interdisciplinary work and of making more efficient use of resources and information. Strengthening research-related information systems is widely regarded as a priority, both as a means of disseminating research outputs and as a means of making relevant information available to researchers. Countries mention, for example, the need to establish systems for monitoring the status and trends of various components of biodiversity or for managing relevant geographical data.

In many countries, policy frameworks for research are reported to be weak, absent or poorly implemented. For example, ensuring support for long-term activities such as monitoring can be a challenge. Some countries indicate that weaknesses stem from a lack of interest or awareness at political level and suggest that advocacy efforts in this regard need to be strengthened. Many also note the need to improve the mechanisms through which research on associated biodiversity informs policy-making.

Links between research and practical activities at production system level are also reported to need strengthening. Concrete proposals in this regard include involving relevant stakeholders throughout the whole research-project cycle from planning to monitoring, improving links to extension services and to producers themselves, and integrating measures of practical impact into evaluation mechanisms for research projects.

8.6 Valuation

- Economic valuation tools can help to make the hidden benefits and costs of biodiversity and biodiversity loss more visible, increasing awareness of the need for conservation and driving more effective conservation policies, including incentive schemes.
- A number of countries highlight the importance of valuation studies, but note that major knowledge gaps remain.
- Quantifying the values of ecosystem services and biodiversity is often challenging because of the difficulty and cost of data collection, the complexity of the ecological processes involved, and geographical and cultural differences in how biodiversity and the benefits it provides are perceived.
- Priorities for enhancing work on the valuation of biodiversity for food and agriculture include:
  - strengthening policy and institutional frameworks for integrating valuation studies into conservation strategies;
  - standardizing valuation methodologies and tools; and
  - ensuring sufficient resources are made available to support valuation studies.

In economic terms, many of the ecosystem services supplied by biodiversity (particularly many supporting, regulating and cultural services) are public goods or common pool resources.[56] In other words, people cannot be excluded from accessing them and are therefore not obliged to pay for doing so. This means that there tends to be little profit to be made from increasing or maintaining their supply. Moreover, as services of this kind are, in normal circumstances, not traded, they have no market prices, which means that they are less easy to integrate into assessments of the costs and benefits of policy interventions. This in turn may contribute to their being neglected not only by the private sector but also in the formulation of public policies and legislation (CBD Secretariat, 2007).

Various economic valuation tools can help to make the hidden benefits and costs of biodiversity and biodiversity loss more visible and may thus help both in increasing awareness of the need for conservation and in the formulation of more effective conservation policies (FAO, 2007a; TEEB, 2018). Interest in applying techniques of this kind has been increasing in recent years. For example, Sustainable Development Goal 15 includes the target: "By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts."

[56] Public goods are goods that non-excludable (i.e. everybody can access them) and non-rivalrous (i.e. people can use them without reducing their availability to others). Common pool resources are goods that are non-excludable, but are rivalrous (i.e. they cannot be used without reducing their availability to others).

Evidence from global assessments in the fisheries and forest sectors shows that the benefits that conservation measures deliver in terms of ecosystem services can significantly outweigh the investment costs involved in implementing them (CBD Secretariat, 2014b). However, conservation often requires significant financial or other investments, involves some economic risk to those doing the investing and may lead to short-term declines in the flow of benefits even if they increase over the longer term. As discussed in Section 8.7, various kinds of incentive measures can help to overcome constraints of this kind and promote actions that increase the supply of ecosystem services. Valuation of the resources and services targeted plays an important role in the development of effective incentive schemes (FAO, 2007a; CBD Secretariat, 2007).

Measuring and quantifying the value derived from ecosystem services and biodiversity are often difficult (and also costly in terms of the resources needed for data collection and analysis). Benefits to humans emerge from complex interactions and interlinkages between different ecological processes and components of biodiversity (Gómez-Baggethun and Ruiz-Pérez, 2011). Moreover, the values people assign to ecosystem services and biodiversity vary geographically and culturally (Atkinson, Bateman and Mourato, 2012). Different valuation techniques (see below) are based on different underlying assumptions and simplifications, and each has its own sources of bias (MEA, 2005b; CBD Secretariat, 2007). Moreover, the whole concept of assigning monetary values to natural assets and ecosystem services has been criticized by some on the grounds that it facilitates the commodification of nature, which it is argued in turn may lead to a distorted or oversimplified understanding of the ecological and social processes involved and to increasing inequalities in access to the benefits of ecosystem services (e.g. Gómez-Baggethun and Ruiz-Pérez, 2011). Services provided by biodiversity are crucial to the survival of complex ecological systems that affect food, water and other aspects of human security. The so-called planetary boundaries for several of these services are now in danger of being breached (Rockström *et al.*, 2009), and it has been argued that sustaining such functions and services should not be traded against other economic benefits.

