# FINANCING SUSTAINABLE, RESILIENT AND INCLUSIVE SOLUTIONS TO ATTAIN SDG 15

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*20 December 2017*

## Contents



## I. Executive summary

An extremely important aspect for attaining the Sustainable Development Goal (SDG) 15 targets is the temporal component—that is, the feasibility of SDG targets (SDTs) over time, given projected population growth and the growing pressures on ecosystems stemming from current limitations in technological/environmental possibilities and, in particular, from limits to intensification of agricultural production. Quantitative estimates already show the infeasibility of zero net deforestation and biodiversity targets in 2030-2050, unless new technologies emerge to provide additional sources of animal protein or traditional food consumption patterns are substantially shifted. This consideration directly links to SDG 12 on sustainable consumption and production patterns.

Based on extensive analysis of the literature, the following aspects become prominent.

**Obstacles to technology adoption**

- Legally binding agreements at the international level are needed to set clear rules of operation and to transfer these to the national level, thereby opening possibilities for private finance;
- The technological aspects should be supported by a set of commonly accepted biophysical and socio-economic indicators. This problem may turn out to be rather complex, however, as these can be location specific;
- The lack of market incentives, insecure land tenure and resource-use rights are major prohibiting factors across many SDTs of SDG 15. The issue is pressing because of the important role of local communities across the SDTs of SDG 15 that are affected by these problems. One of the possible innovative approaches

to resolving this issue is providing affordable land-rights documentation to rural communities, as in the approach of Landmapp;[1]

- In addition to stronger law enforcement, improving the socioeconomic situation is a key to many SDTs of SDG 15. However, it has to be recognized, that, in many cases, under a business-as-usual scenario, there is a trade-off between environment and economics and both cannot be improved at once without changing a particular system;
- Long-term strategy, commitments, planning, and funding are key in the context of SDG 15. Even though there are cases of successful long-term endowments-based funding, this approach has obvious limits in upscaling, so creating market incentives seems to be the way forward.
- Referring to SDT 15.9 (integrate ecosystem and biodiversity values to national planning), there is a need to link national and international levels in order to allow more flexibility in finance. Reducing Emissions from Deforestation and Degradation (REDD) can serve as an example of this approach.

**Science, technology and innovation (STI) solutions and gaps**

- There are many gaps regarding scientific and economic assessments (e.g., delineation of areas to be protected, setting priorities, and definition of targets for each area). In many cases, these gaps are a starting point in resolving apparent issues and are therefore primary targets for funding;
- Current and near-term limits in remote-sensing monitoring technologies imply the need for in-situ measurements that incur considerably higher costs;
- Promising solutions to this gap could include (i) a wider use of (incentives-based) citizen science that has yet to be explored and (ii) data fusion employing multiple sources—for example, satellite and aircraft acquired light detection and ranging (LiDAR). However, these solutions are not yet operationalized;
- SDG 15 directly links to the broad problem of climate change, as there are numerous examples of the effects of climate change on various species providing solid evidence that climate change will be catastrophic for many of them. Joining efforts and uniting "climate change" and "ecosystems" communities may foster cross benefits and facilitate progress at all levels;
- Emergence of a global carbon market could foster valuing ecosystems via REDD and create financial inflow to support actions under SDG 15. To efficiently combat uncertainties associated with it, the innovative approaches employing (a) optionality and (b) a benefit-sharing mechanism have strong potential to amplify mobilization of private finance and allow for maximizing the market size; However, actual costs and environmental benefits of REDD are uncertain;
- Generally, preventive measures are preferable in addressing existing/created problems (i.e., post-interventions), such as quarantine control and early detection as it relates to invasive and alien species.

## II. Introduction

Beginning in 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development officially came into force (United Nations, 2017). Countries will mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind (United Nations, 2017). The SDGs call for action by all countries to promote prosperity while protecting the planet. While the SDGs are not legally binding, Governments are expected to take ownership and establish national frameworks for the achievement of the goals (United Nations, 2017).

This analysis is focused on SDG 15, which is broadly formulated as "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" and has twelve targets (SDTs) that further detail SDG 15. The objective of this analysis is to provide expert knowledge on the theme of financing science, technology and innovation

1 See http://www.landmapp.net/.

(STI) solutions for SDG 15. This analysis is carried out in the format of a background paper comprising a comprehensive overview, grounded in well-established science and factual evidence, representing the latest thinking in the field and including assessments of existing approaches as well as innovative new instruments and novel approaches. A proper differentiation across developed and developing countries is made clear whenever appropriate.

The remaining sections of this paper are structured as follows:

Section III provides an overview and analysis that reflect upon the set of SDG 15 targets (15.1-15.c, as specified in Annex I). This section addresses the following aspects (with their corresponding section numbers):

III.1 Technology and innovation solutions and gaps for attaining SDG 15;

III.2 Financing and other obstacles to the adoption and scaling up of relevant technologies and innovations;

III.3 Existing and novel approaches for addressing financing shortfalls and challenges for natural capital building at different levels (global, national and sub-national);

III.4 The potential for STI road maps (based on concrete examples) to facilitate necessary investments.

The arrangement of SDTs within these topics is such that SDTs 15.1-15.9 and 15.c are put into subsection III.1, which provides primary information on solutions and gaps that are relevant to technology innovation and beyond, as required by the importance of the respective issues. SDTs 15.a and 15.b are put directly into discussion in subsection III.2 for two reasons. First, both SDTs explicitly specify financial aspects that make a respective discussion more relevant for the subsection **III.2**. Second, the technological side of respective topics is covered to a large degree in preceding subsections relevant to SDTs 15.1-15.9. Sections III.3 and III.4 cover in a condensed way the entire SDG 15, with examples and applications from relevant SDTs.

Section IV provides conclusions and suggests a way forward. Section 5 supplies a bibliography for the cited literature sources.

## III. Overview and analysis reflecting on the set of SDG 15 targets

### III.1 *Technology and innovation solutions and gaps*

**15.1. By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements**

This section provides a brief overview of the topic of legislative support to international agreements. Even though this analysis is not explicitly focused on finances, it helps to better understand the legal environment relevant to Sustainable Development Goal Target (SDT) 15.1 in particular and Sustainable Development Goal (SDG) 15 as a whole. It serves as a broad legal framework for future financial efforts and highlights a few important gaps and reports on implemented solutions.

