital accounting, aiming at the supply and monetary value of ecosystem services, in this way including human well-being in the reporting (Maes et al. 2020).

An example of an important driver of monitoring is the Convention on Biological Diversity (CBD), ratified by individual countries but also by the EU as a community. By being a Member State in the EU, each country is bound by EU law and to follow any prescribed efforts to reach the CBD or EU-specific targets, which often involve monitoring and reporting. Another important EU directive related to biodiversity is the Habitats Directive, which, among other things, prescribes recurrent reporting of state and change of listed species and habitat categories (EC 1992).

The Sustainable Development Goals (SDGs) are 17 objectives that Member States of the United Nations (UN) committed to achieve by 2030 and constitute the heart of Agenda 2030, aiming at peace and prosperity for the Earth as well as for people. Each goal has a number of targets that are linked to a set of indicators. Hence, achieving those goals requires measurement and monitoring of more than 240 indicators (United Nations 2015; EC 2022h).

The SDGs cover several dimensions:

- Economics (e.g. no poverty, zero hunger, decent work, and economic growth).
- Social (e.g. quality education, gender equality, reduced inequalities, peace, justice, and strong institutions).
- Environmental (e.g. climate action, clean water and sanitation, affordable and clean energy).

The directives and legislations that govern the waters of Europe went through a fitness check in 2020 to investigate the effects of the directives on water quality and current status and where the EU should alter legislation to make remedies or mitigation activities smoother for the Member States. One of the factors hindering achievement was the difficulty of establishing a governance framework that takes into account the specific conditions in each Member State. Another was the concept of “good status”, which

Table 3.3 Conventions and directives relevant to monitoring, regulating the way of collecting information

International conventions	*Purpose*
Global scale	
Convention on Biological Diversity (CBD)	Conservation and sustainable use of biodiversity, as well as fair sharing of genetic resources. Global coverage. Entered into force in 1993.
Ramsar Convention on Wetlands of International Importance	Protection of wetlands of international importance for waterfowl. Global coverage. Entered into force in 1975.
Paris Agreement	A legally binding international treaty on climate change, reducing greenhouse gases. Adopted by 196 parties at COP 21 in Paris 2015. Entered into force in 2016.
Convention on the Conservation of Migratory Species of Wild Animals	Conservation and sustainable use of migratory species. Global coverage. Entered into force in 1983.
World Heritage Convention (WHC)	Protection of outstanding cultural and natural heritage sites. Global coverage. Entered into force in 1975.
Sustainable Development Goals (SDG)	17 economic, social, and environmental goals encompassing 169 targets to achieve by 2030. Adopted by all UN member states in 2015.
UN Gothenburg Protocol	Reduction in acidification, eutrophication, and ground-level ambient pollutant concentrations and exposure. Agreed on in 1999.
United Nations Framework Convention on Climate Change (UNFCC)	The objective is to stabilize human-induced greenhouse gas concentrations, preventing levels that could be dangerous to the climate system. Ratified by 197 countries, it binds Member States to act in the interests of human safety, even in the face of scientific uncertainty. Entered into force in 1994.
Protocol on Strategic Environmental Assessment	A legally enforced assessment procedure, aiming to ensure consideration of environmental and sustainability aspects to policies and legislation (non-mandatory) as well as plans and programmes. Europe, Caucasus and Central Asia, UN.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	An international agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species. Entered into force in 1975.
EU or community scale	
Bern Convention on the Conservation of European Wildlife and Natural Habitats	Protection of natural habitats and endangered species in Europe and northern Africa. Entered into force in 1982.
European Landscape Convention	Protection, management, and planning of European landscapes. Entered into force in 2004.
Convention on Long-Range Transboundary Air Pollution	Reduction of long-range transboundary air pollution. North America and Europe. Entered into force in 1983.