Although efforts are sometimes made to estimate the full value of a given ecosystem (see further discussion below), it has been argued that for practical decision-making purposes it may be more useful to estimate the marginal changes that particular interventions will bring about in the value of ecosystem services (MEA, 2005b; CBD Secretariat, 2007).

8.6.1 Overview of valuation approaches

Attempts to value natural resources are often based on the so-called total economic value (TEV) framework (e.g. FAO, 2007a; MEA, 2005b; Pearce, 1993; CBD Secretariat, 2007). The TEV of a given ecosystem or component of biodiversity can be described as the sum of its direct use values, indirect use values, option values, bequest values and existence values (Pearce and Moran, 1994).

As the name suggests, direct use values are values that arise from the actual use of resources, whether in the form of tangible products, such as food, water or timber, or in the form of recreational activities, such as angling or photography. Indirect use values, in contrast, arise not from the use of the resources themselves but from their roles in underpinning flows of benefits (or in preventing losses) – for example the value of pollination, flood prevention, carbon sequestration or pest control provided by ecosystems and components of biodiversity. Option values are values derived from the maintenance of a resource for the option of using it in an uncertain future, for example a drought-tolerant crop for possible use in future climate change-affected production systems. Existence values are benefits derived from the mere knowledge that particular resources (e.g. particular species or ecosystems) exist, even if they are never used. Bequest values are derived from the knowledge that resources are being maintained for future generations.

Among the various components of TEV, direct use values are the most frequently quantified, as in many cases they can be traded on markets for cash. The difficulty involved in comprehensively

valuing biodiversity therefore often relates to the other components of the framework, although valuing some use values (e.g. leisure activities for which there is no charge) can also be challenging. Direct and indirect use values often have more immediate influence on governments and companies than option and existence values.

Many methods can contribute to the valuation of natural resources and ecosystem services. The applicability of a particular technique depends on the circumstances, for instance on the type of value under consideration and on the availability of markets for – and data on – relevant products and services (MEA, 2005b). Three main categories of valuation techniques can be distinguished based on the availability of market information: i) direct market valuation approaches; ii) revealed-preference approaches; and iii) stated-preference approaches (e.g. Chee, 2004; TEEB, 2010). Each of these is briefly described below. Information on other methods can be found in the ValuES Methods Database.[57]

Direct market valuation approaches

Direct market valuation approaches use data on prices, costs and quantities derived from existing real markets. Kumar (2010) distinguishes three types of direct market valuation technique: market price-based approaches; cost-based approaches; and production function-based approaches.

Market price-based approaches are often used to obtain use values for provisioning services sold on actual markets (e.g. food and other products). Cost-based approaches estimate the cost that would be incurred if ecosystem services were absent (avoided-cost method), the cost of replacing ecosystem services with artificial substitutes (replacement-cost method) or the cost of restoring ecosystem services if they were lost (restoration-cost method). Production function-based approaches can be used to estimate the contribution of a service that is not sold independently on a market (e.g. a regulating service) to another service that is (e.g. a provisioning service).

The main limitation of direct market valuation is its dependence on the existence of real market data: for many ecosystem services, markets are distorted or do not exist at all. Interlinkages and interdependencies between different ecosystem services make it difficult to derive reliable estimates by using cost-based or production function-based approaches (TEEB, 2010a).

Revealed-preference approaches

Revealed-preference approaches estimate values on the basis of observed behaviour on real or surrogate markets. The concepts underpinning several of these methodologies are willingness to pay (WTP) for obtaining or conserving particular assets and services or willingness to accept (WTA) their degradation or loss (CBD Secretariat, 2007; MEA, 2005b; TEEB, 2010). Two popular techniques in this category are the travel-cost approach and hedonic pricing.

The travel-cost approach is a method used to derive the values people assign to components of biodiversity, landscape features, etc. by analysing monetary expenditure on travel to sites where they can be experienced. It is mainly used to assess recreational values.

The hedonic-pricing approach can be used to estimate the values of particular environmental factors (clean air, beautiful views, etc.) by comparing the prices of goods and services that are traded on real markets and whose values are affected by the factors under consideration, for example real-estate values in different environmental settings (e.g. MEA, 2005b; TEEB, 2010).