Sirakaya, Cliquet, and Harris (2017) provides a review and assessment of the legally binding instruments on biodiversity at the international level that focus on urbanization, causing an adverse impact on biodiversity and ecosystem services. The authors emphasize that, currently, the international biodiversity conservation practice mainly focuses on rural areas, and not on urban conservation and restoration, thus creating a gap. The authors assess legally binding instruments in order to see if they provide a sufficient legal basis for relevant solutions and if there are any gaps in protection of ecosystem services in urban areas. From this point of view, the authors elaborate on the Aichi Targets related to the Biodiversity Convention and the Ramsar Convention on Wetlands of International Importance. Earlier research (Luederitz and others, 2015) highlights the main existing science, technology and innovation (STI) gaps and challenges in securing and enhancing ecosystem services that go far beyond the urban aspect, suggesting a solid framing of the ecosystems-related challenges relevant to SDG 15, which include:

- *Spatial and contextual*. Most work is currently concentrated in the developed countries, whereas some of the most acute problems occur in low- and middle-income countries;

- *Clarification of definitions*. Greater clarity is needed, particularly regarding the definition of "urban" which requires unambiguous description of the environmental, spatial and socioeconomic context;
- *Limited transferability of data*. Global estimates of services and values cannot easily be transferred to local contexts, due to differences in biomes and socioeconomic circumstances;
- *Stakeholder engagement*. Few studies involve stakeholders, leading to the danger that the process could become technocratic, and there is an urgent need for engaging stakeholders in ecosystem service research;
- *Integrated research effort.* Transdisciplinary research efforts are needed. Without them, capturing the full diversity and richness of ecosystem service provision by green infrastructure will be impossible;
- *Closing the feedback loop between urban ecosystem service appropriation and the management of urban ecological structures.* Research and assessment has to be properly connected to the management of urban ecological components.

A good example of existing solutions of legislative integration is the Bern Convention on the Conservation of European Wildlife and Natural Habitat (1979) that has been implemented in the European Union (EU) by the EU Nature Directives. The Nature Directives provide a prime example of strong nature conservation legislation (Born and others, 2015). In the opinion of Sirakaya, Cliquet, and Harris (2017) regarding biodiversity, the SDGs are still in their infancy with no clear indication as yet on urban biodiversity conservation; nor is there information on national implementation at this point. Setting global targets can promote collaboration and agreement on ecosystems and their services (Maxwell and others, 2015), but without detailing these targets and methods of implementation, there is a high risk of not attaining intended goals (Maxwell and others, 2015).

A broad overview of the international biodiversity-related conventions (The Energy and Biodiversity Initiative, 2003) includes the Convention on International Trade in Endangered Species of Wild Flora and Fauna (1973); the Ramsar Convention on Wetlands (1971); the World Heritage Convention (1972), which covers sites of natural or cultural value; the Convention on Migratory Species (1983); and the Convention on Biological Diversity (1992). One of the highlighted gaps here is that, in contrast to other issues (e.g., trade), there is no single international body dealing with the environment, and all five biodiversity conventions operate independently with separate secretariats (The Energy and Biodiversity Initiative, 2003). In addition to the key international conventions related to biodiversity, the authors provide an overview of more specific legislation related to region and nature of potential impact, covering more than 30 conventions and 8 categories (nature conservation; coastal and marine areas; rivers and lakes; wetlands; birds; mammals; pollution prevention; and endangered species). While regional specifics is of great importance (Luederitz and others, 2015), this level of dispersion might point to the need for consolidation of the agreements, with clear separation between the framework and legally binding implementation documents focusing on implementable actions to attain quantified goals within a given time frame.

As SDT 15.1 on terrestrial ecosystems is explicitly mentioning inland freshwater ecosystems that are not covered by other SDTs, a brief look at this topic is included here. An overview paper by Green and others (2015) states that nearly the entire world is serviced by freshwater sources, compromised to a moderate extent by human activities, with 82 per cent of the world's population served by upstream areas exposed to high levels of threat; this analysis further suggests that better management of upstream source areas in poorer countries represents an opportunity to reduce threat, lessening reliance on costly engineering solutions. The authors highlight the practical need for water service management strategies, including service area conservation, threat reduction and both green and gray infrastructure investments. The value of such green technologies and ecosystem services goes beyond traditional infrastructure investment, yet requires systematic evaluation (Green and others, 2015) that implies additional funding needs and an extension of the planning/implementation time horizon. In the context of building and maintaining existing infrastructure, Birnie-Gauvin and others (2017) states that barriers created by the infrastructure may have severe repercussions on population densities and dynamics of aquatic animal species; it further argues that adaptive management provides a relevant approach to managing barriers in freshwater ecosystems, although this approach may not be suitable in all instances. Lira-Noriega and others (2015) presents an example of a first priority assessment of freshwater ecosystems at a national scale in Mexico; the analysis highlights the importance of conducting conservation prioritization assessments at a higher spatial resolution, using information that is up to date to bridge the existing research–implementation gap in conservation planning. A report on protection tools for freshwater ecosystems in Tasmania (Dunn, 2003) presents a broad range of identified tools—legislative, policies and strategies, voluntary and incentive. The analysis further emphasizes that individual sites require assessment of threats and tools with reference to the particular conservation values present. The study demonstrates gaps in legislation (e.g., absence of protection of the riparian zone), gaps in application of key tools (e.g., difficulties in definition of environmental flow requirements to protect estuaries or wetlands), limited staffing for protection activities, and enforcement of legislated controls (Dunn, 2003). We believe the highlighted gaps are universally valid.

**15.2. By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally**

An overview of the state of measurement and monitoring capabilities for forests in the context of Reducing Emissions from Deforestation and Degradation (REDD+) is presented in Goetz and others (2015). The authors explore existing possibilities, analyze the needs for further improvements, and provide a near-term projection on perspectives of new technologies. Satellite- and aircraft-based technologies are applied for monitoring of forests measuring (a) changes in their extent, (b) carbon stock density (estimating areas that are deforested or degraded) and (c) regrowth dynamics following a disturbance. While the technologies currently applied have reached a certain level of maturity, the authors emphasize the synergistic role of integrating field inventory measurements with remote sensing for best practices in monitoring, reporting and verification. This means that existing remote-sensing-based solutions that are extremely cost efficient in covering wide geographical areas still need support by in-situ measurements that incur considerably higher costs. This is one of the examples where existing limits in technology create a potential gap in finance. So, as safeguards for natural forests and biodiversity, the existing monitoring capabilities are approaching operational status in the near term (Goetz et al. 2015) and, as projected for REDD+ needs, measurement capabilities will rapidly advance in the next few years because of new technology.

An important aspect supporting technological development is the expected advances in capacity-building, both within and outside of the tropical forest nations on which REDD+ is primarily focused (Goetz and others, 2015). An example solution of using satellite-based observation systems for support of the enforcement of domestic forest protection policies is Brazil's alert system that utilizes a range of satellite imagery to target illegal logging and forest conversion activities (Goetz and others, 2015; EARSC, 2011). However, on a global scale, there is a considerable gap due to much disagreement in the scientific community about the magnitude and extent of deforestation worldwide (Fonseca, Davis, and Câmara, 2009). An intermediary solution (both in terms of cost and geographic coverage) between in-situ and satellite technologies is the aircraft acquired light detection and ranging (LiDAR) data, which is valuable for estimates of canopy height, cover and vertical structure. There are two challenges connected to the wide application of this technology. First, the errors in LiDAR-based estimates have a mean of about 20 per cent, yet vary with the magnitude of field biomass reported (Goetz and others, 2015). Second, mapping of all tropical areas with aircraft would cost about $250 million, which is deemed rather expensive, even though this sum is only 5 per cent of total current pledged funding for REDD+ (Mascaro and others, 2014). This gap can be filled by approaches linking samples of LiDAR acquisitions with continuous coverage satellite data as suggested in Goetz and others (2015).