(*Continued*)

Table 3.3 (Continued)

International conventions	*Purpose*
Water Framework Directive (WFD)	Ensure good status for all ground and surface waters (rivers, lakes, transitional waters, and coastal waters). Including river basins and their management, as mitigation of runoff. Adopted in 2000.
EU Marine Strategy Framework Directive 2008/56/EC (MSFD)	To protect the marine environment across Europe. Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020 at the latest. Adopted in 2008 (EEA 2008)
The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)	To protect and manage the North-East Atlantic through strategies that are legally binding on the contracting parties, recommendations, and other agreements. Entered into force in 1998. The North-East Atlantic Environment Strategy (NEAES) 2030. Adopted in 2021 (OSPAR Commission 2021).
The Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, HELCOM)	Covers the whole of the Baltic Sea area, including inland waters as well as the water of the sea itself and the seabed. Measures are also taken in the whole catchment area of the Baltic Sea to reduce land-based pollution. Entered into force in 1980 with updates in 2000–2013. HELCOM (2014).
Environmental Quality Standards Directive (EQSD)	Establish environmental quality standards in the field of water policy. Entered into force in 2008.
Groundwater Directive (GWD)	Have been integrated into the Water Framework Directive.
Floods Directive (FD)	To establish a framework for the assessment and management of flood risks. Reduce negative consequences on human health, economy, the environment, and cultural heritage. Entered into force in 2007.
Habitats Directive (or: Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora)	Specified areas for conservation, leading up the Natura 2000 Network to protect species and habitats. Consists of 24 articles of legislation with which all Member States must comply. Article 17 sets the terms and standards for reporting on both the habitats and species. Adopted 1992 in response to the Bern Convention.
Birds Directive (or: Council Directive 2009/147/EC on the conservation of wild birds)	The Birds Directive aims to protect all of the 500 wild bird species naturally occurring in the European Union. Adopted in 1979, amended in 2009.
The INSPIRE Directive	An infrastructure for spatial information in Europe to support community environmental policies and policies or activities that may have an impact on the environment. Entered into force in 2007.
Open Data Directive (Latest version: Directive (EU) 2019/1024)	Focussing on allowing reuse of public sector data (or government data), with open access, because they are publicly funded. Also for commercial use. Adopted in 2019.
Environmental impact assessment (EIA Directive)	All projects listed in Annex I are considered as having significant effects on the environment and require an EIA. Entered into force in 1985.

(*Continued*)

Table 3.3 (Continued)

International conventions	*Purpose*
National Emissions reduction Commitments (NEC) Directive	National emission reduction commitments for five important air pollutants. Replacing the older National Emission Ceilings Directive. Entered into force in 2016.
Regional Scale	
Alpine Convention	Protection and sustainable development of the Alps (covers 13 topics; e.g. biodiversity, water, climate, spatial planning, and green economy). Signed by eight alpine countries and the EU. Entered into force in 1995.
Strategic environmental assessment (SEA Directive)	A legally enforced assessment procedure aiming to ensure consideration on environmental and sustainability aspects implemented in plans and programmes. Regional to local scales. Was adopted in 2001.

The scale can be on several levels: global; a group of countries acting in unison, like the United Nations or the European Union; or smaller groups like the countries around the Alps or the UK. Most countries belong to some of these groups.

depends on measures to mitigate current pressures but often forgets the restoration measures needed to address pressures from the past. Finally, good status of water bodies is highly interconnected to a number of other pieces of EU legislation, such as the Nitrates Directive and the Urban Waste Water Treatment Directive, as well as better integration of water objectives in other policy areas such as agriculture, energy or transport.

There are some directives aimed specifically at water bodies, including:

- The Water Framework Directive (WFD): The policy key in the Water Framework Directive is simply that each country should work to get polluted waters clean again and ensure that clean waters are kept clean, whether marine or freshwater bodies (European Environment Agency [EEA] 2008; EC 2022i).
- The Environmental Quality Standards Directive (EQSD): This directive is a component of the WFD and regulates the monitoring and reporting of priority substances of pollution (currently 45 substances, of which 12 were added in 2013). Some of these are also hazardous substances, being either ubiquitously persistent, bioaccumulative, or toxic substances (EC 2013).
- The Groundwater Directive (GWD): The components of the Water Framework Directive dealing with groundwater cover a number of different steps for achieving good quantitative and chemical status of groundwater. The latest update was made in 2015 and includes the designation (with a view to specify such bodies that run the risk of not achieving the WFD environmental objectives) and reporting of groundwater bodies from each Member State. The EU also wants monitoring networks, established registers of protected areas, and management plans for such things as bathing areas, river basins, and bodies used for drinking water (EC 2006).