A disadvantage of revealed preference approaches is that they are relatively costly and time consuming, as they require good-quality data and involve complex analysis. They also rely on assumptions regarding the relationships between the items under valuation and the surrogates used (TEEB, 2010a). They also do not solve the problem of how to quantify non-use values (i.e. existence and bequest values) (ibid.).

Stated-preference approaches

Stated-preference methods infer WTP or WTA based on what people state about their preferences

[57] http://www.aboutvalues.net/method_database

in hypothetical situations (e.g. CBD Secretariat, 2007; MEA, 2005b; TEEB, 2010). Such approaches have the advantage that they can be used to assess not only use values but also non-use values. Commonly used stated-preference methods include contingent valuation and choice modelling.

Contingent valuation involves directly asking respondents to state their WTP for a given ecosystem service or component of biodiversity or their WTA its loss or decline. Choice modelling is used to estimate WTP or WTA without asking respondents directly. Respondents are instead asked to choose between a given set of predefined products or services that vary in terms of the levels of a number of different attributes. If one of the attributes is measured in monetary terms (e.g. price or cost), it is possible to derive WTP or WTA for other attributes.

A major weakness of stated preference methods is the so-called hypothetical bias: statements about hypothetical behaviour on imaginary markets may not correspond to how people would behave in real life. Other limitations include the difficulty involved in designing adequate questionnaires and analytical models (e.g. Harrison and Rutström, 2008; MEA, 2005b; TEEB, 2010).

8.6.2 State of implementation

Overview

Recent years have seen a growing number of initiatives in the field of valuation of ecosystem services. These have included assessments of the values of specific ecosystem services, such as biological pest control (Daniels *et al.*, 2017; Waage, 2007) and pollination (Calderone, 2012; Gallai *et al.*, 2009), and attempts to estimate the total value of whole ecosystem categories such as forests, rangelands and coral reefs (e.g. Costanza *et al.*, 1997, 2014).

The extent to which the outcomes of valuation studies have had a practical impact on policy-making is difficult to determine (Laurans *et al.*, 2013), although it is clear that valuation studies of particular benefits, such as tourism revenue or flood prevention, do influence policy-making, for example in helping build confidence in investment in nature-based tourism (Balmford *et al.*, 2009). Understanding of valuation approaches is increasing, with a wide variety of tools and methodologies now available, ranging from software packages to bottom-up participatory approaches (Neugarten *et al.*, 2018). A growing range of services are being targeted under payment for ecosystem service schemes (see Section 8.7). Details of a number of initiatives in the field of valuation can be found via FAO's Incentives for Ecosystem Services web page.[58] The following paragraphs provide short overviews of a number of major recent and ongoing international initiatives addressing valuation of ecosystem services and biodiversity.