An important aspect of monitoring forest loss is the problem of attributing the loss to land uses and owners. A study in Bolivia (Killeen and others, 2008) presents a case where land-use change was analyzed for several groups of land owners. A much more granular case is reported in Copernicus Sentinels' products economic value: a case study of forest management in Sweden (EARSC, 2016), which presents an economically sound case of tracking the changes in Swedish forests down to a particular forest owner and triggering certain actions from the Swedish authorities. One of the possible innovative approaches to solving this issue is providing affordable land-rights documentation to rural communities—especially in developing countries, as Landmapp is doing through its operations in Ghana and other countries. These cost-effective solutions utilize a combination of technologies rapidly developed over the past decade: mobile applications on smartphones supporting geolocation services (e.g., via GPS sensors) and remote sensing/satellite information (e.g., imagery); creating user communities/networks (e.g., land owners and their neighbors); and, most importantly, linking to authorities to make sure the final intellectual product has a legally binding status.

On the technological side of forest management, investment into the newer management/harvesting technologies to better comply with sustainable forest management requirements does not seem to be a hot topic, as the largest share of total investments goes into building and maintaining the forest road network. There are not many technical possibilities to change the technology in the tropics (e.g., chainsaw felling to harvesters) due to the large size of the trees. Similar limitations and conclusion are valid for moving from manual planting to automatic planting. Overall, there is more need for capacity-building and exercising good practices, which are not directly related to technology and are considered to be a minor investment.

**15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world**

As stated by the United Nations Convention to Combat Desertification (UNCCD) secretariat, land and the fertility of its soil are critical natural capital, essential for sustainably ensuring food, renewable energy and water security while eradicating rural poverty, conserving terrestrial biodiversity, and building the resilience of our agricultural systems to climatic shocks. Desertification, land degradation and drought are challenges of a global dimension that pose serious obstacles to sustainable development in all countries, especially for the rural poor in developing countries. Targets require indicators and mechanisms to establish baselines and monitor progress in order to demonstrate to governments, businesses, communities and individuals the consequences and impacts of their actions. In addition to having the capacity to measure trends in land degradation and restoration, biophysical and socioeconomic indicators should be linked in order to capture the complexity of desertification, land degradation and drought (DLDD) processes and impacts (UNCCD secretariat, 2013).

Adopting and scaling up sustainable land-management practices, both in terms of area and effectiveness, and improving land-use planning and governance structures at the national and local levels are often the most effective ways to overcome these challenges. The increased use of strategic and environmental impact assessments leading to the adoption of new technologies and innovative land- and water-use policies, planning and practices will also serve to further mitigate the extent and degree of land degradation (UNCCD secretariat, 2013).

Sustainable land management (SLM), with its focus on improving soil structure, land cover and water efficiencies, also contributes to progress in achieving three critical global sustainability goals, namely food security, renewable energy and water availability. SLM practices enhance soil water retention capacity and improve water availability by replenishing and elevating groundwater tables. Many renewable energy sources, such as timber, hydroelectricity and biofuels, depend on productive land and well-functioning hydrological regimes.

Conservation and SLM practices alone are not sufficient to stem the loss of biodiversity and ecosystem services that result from DLDD processes. Thus, a third critical pathway of action calls for increasing health and productivity by restoring and rehabilitating land that is already degraded. Global assessments estimate that there are more than 2 billion hectares of degraded lands worldwide that have the potential for forest, landscape and mosaic restoration in which forestry is combined with other land uses, such as agroforestry and smallholder agriculture (UNCCD, secretariat 2013).

The slow uptake of SLM practices is often due to a lack of market incentives, insecure land tenure and resource-use rights, high upfront costs and labour intensity, and limited access to education, information, vocational training and extension services. A target-setting approach would foster institutional and technical capacities to assist local communities and inspire action on the ground (UNCCD secretariat, 2013).

There are some countries in the world, such as Australia and Iceland, which have long-standing traditions of land restoration and often apply very effective participatory approaches involving the local populations. In general, however, land restoration has only been applied in very limited areas and without an overall implementation framework. Adopting a sustainable development goal regarding land degradation neutrality will require an in-depth analysis of land restoration practices and the development of clear criteria for their evaluation and impact assessments (Montanarella, 2016). In different parts of the world, degradation processes are different, requiring approaches tailored to local conditions. It is clearly demonstrated that local communities can effectively restore degraded areas by implementing relatively simple and effective management practices (Montanarella, 2016). Although the EU established the Thematic Strategy on Soil Protection, the existing EU legislation varies in scope and objective and does not sufficiently address significant soil problems as it does not cover all soils and does not address all soil threats (European Commission, 2006).

An overview of restoration practices in degraded landscapes of Eastern Africa that is based on a set of case studies (Chirwa, 2014) presents an approach to restoration of degraded landscapes and woodlands—referred to as exclosure, which is a practice of land management that involves the exclusion of livestock and humans from openly accessing an area that is characterized by severe degradation. Under these conditions, the options to be implemented are (i) natural regeneration, that is, protecting rehabilitation sites from external interference to facilitate natural regeneration and (ii) aided regeneration, which involves planting indigenous tree species that can dominate the degraded sites during early stages of secondary forest succession. The trees planted are intended to act as nurse trees that provide shade, enrich the soil and support the microhabitat in naturally recruiting woody species. The technique is employed in situations where deforestation has led to loss of seed sources and in areas where harsh site conditions are unfavorable for natural regeneration. Another approach to rehabilitation of the land is agroforestry, which is the most common in human-dominated landscapes where trees with multipurpose characteristics are used, including some nitrogen-fixing species for soil fertility improvement, as well as wood and fiber and fruit trees. The most common agroforestry technologies promoted in Eastern Africa include improved fallows in Western Kenya and rotational woodlots in the western dryland areas of the United Republic of Tanzania. Some traditional agroforestry systems consist of the multistory tree garden, which involves the mixing of trees and farm crops in a spatial arrangement. As regards plantations and woodlots, the major problems identified in tree planting include poor land tenure, limited extension services and financing mechanisms, and low quality germplasm.

In the United Republic of Tanzania, techniques already in use include plantations, natural regeneration, agroforestry and various soil and water conservation techniques (Chirwa, 2014). Plantations are too restricted in extent to provide sustainable livelihoods and environmental services for the large land areas demanding restoration, while assisted natural regeneration and enrichment planting have been tried only in research activities. Several reports have indicated that natural regeneration through active involvement of local communities promoted under participatory forest management, and supported by the new forestry legislation and programme, is by far the most promising option for restoration of the large areas of degraded land in the United Republic of Tanzania. This community-based forest management is regarded as the most appropriate way to achieve forest landscape restoration and is expected to be successful because local communities are allocated forest land rights that are clear, and traditional knowledge and practices are taken into account.

In summary, regarding the issue of combating land degradation, the most needed measures (e.g., good practices, funding work on the ground, active involvement of local communities, etc.) are not directly related to specific technologies, even though some solutions—those related to land rights, for example—can be supported by those measures, as mentioned earlier in this document (e.g., provision of land-use rights documentation to the poor, as done by Landmapp).