- The Floods Directive (FD): This directive deals with the assessment and management of flood risks and requires Member States to assess all watercourses and coastlines for risks of flooding and to map humans and assets at risk and to take measures to reduce those risks (EC 2007).

Specific directives also exist directly relevant to wetlands, one of the first nature conservation issues for European and international policy consideration under the 1971 Ramsar Convention on the conservation and wise use of wetlands and their resources (Ramsar 1971). Many of the objectives, targets, and actions in the following CBD and the Agenda 2030 (especially SDG 6), are directly relevant to the conservation and wise use of wetlands.

However, the Habitats and Birds directives and the WFD are the main pieces of legislation ensuring the protection of Europe's wetlands. The Natura 2000 network of protected sites and the integration of wetlands into future river basin management planning (under the WFD) provide ways to ensure their future conservation and sustainable use (EC 1992, 2022i).

Monitoring for fulfilment of policies, some examples

The Natura 2000 network

Most data, aside from curiosity-driven surveys for research, are collected to be analyzed and reported to some authority, which in turn can collate several data sources and report further on. One example of such monitoring is the national report from each Member State, due every sixth year, reporting on the status and change of a large series of protected areas, in a framework called the Natura 2000 network of protected areas by the European Commission, organized under the Habitats Directive. The network was set up to fulfil the obligation as one of the contracting parties to the Bern Convention on the Conservation of European Wildlife and Natural Habitats as the contribution to a higher level, the Pan-European Emerald Network of the Bern Convention (Council of Europe 1979; EC Directorate-General for Environment 2008).

The network celebrated 30 years in 2022 and now constitutes the largest coordinated network of protected areas in the world, covering about 18% of the EU's land area and more than 8% of its marine territory (EEA 2022; EC 2022g).

The policy behind the network was to offer a long-term haven to Europe's most valuable and threatened species and habitats, regulated in two directives, the Birds and Habitat directives. These directives have allowed the creation of a representative system of legally protected areas throughout the EU, called Sites of Community Importance (SCI; EC 1992). On the dedicated web site of the EEA, more information and maps and data are provided for the conservation of the 233 habitat types listed in Annex I of the Directive and the 900-plus species listed in Annex II (EEA 2022). Figure 3.1 shows such a site of community importance, a grassland with long-term management of grazing in southern Sweden.

Green spaces and human well-being

An example of complying with directives about human well-being and monitoring that integrates the social component of humans and how they integrate with their environment is the investigation into the health benefits of access to green areas;

Figure 3.1 An example of a Natura 2000 Site of Community Importance in the county Scania, southern Sweden. A grassland with long-term management of grazing by the seaside, with high biodiversity in plants and insects, providing good conditions for many birds.

Credit: Photo by Anna Allard.

see Figure 3.2. More than half of the population worldwide live in cities, a number that the UN (2019) expects to increase to 64% by the year 2050. This poses problems, for both planners of designers of urban areas and in the increasing demand for housing, because this massive urbanization is associated with severe environmental problems that negatively affect human well-being (Reyes-Riveros et al. 2021). Academically, the concept of human well-being is multi-faceted and can easily fit into social sciences, philosophy, or biodiversity and on the whole is multidimensional, including various aspects of life, upon which the measurements are based, aiming to study the links between ecosystem change and human well-being. The definition of what is perceived as good and beneficial to well-being is not always clear and may well differ depending on who you are and where you were born (did you grow up by the sea, in the highlands, on a farm, or in a city?). It is important to explore the different individual ways of looking at green spaces (Wood et al. 2018; Jabbar et al. 2021; Reyes-Riveros et al. 2021).