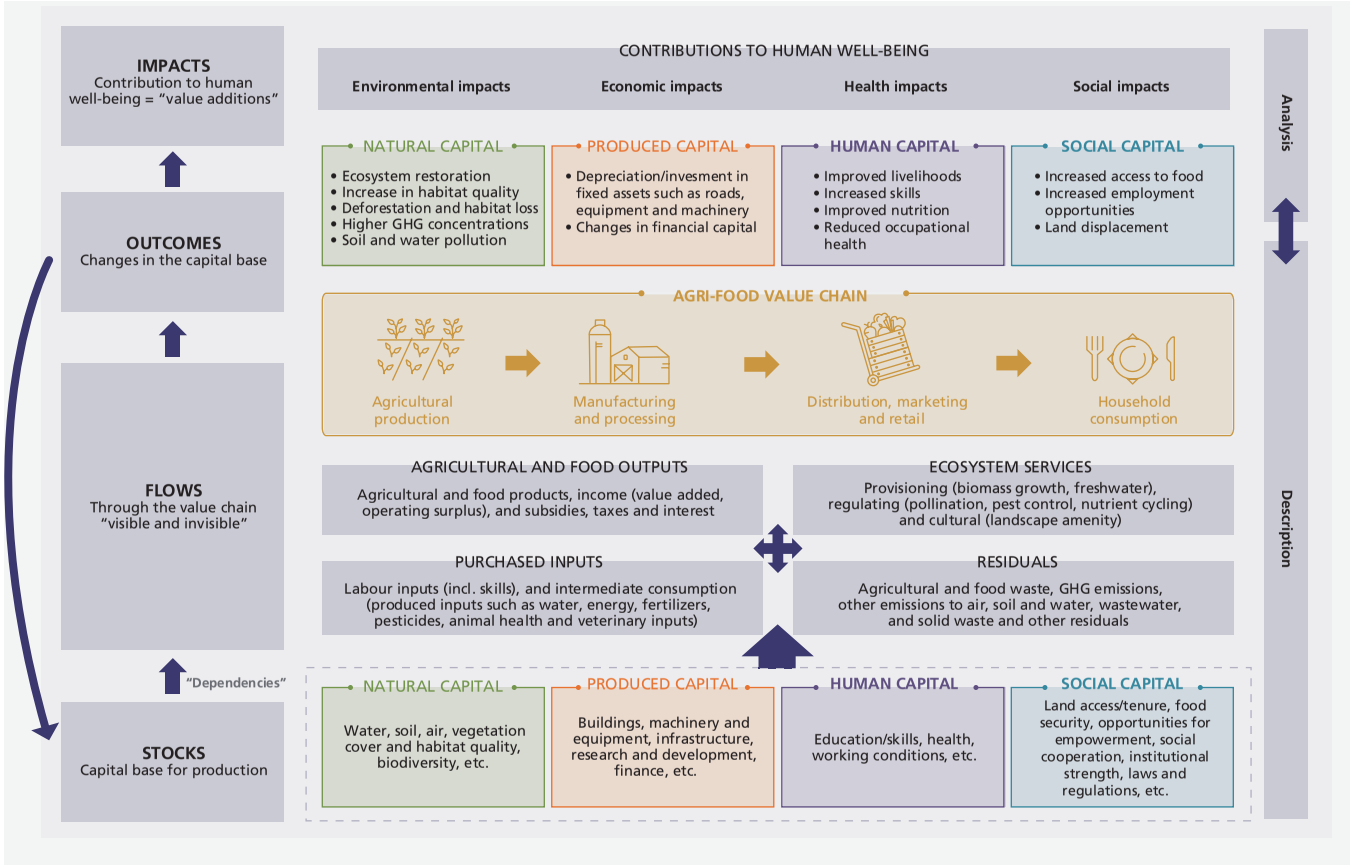
The Millennium Ecosystem Assessment (MEA)[59] was initiated in 2000 by United Nations Secretary-General Kofi Annan as a global effort to assess human impacts on the environment and the benefits humans receive from ecosystems. Outputs included a review of the merits and deficiencies of valuation paradigms and their potential contributions to decision-making and policy formulation to support the sustainable management and use of ecosystems (MEA, 2005b).

The Economics of Ecosystems and Biodiversity (TEEB),[60] launched as a global initiative in 2007 under the auspices of the United Nations Environment Programme, aims to assess the economic values of biodiversity and ecosystem services and raise awareness of the costs of biodiversity loss. The TEEB approach consists of three steps: (i) recognizing the value of ecosystem services and biodiversity; (ii) demonstrating value in economic terms; and (iii) capturing value in policy decisions (TEEB, 2010a).

TEEB for Agriculture and Food (TEEBAgFood)[61] was initiated in 2014 as a project focusing explicitly on the valuation of the externalities of so-called eco-agri-food systems. The term is intended to emphasize the inter-relations and dependencies between agriculture and food systems, biodiversity and ecosystems and human (social and economic)

[58] http://www.fao.org/in-action/incentives-for-ecosystem-services/toolkit/assessment-and-valuation/tools-and-models/en
[59] http://www.millenniumassessment.org
[60] http://www.teebweb.org
[61] http://www.teebweb.org/agriculture-and-food

FIGURE 8.1
Elements of the TEEBAgriFood Evaluation Framework



Note: GHG = greenhouse gas.
Source: TEEB, 2018.

systems. TEEBAgFood aims to "make visible" the hidden impacts and externalities associated with these systems and to provide policy recommendations that will promote sustainability in agriculture and food production. It has developed a universal valuation framework specifically for the agrifood sector, covering the whole value chain from production to consumption, and assessing the flows of a broad range of benefits and disbenefits, many of which are normally invisible in economic terms (TEEB, 2018). The main components of the framework are shown in Figure 8.1.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), under its Deliverable 3(d): "Policy support tools and methodologies regarding the diverse conceptualization of values of biodiversity and nature's benefits to people including ecosystem services", is assessing methodologies related to the values of biodiversity to human societies and evaluating their policy relevance (IPBES, 2014).