**15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development**

Conservation and sustainable use in mountain ecosystems present special challenges because of the harsh climatic conditions, the fragility of mountain soils and the increasing threat of habitat fragmentation and degradation (Mackinnon and others, 2002).

The World Bank reports on a wide range of projects supporting mountain ecosystems that include establishment and strengthening of new protected areas and biological corridors (in Central America, Colombia, Georgia, Laos); improved management of existing protected areas (in Ecuador, Indonesia, Madagascar, Mexico, Uganda, Venezuela (the Bolivarian Republic of)); conservation of medicinal plants (in Ethiopia); and promoting community management of mountain-protected areas and indigenous reserves (Colombia, Ecuador, Peru); watershed projects (in the Middle East and Northern Africa) incorporating natural forests and endemic riparian woodlands as part of microcatchment vegetation management with local communities (Mackinnon and others, 2002). Due to the wide variety of ecosystems and the different priorities among targets, the projects use tailored approaches.

As reported by the World Bank (Mackinnon and others, 2002), the Kyrgyz Republic's Sheep Development Project, targeting the improvement of rangeland management in mountain ecosystems, has piloted new models of rangeland tenure, management, and monitoring to address the problems of environmental degradation and improve livelihoods. The resulting improvements in pasture use also reverse biodiversity degradation resulting from decades of severe overgrazing. Under the project's pilot programme in sustainable pasture management, pilot leasing rights were defined for local communities and households; rangeland management plans were drawn up that identified grazing loads and protection zones; and technical assistance was provided to farmers on rangeland management and forage improvement. The project has developed a geographic information system-compatible database for the country's rangelands, including degraded ranges that require protection from further overgrazing (Mackinnon and others, 2002).

The approaches that are rather indirect can help protect mountain ecosystems by, for example, providing financial and technical assistance to buffer-zone communities and community-based organizations to finance demand-driven activities in sustainable agriculture; developing alternative livelihoods (e.g., honey and medicinal plants, tourism); and using alternative energy systems. All these activities are designed to reduce pressures in and around the protected areas (Mackinnon and others, 2002). In addition to national-level activities, projects may need to support a strong regional cooperative component, including development of framework laws on protected areas (Mackinnon and others, 2002).

The aspects highlighted above are relevant for the long-range success of conservation measures in mountain regions, as such success requires that the following discrete but interconnected interventions be pursued concurrently: (i) the protection of biodiversity and ecosystem services; (ii) an empowerment of mountain communities (including family farming); and (iii) elaboration of more thoughtful, context-specific policy environments for sustainable mountain development (Foggin, 2016).

While virtually all mountain biodiversity initiatives documented in Chettri and others (2012) emphasize community involvement, a few have also leveraged local institutions and indigenous knowledge systems, blending them with scientific knowledge to find a way forward. Most case studies capture good practices that can be replicated and scaled up, as well as lessons learned, thereby contributing to the Programme of Work on Mountain Biodiversity adopted by the Conference of the Parties to the Convention on Biological Diversity.

One of the projects presented in Chettri and others ( 2012) reports on innovation through a pilot fodder bank model using fast-growing and high biomass-yielding nutritious species (both indigenous and introduced) to reduce the drudgery women experience by decreasing fodder collection time and distance travelled. Another innovation reported consists of improving a traditional soil conservation system practiced by the farmers in districts of Nagaland, India. This system has historically involved placing bamboo or logs randomly across the slope in the fields. The logs conserve the soil and are replaced after two or three years, depending on the durability of the logs. This method has been scientifically modified so that logs are now placed across the slope along the contour line at a vertical interval of 3 metres, depending upon the slope. Results reveal that this configuration significantly minimizes soil loss.

The broad analysis of 15 case studies (Chettri and others, 2012) concludes that the following aspects are of primary importance:

- Conservation measures should enhance local people's livelihoods, technical and management capacities, and decision-making roles. Otherwise, sustainability can prove elusive;
- The best hope for conservation may come from the fusion of traditional/indigenous knowledge and science;
- There is need for good governance and for regional and sometimes transboundary cooperation;
- Focusing on a long-term, integrated landscape approach to conservation with long-term monitoring can have lasting positive impacts;
- Putting in place mechanisms such as payment for ecosystem services (PES), and appropriate strategies

promoting a green economy can further build the resilience of socioeconomic and ecological systems in the landscape.

The PES mechanism assumes quantification and valuation of the targeted services and can help set priorities and incentivize investors. There are some vivid case studies on this type of assessment (even though not specifically related to mountain ecosystems) on China and New Zealand (Moran, Cullen, and Hughey, 2005; Xu, Ding, and others, 2006).

**15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species**

Threats to biodiversity vary both within and between species groups (Craig Hilton-Taylor, 2007). Although habitat destruction is universally the most dominant threat, over-exploitation (harvesting, trade, etc.) is a major threat to mammals, affecting 33 per cent of threatened species. For birds, over-exploitation and invasive alien species both affect about 30 per cent of threatened species. Of the amphibians, 29 per cent of species are affected by pollution (including climate change) and 17 per cent by disease (particularly chytridiomycosis). The interaction between disease and extreme climatic events (drought) is the leading theory behind widespread amphibian declines. Threats in marine and freshwater systems are poorly understood but it appears that over-exploitation is presently the greatest threat to marine species, followed by habitat loss. There are many examples of the effects of climate change on species from around the world that, taken together, provide compelling evidence that climate change will be catastrophic for many species (Craig Hilton-Taylor, 2007). This means that this SDT directly links to a broad problem of climate change.

As for geographic distribution, most threatened species occur in the tropics, especially on mountains and on islands. Most threatened birds, mammals and amphibians are located in Central and South America; Africa south of the Sahara; and tropical South and Southeast Asia (Craig Hilton-Taylor, 2007). Globally threatened species frequently require a combination of conservation responses to save them. These responses encompass research, species-specific actions, site- and habitat-based interventions, policy responses and communication and education. It is much more effective and economical to protect a habitat in the first place than to try to restore it after it has been destroyed or to reintroduce a species that has disappeared.

The tools in the conservation arsenal are many and varied (Craig Hilton-Taylor, 2007), and are in agreement with practical strategies (see Natural Resource Management Ministerial Council of Australia, 2010).

They include:

- Effective management and restoration of habitats and ecosystems (including establishment of protected areas and protected area networks);
- Limiting the use of pesticides, herbicides and other chemical pollutants;
- Enforcement of key agreements such as the Convention on Biological Diversity, Convention on Migratory Species, Convention on International Trade in Endangered Species of Wild Fauna and Flora;
- Creating incentives and finance for conservation;
- Equitable sharing of costs and benefits of conservation;
- Assessment of biodiversity and the social and economic factors affecting it;
- Captive breeding and reintroduction, including seed banks;
- Conservation information management and communication;
- Training and technical capacity-building.