In a review of 153 research articles, Reyes-Riveros et al. (2021) found that the number of green spaces available and their percentage of vegetation cover and size improved human well-being in all aspects, especially health. The naturalness of the landscape and biodiversity were the characteristics most valued in the articles, and especially improved mental health and social relations.

Figure 3.2 A small park in a stone city provides the opportunity for a moment of tranquillity with the city noise replaced by birdsong (Visby, Sweden).

Credit: Photo by Anna Allard.

Monitoring oceans: the ICES example

A number of collaborations exist on the monitoring of the oceans, some for weather models or litter analysis and others for monitoring the resource of fish; the International Council for the Exploration of the Sea (ICES) is one example. EU fisheries management is governed by the Common Fisheries Policy (CFP), which is based on the need to ensure environmentally sustainable use of marine biological resources and long-term profitability for the fisheries sector. A priority area for the CFP is to safeguard fishery resources by adapting fishing capacity to fishing opportunities. To achieve sustainable exploitation, fish stocks are managed with the principle of maximum sustainable yield (MSY). Annually, the EU allocates fishing opportunities for most commercial species, expressed as total allowable catch (TAC). Based on scientific assessments by ICES and EU's Scientific, Technical and Economic Committee for Fisheries (STECF), the Commission presents its proposals for total allowable catch to the Council at the end of each year.

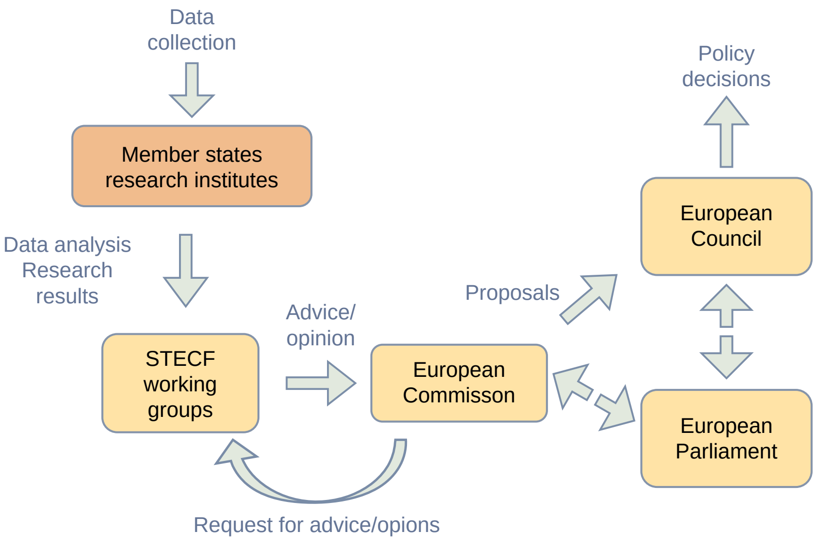

Figure 3.3 A simplified overview of STECF's role in the EU's marine policy.

Source: EC (2016).

The marine planning cycle for monitoring of aquatic resources includes several steps and authorities (EC 2016). Following the EU's data collection framework (DCF), Member States annually collect fish and fisheries data in support of CFP. The Member States data collection follows a national work plan, which is coordinated in regional coordination groups (RCGs) that can also suggest regional work plans. The data collected from the Member States are used by ICES for further analyses, and some of the data are uploaded to the EU's joint research centre (JRC) databases to fulfil the needs of the European Commission. After analysis and quality assurance, STECF working groups provide scientific opinions and recommendations in support of the Commission's policymaking (see Figure 3.3).

ICES provides advice and services on marine ecosystems for several different authorities and organizations. Among those, ICES has standing requests for recurrent advice from the European Commission. The advisory process for fishing comprises four major steps (ICES 2019; Figure 3.4). First, the request is formulated in an iterative dialogue with the requester's need for advice. Secondly, in accordance with ICES data policy (ICES 2016) and codes of conducts (ICES 2018), expert groups bring forth the best available knowledge. Thirdly, after an independent review of the data and methods used, a draft of the advice is produced and then the advice is finally approved in consensus by the ICES Advisory Committee (ACOM) as the final step. To ensure the relevance of the methods and data series used by the expert groups for ongoing advice, a benchmark process is conducted addressing the requests. This process is subjected to a peer review process. To keep the process transparent, stakeholders with observer status have the possibility to attend the workshops and drafting groups and receive approval of the ACOM.