The System of Environmental Economic Accounting (SEEA)[62] is a framework developed by the United Nations Statistics Division to integrate environmental and economic data in the interest of better-informed decision-making. The SEEA Central Framework (UN *et al.*, 2014a) was endorsed as the international statistical standard for environmental–economic accounting by the United Nations Statistical Commission in 2012. The objective is to enable the integration of environmental information into national macroeconomic accounting systems so that national income accounts reflect environmental externalities and ultimately that these externalities can be better accounted for in decision-making. While the Central Framework takes an economic perspective, the complementary SEEA Experimental Ecosystem Accounting starts from an environmental point of view (UN *et al.*, 2014b). A sectoral subsystem, the System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries, has also been developed.[63]

Wealth Accounting and the Valuation of Ecosystem Services (WAVES),[64] a global partnership linked to SEEA, was launched at the tenth meeting of the Conference of the Parties to the CBD in 2010. WAVES aims to mainstream natural resources into development planning and national accounts through an approach referred to as natural capital accounting.

The Natural Capital Project,[65] a partnership between the Universities of Stanford and Minnesota, the Nature Conservancy[66] and WWF,[67] has developed InVest (Integrated Valuation of Ecosystem Services and Tradeoffs),[68] a suite of open-source software models for mapping and valuing ecosystem services.

Country-report analysis

The guidelines for the preparation of country reports did not contain specific questions on the valuation of biodiversity and ecosystem services. A substantial number of country reports, nonetheless, either provide information on the implementation of valuation studies or note needs and priorities in this field.

Several countries refer to published studies or ongoing research projects addressing the valuation of ecosystem services and biodiversity, although not all of these are explicitly related to BFA. While the information provided is fragmentary and the studies mentioned are mostly in the early stages of implementation, the general impression conveyed by the country reports is that there is an overall positive trend in the implementation of valuation studies on BFA and in the use of the outcomes of such studies in management and policy-making. The difficulties involved are, however, illustrated by the fact that some reports mention valuation studies that either were not completed or failed to get off the ground.

The reported studies generally target either specific geographical areas or specific types of

[62] https://seea.un.org
[63] http://www.fao.org/economic/ess/environment/methodology/en
[64] https://www.wavespartnership.org
[65] https://www.naturalcapitalproject.org
[66] https://www.nature.org
[67] https://www.worldwildlife.org
[68] http://www.naturalcapitalproject.org/invest

ecosystem at local or national scale. The former include, for example, a study reported by the Netherlands (Hein, 2011) that analysed the value of ecosystem services provided by the Hoge Veluwe forest (a protected area consisting of woodland, heath and grassland), including wood production, meat from hunting, groundwater infiltration, carbon sequestration, air-pollution removal, recreation and biodiversity. Belgium refers to the project Valuation of Terrestrial Ecosystem Services in a Multifunctional Peri-urban Space, which targeted a multi-ecosystem area in the central part of the country, deploying integrated social, biophysical and economic valuation approaches with the aim of informing decision-making in landscape planning.[69] Countries reporting an approach based on ecosystem categories include Yemen, which mentions valuation exercises for the environmental goods and services provided in rangelands, forests and mangroves. In the case of rangelands, it notes that the main service is the provision of fodder for livestock, but that other valuable benefits include the supply of pollination services to crop production, the supply of honey and medicinal plants, and the prevention of soil erosion.

A few countries refer to valuation studies targeting particular regulating or supporting ecosystem services at national level. For example, Finland mentions TEEB Nordic and TEEB Finland studies that, *inter alia*, estimated the value of pollination by honey bees at EUR 18 million for selected crops, EUR 39 million for produce from home gardens and EUR 3.9 million for wild berries.