An important practical aspect relevant to protecting both forests and biodiversity on a large scale is the monitoring of forests, making a distinction between natural and plantation forests, as the biological diversity and ecosystem services provided by the two systems differ greatly (Goetz and others, 2015). This monitoring issue has a clear technological component. The body of literature addressing the identification and monitoring of the extent and change of plantation forests by using remote sensing has been limited; this creates another practical challenge that can potentially be addressed by automated approaches emphasizing multitemporal and multi-sensor data fusion techniques (e.g., RaDAR-optical-LiDAR) (Goetz and others, 2015).

**15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed**

In the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization to the Convention on Biological Diversity[2], article 17 specifies the approach to monitoring the utilization of genetic resources; this includes designation of checkpoints that collect/receive relevant information related to (a) the source of the genetic resource; (b) the establishment of mutually agreed terms; and/or (c) to the utilization of genetic resources. The checkpoints should be relevant to the collection of information at, inter alia, any stage of research, development, innovation, pre-commercialization or commercialization. Financial mechanism and resources for implementing the Nagoya Protocol take into account the provisions of article 20 of the Convention on Biological Diversity and, according to article 25 of the Nagoya Protocol, the financial mechanism of the Convention shall be the financial mechanism for the Nagoya Protocol. As noted in Greiber (2012), the Nagoya Protocol builds the basis for providing financial assistance to developing-country Parties and to Parties with economies in transition for the implementation of the Protocol. The underlying rationale of this provision is that Parties with limited capacity need assistance if they are to comply with their obligations under the Protocol. Such compliance is in the interest not only of the Parties concerned but also of the entire community of Parties to the Nagoya Protocol. In order to operationalize the Nagoya Protocol, all Parties need to be in a position to implement it at the national level.

The extreme importance of international collaboration is outlined in Antons (2010), which concludes that national development goals and interests in royalty collection frequently dominate the discussion and that key concepts are still not sufficiently defined to avoid overlaps and conflicts. Genuine local support for conservationist aims will depend on whether a benefit flow to communities can be ensured and if the original role of benefits to act as incentives can be realized. International collaboration is important in avoiding disputes concerning biodiversity-related knowledge held across borders.

From this perspective, exploration of the available (bio-) technologies serving the purposes of (back) tracking products to genetic resources (which is not mentioned in the Nagoya Protocol) is left beyond the scope of this paper. On a more explicit technological side, the Nagoya Protocol is to a certain degree centered on data collection (and monitoring) as it is encouraging the use of cost-effective communication tools and systems. These systems, however, are part of a large international organizational framework and subject to compliance with policies accepted at that level; hence, these systems are a tool rather than a driving factor and therefore left out from further analysis here.

**15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products**

As reported by the American Wildlife Association, building on its decades of experience combating rhino and elephant poaching in Africa (African Wildlife Foundation, 2014), the global nature of this crisis is being addressed through a multi-tiered effort to:

- Support the work of protected-area authorities and other anti -poaching efforts on the ground;
- Increase global awareness of the urgency of reducing demand;
- Expand law enforcement efforts to crack down on illegal wildlife trafficking and engage with partners and policymakers to ensure broad support in combating this serious issue.

These tasks are in full agreement with the US national strategy for combating wildlife trafficking, which aims to strengthen enforcement, reduce demand and increase cooperation to address these challenges (The White House, 2014).

The methods used to protect animals include creation of artificial water points during the dry season to keep el-

2 See https://www.cbd.int/abs/about/default.shtml/.

ephants within protected areas; aggressive anti-poaching protection so that conservancy has minimal poaching losses and poachers are being arrested; coordination of trans-border patrols and other scout support in the cross-border region; supporting sniffer dogs and other enhanced law enforcement efforts to increase the rate of detection of contraband wildlife products before they leave African ports; tracking teams to patrol regions of interest regularly (e.g., monthly) to identify individual animals and collect ecological data; professional training (e.g., a three-month, physically strenuous programme that equips community scouts and rangers with the necessary skills and knowledge to protect themselves and wildlife); implement anti-poaching efforts, plan patrols, and more (African Wildlife Foundation, 2014).

To halt the poaching epidemic in Africa, consumer countries must institute national bans on the ivory trade to prevent illegal ivory from being laundered into the legal domestic markets (African Wildlife Foundation, 2014). With its connections to organized crime, terrorism and corruption, combating elephant poaching and ivory trafficking is no longer the sole concern of the conservation community. Governments, international law enforcement agencies, the private sector, revenue agencies, global financial institutions and others have joined the fight, and many countries are deploying new legislative and law enforcement tools to fight wildlife crime. Several countries, including China and the United States of America, have also destroyed their stockpiles of confiscated ivory, sending a clear message that there is no economic future in ivory (African Wildlife Foundation, 2014).

In the review of the academic and grey literature on the links between poverty, poaching and trafficking, Duffy and St. John (2013) concludes that (i) poaching and trafficking of ivory and rhino horn from sub-Saharan Africa are directly and indirectly linked to poverty; (ii) poaching and trafficking of ivory and rhino horn are ultimately driven by wealth and not by poverty per se; and (iii) there are direct links between conflict zones, illegal killing of wildlife, trafficking and poverty. From this perspective, addressing the economic situation of the population in problem areas, especially in zones of armed conflict, seems to be an important part of the problem's solution.

On the technological side, there are reports of successful application of citizen science methods to address various problems, including poaching and trafficking of protected species, like those provided by CyberTracker ecological monitoring units (African Wildlife Foundation, 2014).

Scientific literature presents examples that examine the role of citizen science in monitoring biodiversity, concluding that some of the data collected in these networks can be used to fulfil national statutory obligations for nature conservation (Donnelly and others, 2014). Other results (Chandler and others, 2017) show that existing citizen science and community-based monitoring data provide large-scale data on species distribution and population abundance; species traits, such as phenology; and ecosystem function variables, such as primary and secondary productivity. Most citizen science schemes are found in Australia, Europe, India, North America and South Africa. Chandler and others (2017) explores what can be learned from successful programmes that would facilitate the scaling up of current efforts, how existing strengths in data coverage can be better exploited, and the strategies that could maximize the synergies between citizen science/community-based monitoring and other approaches for monitoring biodiversity—from remote sensing, in particular. The authors conclude that more and better targeted funding will be needed, if citizen science/community-based monitoring are to contribute further to international biodiversity monitoring.

**15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species**

A report of the Global Invasive Species Programme (GISP) (Barnard and Waage, 2004) synthesizes a series of eight regional workshops held around the world where a total of 99 nations and territories met to discuss questions including regions' priorities, gaps, and unmet needs for effective management. The document states that the overriding need expressed by most regions is the capacity to tackle invasive alien species (IAS) effectively. Much better capacity for IAS prevention, eradication and control is the bottom-line need—technical capacity (scientific, policy, economic, legal), institutional capacity (including educational), and logistical capacity. This includes phytosanitary and quarantine control, early detection and rapid-response systems, better field equipment, intersectoral planning, economic valuation, and the integrated policy and legal frameworks needed to underpin effective control. GISP reports that many countries and regions have started to secure financing and mobilize trained and equipped teams so that regionally appropriate solutions are found (Barnard and Waage, 2004).