The advice on fishing opportunities integrates ecosystem-based management (EBM) with MSY, an objective aiming to achieve highest yield over time. The basis for the advice depends on the request for the advice as well as the information and knowledge

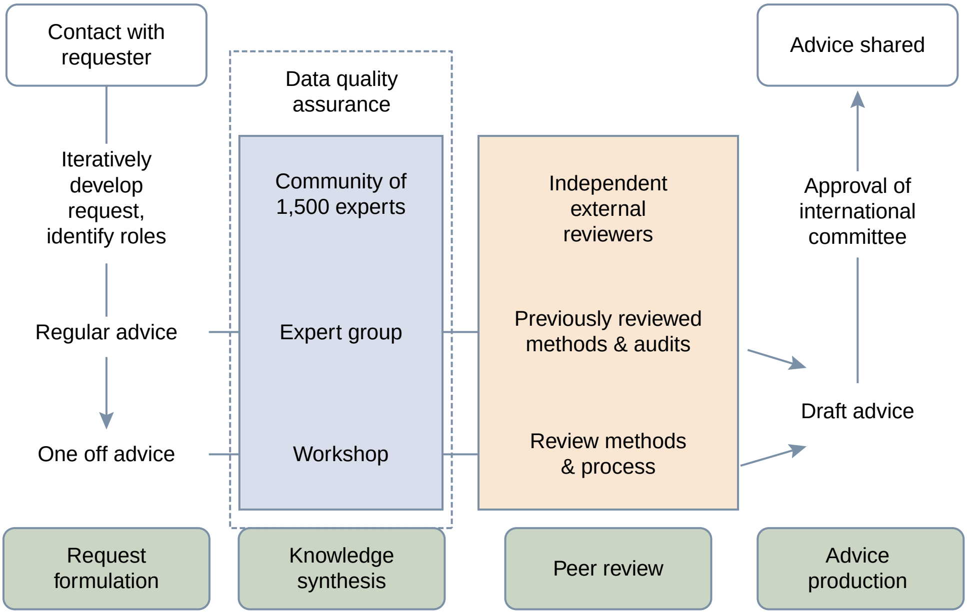

Figure 3.4 Simplified description of the ICES advisory process.

Source: ICES (2019).

available for the fish stock/stocks in question. For fish and shellfish stocks where sufficient data are available, advice based on so-called full analytical assessments and forecasts is provided. Data used are estimates on fishing mortality (F) – that is, the number of fish taken by the fisheries – and spawning stock biomass (SSB), which is the biomass of fish that would reproduce. To ensure that the spawning stock does not become too low, a number of precautionary reference points are used, both for mortality and for the biomass.

For fish stocks where data only include time series and indices on trends, advice based on proxies for MSY could be used. For other fish stocks with less data, or if knowledge of the fish stock in any sense is insufficient, ICES employs a precautionary approach (UN 1995).

Monitoring forest, assessments of stock, and estimations of greenhouse gases are global issues

Maintaining and increasing forest is a worldwide issue and hence also policy concern (see Text box 3.1). To provide answers to follow trends in forests worldwide, monitoring is important. When trying to compile data from many different countries, with various capabilities, it is also important that the rules and the framework for how to perform the monitoring be clear and concise. Forest ecosystems play a critical role in the global carbon cycle and help stabilize the climate; they regulate ecosystems, protect biodiversity, support human livelihoods, and supply goods and services that can drive sustainable growth (e.g. Mitchell et al. 2017; Food and Agriculture Organization [FAO] 2020a, 2022; Sleeter et al. 2022). The role of forest in climate change is twofold, acting as both a cause of greenhouse gas emissions and a solution for addressing it. According to the International Union for

Text box 3.1: The Global Forest Resources Assessment

The need to know the status of the forest resource and how it is changing was recognized in 1948 (after World War II), when the FAO stated that "the whole world is suffering from shortages of forest products" (FAO 1948). At that time, a future shortage of wood products preventing industrial and economic growth was the major issue. Over the years, other issues linked to the role and sustainability of the forests have come to the forefront – for example, wood fuel, poverty, biodiversity, desertification, climate change, and sustainable development – and the FRA data form one important input to global discussions, climate negotiations, and UN-promoted agreements (FAO 2020b).