A number of countries report the integration of valuation efforts into national strategies, policies or programmes targeting biodiversity and ecosystem services or describe institutional arrangements for work in this field. Viet Nam mentions that several ecosystem service-valuation studies are planned in the context of the development of a policy on payments for ecosystem services related to biodiversity protection, ecotourism, carbon sequestration and watershed protection (see also Section 8.7). Several countries specifically mention the inclusion of valuation-related targets in their national biodiversity strategies and action plans. For example, Switzerland notes that one of the strategic goals of the Swiss Biodiversity Strategy (Government of Switzerland, 2012) is to quantitatively assess ecosystem services by 2020 and to develop welfare indicators to complement gross domestic product. Ethiopia mentions that research aimed at addressing gaps in knowledge in the field of valuation is included in its National Biodiversity Strategy and Action Plan 2015–2020 (Government of Ethiopia, 2015) and that valuation is regarded as a key means of promoting conservation, sustainable use and access and benefit-sharing. Reports of institutions established to support valuation efforts come mainly from developed countries. For example, Ireland mentions the Irish Forum on Natural Capital,[70] a body supported by public and private agencies that aims to prioritize the integration of natural capital into national accounting. The United Kingdom refers to the Natural Capital Committee,[71] a body formed to provide expert advice to the government on the state of natural capital.

8.6.3 Needs and priorities

The importance of valuation of biodiversity and ecosystem services is emphasized in a number of country reports.[72] Several mention the need to integrate the value of these resources into national accounting systems or into broader measures of social welfare, as well as to use the outputs of valuation studies to guide national policies and research programmes. Several note the importance of valuation data in efforts to develop financial incentive mechanisms for biodiversity conservation.

Countries that mention valuation efforts for natural resources and ecosystem services generally indicate that major knowledge gaps remain to be

[69] See Fontaine *et al.* (2013) for further information.

[70] http://www.naturalcapitalireland.com

[71] http://www.naturalcapitalcommittee.org

[72] As noted above, countries were not specifically invited to report on this topic or to list needs and priorities in this regard.

filled. Some countries note specific gaps or priorities (e.g. microbial genetic resources in Ethiopia, wild pollinators in the United States of America and wild medicinal plants in Jordan).

A number of countries identify the need to strengthen institutions and policies that address the integration of the results of valuation studies into conservation strategies and other policies. Specific priorities mentioned include fostering cross-sectoral and interinstitutional cooperation in valuation efforts. Several countries mention the need for standardized valuation methodologies and tools for use in valuation exercises. The need for additional financial resources to support valuation efforts is also noted.

8.7 Incentives

- Incentives for the conservation and sustainable use of biodiversity for food and agriculture (BFA) can take a range of forms and originate from public programmes, private-sector investments or civil-society initiatives.
- Incentive measures are still often absent, and where they do exist a lack of coordination in their implementation often hampers success.
- Combining a range of incentive measures into an integrated package can help produce a greater impact in terms of promoting the sustainable use and conservation of BFA.
- Priorities for strengthening incentive measures include:
  - better documenting, mapping and coordinating existing schemes;
  - improving coordination between the public, non-governmental and private sectors; and
  - strengthening links between the environmental and food and agriculture sectors.
  - Steps also need to be taken to remove perverse incentives.

8.7.1 Overview

As described elsewhere in this chapter, and in Chapters 5 and 7, a range of different management practices, programmes, policies and legal instruments can contribute to the conservation and sustainable use of BFA. However, adoption of BFA-friendly management practices is often constrained by various barriers, including risk aversion, technological and knowledge gaps, and the need to invest money, time or effort (even if benefits exceed costs over the long term). Incentive measures can be a means of overcoming such barriers. Incentives can take a wide range of different forms and originate from public programmes or from private-sector investment (see Figure 8.2).

Single incentive measures implemented in isolation are unlikely to be sufficient to address the multiple threats facing particular components of BFA and overcome all the barriers to their conservation and sustainable use. Mechanisms that combine multiple incentives have been encouraged by the CBD for over a decade (CBD, 2008b). In 2016, the Conference of the Parties to the CBD called again for countries to

> *use an appropriate mix of regulatory and incentive measures … including the elimination, phasing out and reform of incentives harmful to biodiversity in order, … to increase the efficiency of use of water, fertilizer and pesticides, and to avoid their inappropriate use, and to encourage public and private sources of finance to be channelled into practices that improve the sustainability of production while reducing biodiversity loss, and to promote and support the restoration of ecosystems (CBD, 2016c).*

Combining incentives into an integrated package not only supports transition to practices that are biodiversity friendly on a local scale but also enables improvements in productivity and food security that reduce pressures on biodiversity (and other natural resources) more generally. FAO's Incentives for Ecosystem Services project (FAO, 2018v) is working to promote the development of efficient packages of incentives to support the sustainable use and conservation of BFA. Activities include case-study analysis, regional policy dialogues to help member countries develop enabling policy frameworks for locally adapted packages of incentives, and a web-based toolkit to guide decision-makers and practitioners in mapping and combining incentives.