Invading alien organisms are widely regarded as the second greatest threat to biodiversity after direct habitat destruction. This is a biodiversity problem that affects all countries, developing and developed, rich and poor. Invasive species (plant and animal) are not only a serious threat to biodiversity, but also threaten ecosystem services and sustainable development with serious economic and environmental costs (Mackinnon and others, 2002). An example from South Africa demonstrates that in mountain regions and catchments, the invasive exotic trees have been shown to reduce water flow and smother native vegetation. They convert species-rich vegetation to single-species stands of trees, increasing biomass and decreasing stream flow dramatically. It has been estimated, for example, that invasion of the catchment areas surrounding Cape Town, if left to spread at current rates, could reduce water resources for this rapidly growing city by 30 per cent. Additionally, invasive plants in indigenous grasslands and shrublands increase fuel loads and fire risk which leads to increased soil erosion and degradation of mountain catchments (Mackinnon and others, 2002). This study is one of a few providing economic costs of invasive alien plants and, therefore, a direct link to financing opportunities.

A study on ecological and environmental consequences of IAS in China (Xu and others, 2006) concludes that quarantine measures should be strictly implemented. Meanwhile, the intentional introduction of alien species should be strictly managed and a system of risk assessment should be implemented. This broad study is based on data of classification, origin, pathway and environmental impacts of invasive alien microorganisms, invertebrates, amphibians and reptiles, fish, birds, mammals, weeds, trees and marine organisms in the terrestrial, aquatic and marine ecosystems of China.

Addressing at a regional level the problem of scientific and economic assessments mentioned above, a case study including an assessment of total economic losses caused by IAS in China in 2000 estimates those losses to be $14.45 billion, with direct and indirect economic losses accounting for 16.59 per cent and 83.41 per cent of total economic losses, respectively (Xu and others, 2006). This figure accounts for 1.36 per cent of China's gross domestic product.

As impacts and solutions are both determined by local conditions and particular invasive species, there is no one-size-fits-all solution. Therefore, targeted research is needed on a case-by-case basis. Quarantine control and early detection seem to be justified preventive approaches.

**15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts**

The United Nations Environment Programme (UNEP) Ecosystem Management subprogramme provides core services to regions and national Governments around the world. UNEP (2009) provides a list of relevant projects of global, national and regional scope. The document further states that protection and sustainable management of ecosystems is a critical element of poverty reduction strategies, as it helps maintain or enhance delivery of the water, food and other ecosystem services poor people rely on. UNEP works with ministries of environment, planning and finance to promote the incorporation of the ecosystem approach into national development planning and investment strategies.

UNEP is working with national and regional governments, developing tools and methodologies for valuing ecosystem services, and helping to incorporate these values into planning decisions, the design of policy instruments such as taxes or payments for ecosystem services, and national systems for accounting, planning, and management (UNEP, 2009).

Australia's biodiversity conservation strategy 2010-2030 (Natural Resource Management Ministerial Council of Australia, 2010) can serve as an example of a detailed national plan. The strategy consists of three sections: (i) setting the context, (ii) priorities for action, and (iii) implementation and action. This document presumably can be used for the purposes of benchmarking other similar initiatives when needed.

There is a need to link national and international levels in order to allow more flexibility in finance. REDD+ can serve as an example of this approach (Lubowski and Rose, 2013; Golub, Lubowski, and Piris-Cabezas, 2017).

**15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities**

The EU Approach to Combat Wildlife Trafficking (European Commission, 2017) states that wildlife trafficking has become one of the most profitable criminal activities worldwide, with devastating effects for biodiversity and negative impacts on the rule of law due to its close links with corruption. The European Commission recognizes that the EU has an important role to play in addressing this, as Europe is currently a destination market, a hub for trafficking in transit to other regions, as well as, for some species, the source region for illegal trade. In February 2016, the European Commission adopted a Communication on the EU Action Plan against Wildlife Trafficking, which sets out a comprehensive blueprint for joined-up efforts to fight wildlife crime inside the EU, and for strengthening the EU role in the global fight against these illegal activities. The Action Plan has three main strands:

i. Greater enforcement;

ii. Better cooperation;

iii. More effective prevention.

The Action Plan, implemented jointly by the EU (Commission services, EEAS, Eurojust, Europol) and its member States, covers the five years from 2016-2020. Numerous actions and initiatives have been taken by EU member States and the European Commission since the inception of the Action Plan (European Commission, 2017), indicating importance of coordinated efforts on both international and national levels.

Ranging from the international policy level to approaches for fighting wildlife crime on a case-by-case basis, a review based on the fact that various types of wildlife crimes concentrate in time and space suggests that crime scientists may be able to collaborate with conservationists to improve the overall efficiency of combating the problem (Kurland and others, 2017)—a potentially promising approach. Crookes (2017) provides an insight on the efficiency of curbing poaching via economic means and implications for methods proposed for reducing the value of rhinos. This type of analysis may potentially inform on the viability of particular solutions targeted for funding.

In this context we would like to re-emphasize the conclusions of the research mentioned earlier: (i) poaching is linked to poverty; (ii) poaching and trafficking are ultimately driven by wealth; and (iii) there are direct links between poaching and trafficking and conflict zones (Duffy and St. John, 2013). These findings stress the need for solving issues (i) and (iii) and strongly link to SDGs other than SDG 15. On the solutions/technology side, the potential role of citizen science in monitoring is worth mentioning here (Donnelly and others, 2014; Chandler and others, 2017).

### III.2 *Financing and other obstacles to technology adoption and scaling up*

**15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems**

**15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation**

The monetary value of goods and services provided by ecosystems is estimated to amount to some 33 trillion dollars per year—nearly twice the global production resulting from human activities (Craig Hilton-Taylor, 2007). Despite the considerable estimated value created by ecosystems, there are obvious problems with maintaining the source of that value being created.

A detailed analysis carried out in New Zealand reports an obvious gap: total annual funding allows 15 per cent of the 2,400 threatened species to be targeted for management, whereas estimates of costs are not usually included in applications for funding or in the preparation of recovery plans (Moran, Cullen, and Hughey 2005). Cost is also not generally a factor in priority-ranking systems, and cost-effectiveness analysis is rarely conducted. Yet, although basic estimates of the costs of single-species programmes can be calculated, they often remain unquantified. The task can be complex, particularly if there is limited knowledge about a species, and, as a result, cost estimates are subject to a great deal of uncertainty. Given the importance of cost information, however, this does not provide sufficient justification for such an exercise not to be undertaken. Estimating the costs of programmes is, in itself, likely to be useful because it requires systematic consideration of the plan of actions to be undertaken and how these are linked to the objectives and goals of a programme.

An example from New Zealand that is relevant to many other countries shows that the management of threatened species is limited by budget constraints (Moran, Cullen, and Hughey, 2005). The impact of the budget constraints is that a decision to implement a programme for one species will have an opportunity cost in terms of the management of other species at risk. This impact is apparent both in the persistent underfunding of programmes for some species and a complete lack of funding for those still on the waiting list.