Conservation of Nature (IUCN), in 2021, around 25% of global emissions were from the land sector (next after the energy sector) and about half of that was from deforestation and forest degradation. On the other hand, forests are also the best solution to the problem, because an estimated one-third of the CO_2 released from burning fossil fuels is absorbed by forests every year (UNESCO, WRI, and IUCN 2021; Sleeter et al. 2022).

In most tropical areas, deforestation is commonly driven by changes in land use and agriculture, and the underlying causes relate to existing policies and strategies combined with demographic, economic, market, institutional, and technological issues. In many low-income countries, especially those with a centrally planned economy, governments assess and monitor agricultural production and other social, economic, and landscape-related parameters for purposes of governance; for example, as a basis for five-year plans and development strategies. In some countries, like Vietnam, strategies and policies firmly direct the resource management at central as well as local levels, which is further discussed in chapter 10. Those data are usually based on questionnaires and not sufficiently consistent and unbiased to reflect long-term change processes and trends. To satisfy the need for strategic landscape data, many countries develop continuous national forest assessment and monitoring systems, or NFAs (Sandewall et al. 2001; FAO 2022). NFAs are usually highly sophisticated, continuous and designed to cover a country with a representative sample over time. They involve significant costs and require a permanent organization. Although they generate high-quality data, local perspectives are not easily integrated. Monitoring can, however, be designed in many different ways, and an example of a participatory approach for setting up monitoring landscapes in a policy context is presented by Sandewall and Gebrehiwot (2015).

The FAO runs a support system for developing national forest monitoring systems (FAO 2022a). The support includes a number of tools for in situ collection of forest data, to assess greenhouse gas emissions and help to set up satellite land monitoring systems. Examples are deforestation or afforestation, where countries get help to identify and collect data for their relevant land use and its change (LULUC); forestry; and REDD+ activities (FAO 2022). REDD+ is an international framework whose name stands for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN, Framework Convention on Climate Change 2022).

At the global scale, the FAO coordinates a program for standardizing the forest monitoring reports from different countries. The FAO also compiles and publishes global assessments periodically to provide a consistent approach to describing the world's forests and their changes over time. Those Global Forest Resources Assessments (FRA) are based on country reports prepared by some 340 nominated national correspondents. In addition, FAO promotes the development of national forest monitoring systems (FAO 2020a; Ramirez and Morales 2021; EC 2022e) in low-income countries through local capacity building.

In addition to forests and peatlands, permanent grasslands (non-ploughed grassy fields) naturally hold large stocks of carbon, preventing its escape into the atmosphere. Assuming we know the carbon stock, we also need to follow changes in both land cover and land use to estimate how much of the carbon dioxide currently kept in the ground could potentially be released, should the land use change (e.g. Mitchell et al. 2017). Monitoring for this question reports to the policy sector of land use, land use change, and forestry, including our use of soils, trees, plants, biomass, and timber, to provide information on how we are meeting our goals (Intergovernmental Panel on Climate Change [IPCC] 2006, 2014; EC 2022e). Copernicus Services has a few products in the catalogue, among which is the Gothenburg Scenario for reduction of greenhouse emission (Programme of the European Union 2022a).

Integrated farm-level surveys

Though agriculture has the potential to provide numerous ecosystem services, the global focus is mainly on production of food, feed, and energy, providing a limited supply of other valuable ecosystem services such as carbon sequestration, preservation of habitats and biodiversity, infectious disease mediation, water quality regulation, and water flow regulation (Foley et al. 2005). Moreover, agriculture remains a significant source of environmental degradation, contributing to nearly 25% of global greenhouse gas emissions, half from farming activities and the rest from land use change (IPCC 2014). Agriculture is also one of the main sources of water pollution, causing pesticide and nutrient contamination; it is also one of the main drivers of biodiversity loss due to deforestation and intensive agriculture practices and the main source of ammonia emissions.