While REDD has a clear connection to the climate agenda, the topic is fully relevant to SDG 15, as the ultimate REDD targets are reduction of deforestation and forest degradation. A paper by Bosetti and others (2011) provides an analysis of potential implications of linking REDD credits stemming from developing countries to a global carbon market. Even though the authors conclude that integrating REDD into a global carbon market lowers the estimated total costs of a policy to achieve 535 parts per million by volume of $CO_2$-equivalent concentrations in 2100 by up to 25 per cent, there are obvious obstacles to this approach. The results reported in the paper indicate that market linkage of REDD induces reductions in clean energy innovation overall, but only slightly enhances development of particular technologies, including carbon capture and storage. The impact of REDD on innovation and transition to new technologies still remains a subject of debate with the major concern that inclusion of REDD credits may lead to unwanted crowding out effects (Beltran and others, 2013). Among the suggested solutions to this problem (Bosetti and others, 2011) is a combination of REDD with credit banking that encourages greater mitigation in the near term, enhancing the flexibility to potentially tighten emission targets at lower cost in response to future information. Inclusion of REDD credits as part of the international carbon market can mobilize the funding needed to realize the full REDD potential (Beltran and others, 2013). Analyses of implementation uncertainties and challenges suggest a more limited and nuanced mitigation role for REDD+, especially in the near future (Lubowski and Rose, 2013). These insights, as well as modeling challenges, suggest that the actual costs and environmental benefits of REDD+ are uncertain and highly dependent on policy and implementation features (Lubowski and Rose, 2013).

Taking the great potential of REDD into account and the need to resolve a range of complex problems associated with its implementation, a promising approach to promoting REDD on a global scale could be raising awareness of its double benefit on both climatic and ecosystems sides, since these benefits seem to be perceived in isolation from each other and generally dealt with by two separate scientific communities. This view is supported by the findings of Laing, Taschini, and Palmer (2016), which argue that as a carbon offset, REDD+ provides insufficient motivation for investment, particularly if cheaper alternatives exist. Co-benefits such as biodiversity conservation and community development are more important when traditional corporate social responsibility motivations play a role.

On a local scale, this study analyzed the motivation of private sector stakeholders to engage in REDD+ and the respective critical obstacles to doing so. The study highlighted that although smaller projects are viewed as offering more visible benefits to stakeholders, in terms of having more control over risks on the ground, they pose a challenge for the design of jurisdictional REDD+ (Laing, Taschini, and Palmer, 2016).

Many stakeholders, especially those anticipating regulatory markets, view a lack of regulatory frameworks and a lack of clarity regarding future regulations as a major barrier to investing in REDD+ (Laing, Taschini, and Palmer, 2016). Concerns were also raised by both potential purchasers and suppliers over actual emergence of regulatory markets and the eligibility of REDD+ in such markets. Emerging pilot institutions and procedures to register projects were perceived by project developers as being too bureaucratic, with a lack of clarity regarding the types of projects that would be allowed to generate credits and conditions under which they might be created. The importance of REDD+ eligibility (acceptance) is explored in detail in Krasovskii and Khabarov (2017).

The authors demonstrated quantitatively (illustrative example) the impact of REDD fungibility uncertainty and concluded that, due to a possible partial acceptance, the contracted amounts and prices are lower (by approximately 25 per cent and 35 per cent, respectively, meaning an overall 50 per cent reduction of potential REDD finance). The study demonstrates an objective reduction of financial potential of REDD due to policy uncertainty.

### III.3 *Existing and novel approaches for addressing financing shortfalls*

A review and assessment of the legally binding instruments on biodiversity presents some international regional examples, but also highlights the need for the protection at multiple levels, including legal and policy commitments at global, regional, national and local levels (Sirakaya, Cliquet, and Harris, 2017).

A report by the World Bank (Mackinnon and others, 2002) on long-term funding for conservation in mountain and other ecosystems states that, with Global Environment Facility (GEF) resources, the Bank has helped to establish several trust funds to support protected-area management and other conservation activities. In Uganda, the Bwindi Trust was the first conservation trust established in Africa with GEF funding. The Trust, established in 1995, provides long-term funding for the conservation of the Mgahinga Gorilla National Park and Bwindi Impenetrable Forest National Park, home to one third of the remaining mountain gorillas. The trust fund provides resources for park management to strengthen protection of the gorilla population and for research to better understand the ecology and social behaviour of the gorillas and other native wildlife. The majority of the income (60 per cent), however, is used to support community development for local people to provide sustainable livelihoods as an alternative to agricultural encroachment into the park.

Another example of long-term financing is the Malawi Mulanje Mountain Biodiversity Conservation Trust (MMCT) (Mackinnon and others, 2002). The MMCT was established through funding from the GEF in 2001. The aim of the project is to establish an endowment aimed at providing long-term conservation finance for the conservation and management of the Mulanje Mountain ecosystem. The project and long-term funding from the Trust focus on three main activities: (i) biodiversity conservation, research and monitoring; (ii) environmental education; and (iii) forest co-management and sustainable livelihoods. The objective of the MMCT is to provide support to the government of Malawi, the Forest Department and the local communities, and to conserve the globally significant biodiversity and the unique ecosystems of the Mulanje massif.

An example of a long-term conservation trust fund in the United Republic of Tanzania is the Eastern Arc Forests Conservation and Management Project (Mackinnon and others, 2002). The mountain rain forests in the eastern region of the country are one of the most important sites for forest biodiversity in continental Africa. These forests lie on ancient hills and are recognized as a biodiversity hotspot and center of endemism, especially for plants, birds, amphibians and primates. The World Bank is supporting a major forest management and conservation project in the United Republic of Tanzania and an associated GEF-funded project specifically designed to provide a long-term conservation trust fund for biodiversity conservation activities in the Eastern Arc Mountains. A partnership between the World Bank and the United Nations Development Programme, the project aims at developing an integrated conservation strategy for the Eastern Arc Mountain Forests to be implemented through funds generated under the endowment. Other examples focused on establishing long-term support (all based on trust funds (endowments).

It is necessary to mention that, in many cases, research has to be carried out to understand the needs, suitable approaches and necessary actions for solving apparent ecosystems problems that, within themselves, contain the complexity of many interacting subsystems. For instance, the World Bank provided a five-year grant to the Mongolian Academy of Sciences for a study entitled "Dynamics of Biodiversity Loss and Permafrost Melt in Hövsgöl National Park, Mongolia" (Mackinnon and others, 2002). The objectives of that study were to identify the impacts of pasture use and forest cutting on the dynamics of forest, steppe, riparian zones and streams in tributary valleys of Lake Hövsgöl; to define how those impacts interact and are affecting the melting of permafrost, soil characteristics, and plant and animal biodiversity; to inventory climate change effects in the National Park; to determine sustainable resource-use patterns that will also protect biodiversity, permafrost and soil sequestration of carbon; and to estimate costs and benefits of alternative land-use practices, especially as related to pastoral nomads. This set of questions is a good candidate for an STI research project related to ecosystems; addressing them is a necessary prerequisite for further successive actions to be funded.