Unsurprisingly, the focus of most farm surveys is on the economic performance of the sector. For instance, the EU has the farm accountancy data network (FADN), which is a harmonized farm-level survey used to monitor farm income and business activities and to evaluate the CAP (EC 2018). The survey targets agricultural holdings, surpassing a minimum size threshold, thereby capturing the largest producers and agricultural land users. It collects information on income, labour, assets, input costs, output value, and socioeconomic characteristics of farms.

However, both the major role that agriculture plays in environmental degradation and its potential to provide ecosystem services have prompted some governments to promote initiatives to improve the environmental performance of the sector and propose farm surveys that focus on multiple dimensions (economic, social, and environmental). Recently, the EU has adopted the Farm to Fork strategy and the Biodiversity strategies. Farm to Fork aims at making the food system fair, healthy, and environmentally friendly (EC 2022d), and the Biodiversity strategy offers a plan to protect nature and reverse ecosystem degradation (EC 2022b).

In accordance with these initiatives, the EU is proposing to transform the FADN into the Farm Sustainability Data Network (FSDN) with the purpose of widening the scope of the farm surveys to cover environmental and social factors and to provide a comprehensive overview of farming activities in the EU. Integrated data collection on sustainability and economic indicators at the farm level can be done as high-precision hyperspectral remote sensing (see chapter 8) or by combined measurements and has both advantages and disadvantages (see Table 3.5). The advantages are that it facilitates evaluating the jointness and trade-offs between economic and environmental performance indicators, it permits combined policy evaluation of environmental and economic outcomes, and it can be done using existing data collection processes. For example, surveys of financial flows (e.g. input costs and sales) can be extended to collect data on physical flows related to inputs (e.g. fertilizer, pesticides, active substances, energy consumption; Vrolijk et al. 2016). Nevertheless, the integrated collection of data also comes at a cost. It increases the complexity of data collection and may require adjustment of the observation unit (e.g. commercial farms vs. small farms) and re-adjustments of sampling design, standard collection systems, and working processes.

However, providing this detailed and range of data is not always easy to do. Ireland's Agriculture and Food Development Authority (Teagasc) is one of the few government agencies in EU Member States that collect integrated information on economic, social, and environmental performance of farms. This integrated approach permits a joint economic, social, and environmental assessment of the Irish farm sector. Teagasc publishes The Teagasc National Farm Survey Sustainability Report annually, based on information from a representative sample of 900 farms in the National Farm Survey, summarizing the performance of dairy, cattle, sheep, and tillage farms. Table 3.4 shows the economic, social, and environmental indicators collected in the 2020 Sustainability Report (Buckley and Donnellan 2021). The integrated assessment of the economic, social, and environmental performance of farms has proven to be valuable for policymaking in Ireland.

Key messages

- This chapter has discussed the synergies and mutual developments between monitoring and policies and legislation. We stress the importance of creating a monitoring scheme that can be flexible enough to incorporate new demands that arise from new concerns of potential environmental problems in the ever-changing world around us.
- Sometimes it is better to simply give up trying to accommodate new demands in a cluster of older schemes and instead start another targeted scheme, which avoids the expense and labour-intensive effort to force the old ones into compliance. However, changing the whole setup of classes or variables measured also means that an older time series will be discontinued and a mismatch in the time depth is created instead.
- We also touch upon cases where the required geographical scale is not matched by the scale of monitoring or when the questions and categories framed by policy are ambiguous or fuzzy, making any questions hard to answer.
- New data covering the entire planet have become free to users (until recently, they were expensive enough to hinder most from acquiring satellite data, whether images or laser or radar data).
- The ready-made layers of analyzed data provided on many data portals around the globe constitute end products made up of a large number of different national monitoring schemes and national reporting. Examples highlight a few of the monitoring schemes being made in response to some demand. Some of the relevant directives, policies, and legislation are being addressed on global, community, and national levels.
- Lastly, we discuss a case of the most local type, where the single human observer is the data provider. Table 3.5 summarizes some advantages and disadvantages with this type of locally integrated data collection.

Table 3.4 Indicators for measuring the economic, social, and environmental performance of farms in Ireland

Dimension	*Indicator*	*Measure*	*Unit*
Economic	Economic return to land	Gross output per hectare	€/hectare
	Profitability	Market-based gross margin per hectare	€/hectare
	Productivity of labour	Family farm income per unpaid labour unit	€/unpaid labour unit
	Economic viability	Economic viability of farm business	1 = viable, 0 = not viable
	Market orientation	Output derived from market rather than subsidies	%
	Family farm income	Family farm income per hectare	€/hectare
Environmental	Agricultural GHG emissions per farm	Absolute GHG emissions per farm	Tonnes CO_2 equivalent/farm
	Agricultural GHG emissions per hectare	Absolute GHG emissions per hectare	Tonnes CO_2 equivalent/hectare
	Agricultural GHG emissions per kg of output	GHG emissions efficiency	kg CO_2 equivalent/kg output AND kg CO_2/€ output
	Energy GHG emissions per farm	Farm GHG energy use efficiency	kg CO_2 equivalent/kg output
	Energy emissions per kg of output	Energy GHG emissions efficiency	kg CO_2 equivalent/kg output AND kg CO_2/€ output
	NH_3 emissions per farm	Absolute NH_3 emissions per farm	Tonnes NH_3 equivalent/farm
	NH_3 emissions per hectare	Absolute NH_3 emissions per hectare	Tonnes NH_3 equivalent/hectare
	NH_3 emissions per kg of output	NH_3 emissions efficiency	kg NH_3 equivalent/kg output AND kg NH_3/€ output
	N balance	N transfer risk	kg N surplus/ha^{-1}
	N use efficiency	N retention efficiency	% N outputs/N inputs
	N surplus per kg of output	N emissions efficiency	kg N surplus/kg output
	P balance	P transfer risk	kg P surplus/ha^{-1}
	P use efficiency	P retention efficiency	% P outputs/P inputs
Social	Household vulnerability	Farm business is not viable and no off-farm employment	Binary variable: 1 = vulnerable
	Agricultural education	Formal agricultural training received	Binary variable, 1 = agricultural training received
	Isolation risk	Farmer lives alone	Binary variable, 1 = isolated
	High age profile	Farmer is over 60 years old and no members of household under 45	Binary variable: 1 = high age
	Hours worked on farm	Farm workload of farmer	Hours worked on the farm
	Total hours worked	Workload of farmer	Total hours worked on- and off-farm

Source: Buckley and Donnellan (2021)
Abbreviations: GHG = greenhouse gases; CO_2 = carbon dioxide; NH_3 = ammonia; N = nitrogen; P = phosphorus.

Table 3.5 Advantages and disadvantages with integrated collection of environmental and economic data

Advantages	*Disadvantages*
Jointness and trade-off between objectives/ indicators	Increased complexity of data collection
Allows for integrated policy analysis	Possible need to reconsider field of observation
Use of existing procedures and quality mechanisms	Wide variety of objectives complicates sample design
	Need to re-adjust current systems and working processes

Source: Vrolijk et al. (2016).

Study questions

1 What are the main advantages of directives and the common goals?
2 Why can the organized monitoring of oceans act as a role model to other areas of monitoring?
3 What are the 17 Sustainable Development Goals? What dimensions do they cover and why?

Further reading

Laws and legislation, with explanations and most recent updates, can be found at the web pages of the European Commission and the EU as well as the European Environment Agency. We recommend always reading up on the latest news, because new policies or health checks on the outcomes from current policies and international ratifications of agreements will, from time to time, be altered or added to. By knowing what lies behind the laws or policies, it is easier to understand the questions we need monitoring to answer.

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