According to (Greiber, 2012), the Nagoya Protocol Implementation Fund (NPIF) is a multi-donor trust fund that started operations in May 2011. The World Bank serves as the trustee of the NPIF, which supports signatory countries, and those in the process of signing the Nagoya Protocol that intend to ratify it, in order to accelerate its ratification and implementation. It also supports existing opportunities leading to development and implementation of concrete Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) agreements with involvement of the private sector. The projects funded under the NPIF encourage engagement with private sector entities interested in exploring the economic potential of genetic resources and facilitating the transfer of appropriate technologies. Through this type of project, countries should be generating additional information that can help them understand their capacities and needs on ABS, with a focus on the provisions from existing policies, laws and regulations affecting genetic resources.

In the climate change context, the potentially unique role of tropical forest protection—unique, that is, by providing a cost-effective "buffer" of near-term emissions reductions at a globally significant scale—is highlighted in Golub, Lubowski, and Piris-Cabezas (2017). This work also explores a promising private finance instrument in the form of long-dated call options on verified reductions in emissions from deforestation and forest degradation. Options on REDD could aid both regulated businesses and tropical nations to manage their respective risks. The authors further conclude, that REDD+ options could deliver sufficient abatement to significantly hedge exposure of regulated entities to potential corrections in climate policy while channeling financial resources to defer deforestation even as climate policies continue to evolve (Golub, Lubowski, and Piris-Cabezas 2017).

Golub, Lubowski, and Piris-Cabezas (2017), which focuses on the economics at small to medium scale, considers both a forest owner—that is, the REDD credits supplier—and a consumer, when each is evaluating the credits (REDD-based offsets), in terms of an enabled benefit-sharing mechanism—meaning that contracted but unused credits will be sold to a third party later and the profit from that sale will be shared between the initial supplier and consumer. The analysis demonstrates that, under future uncertain $CO_2$ prices, the approach based on benefit-sharing facilitates mobilization of private finance and allows for maximizing the contracted amount of REDD.

### III.4 *The potential for STI road maps based on concrete examples*

A successful project reported by Mackinnon and others (2002)—the Turkey Eastern Anatolia Watershed Rehabilitation Project (US$115 million)—had two objectives: (i) restoring sustainable land-use management of degraded watersheds in three provinces of the Upper Euphrates River Basin and (ii) increasing the incomes of the local population living in these areas, among the poorest in Turkey. This is an example of community-based natural resources projects that empower local communities in managing their use of natural resources (forests, pastures, soils and agriculture, water, and wildlife); it demonstrates that ecosystem restoration projects have to be designed with a focus on the economic situation of the local population. Villagers participate in the design of investments for their specific microcatchment. Based on their specific problems and opportunities, they select the most appropriate investments from a menu of interventions and contribute to implementation through provision of labour, working in an integrated fashion with sectoral agencies (agriculture and forestry). To date, investments include rehabilitation of degraded slopes by planting trees, especially fruit and nut trees; conversion of marginal croplands to pasture or hayfields; reduction of grazing intensity through prohibition (e.g., fencing) and positive incentives; small-scale irrigation works for mountain agriculture; conversion of rainfed croplands to irrigated orchards using indigenous fruit and nut trees; and beekeeping. Social and economic benefits of the project include improved rural employment; better income and living standards; enhanced skills and confidence of communities and government agencies in natural resources management; strengthened interagency collaboration; and new opportunities for women. Environmental benefits include improved land use and soil conservation and flood prevention as well as ecological balance and restoration of degraded habitats and increased biodiversity.

In a very similar way, as reported by the biodiversity project in the highlands of northeastern Cambodia (Mackinnon and others, 2002), a project supporting the protection and management of Virachey National Park in the Ratankiri province finds the socioeconomic aspects to be a high priority because of human-driven pressures, including increasing demand for agricultural land; hunting pressures, both for subsistence needs and to fuel the rapidly changing demand for wildlife through black markets; logging, which remains a major medium- to long-term threat despite having slowed in recent months; the pressures for major development initiatives such as national road construction and hydropower development projects.

Silvo-pastoral approaches combined with indicator-based payments might have good potential for promoting environmentally friendly changes in land use. According to the World Bank report (Mackinnon and others, 2002), a regional project was launched in July 2002 in Colombia, Nicaragua and Costa Rica to promote and measure the effects of the introduction of payment systems for environmental services to farmers in degraded pasture systems. This innovative pilot project worked with about 300 farmers in 6 watersheds who were paid on the basis of environmentally friendly changes in land use resulting from the silvo-pastoral approaches implemented on their farms. Silvo-pastoral approaches focus on the promotion of multiple species vegetation (trees, shrubs, grasses and leguminous plants) and multiple use (grazing, cutting for fodder, soil fertility improvement, wood production), replacing the monoculture grass vegetation of the degraded pastures of the region. A baseline study has determined a current "land-use index" against which future changes on the 300 ranches can be assessed. Farmers are paid on a sliding scale and each incremental land-use point has an annual value of $50. Under current assumptions of carbon fixation of different land-use types, this value equals $5 per ton of carbon sequestered. Values are also allocated for improved biodiversity benefits. Since the shift in vegetation provides local environmental benefits—such as the reduction in erosion, improvement in soil and water quality, increased production, higher income and employment in rural areas—the payment for environmental services is only "to tip the balance," the objective being to provide incentives to induce farmers to shift from expanding ranching into tropical forests to the restoration and intensification of degraded pasture to woodlands and improved pasture under the silvo-pastoral system.

The analysis (Chirwa, 2014), along with examples of successful practices in sub-Saharan African countries, presents preconditions for upscaling. Whereas the most promising adaptation strategies to declining tree resources in sub-Saharan African countries include natural regeneration of local species, sustainable forest management and community-based natural resources management (CBRM), the success of such strategies generally depends on the ability of local people to exercise the power to inventory and manage local resources in systems of CBNRM. Most of the national appropriate mitigation actions in Eastern Africa identified agricultural expansion and overgrazing as some of the causes of deforestation. One of the factors that has contributed to forest degradation in Ethiopia, Rwanda and Uganda was frequent drought. Different countries seem to have different forms of practices for restoration. For example, Ethiopia and the United Republic of Tanzania seem to promote exclosures and natural regeneration in areas associated with overgrazing. Artificial regeneration is advocated for community woodlots in Rwanda and the United Republic of Tanzania, reforestation of degraded hill areas in Ethiopia, and farm forests in Uganda.

Based on these examples, and also those mentioned earlier in this document, a concise image of the components an STI road map (case/project/higher-level) should include is shown in figure II.4.1.

**Figure II.4.1**

**STI road map for diagnostics and decision-making related to SDG 15**

| | |
|---|---|
| Diagnostic | • Legal context framing<br>• Quantification of<br>  o biophysical indicators<br>  o socioeconomic indicators |
| Decision-making | • Estimation of existing possibilities (incentives) to improve those based on:<br>  o available funding and/or<br>  o change in policies to create market value and attract private capital<br>• Agreement on possible trade-offs between stakeholders |

Source: UN/DESA.

Supported by the cited literature, creating a market value to attract private capital has promising potential for financing SDG 15 in particular.

An extremely important component in attaining SDG 15 targets is the temporal component. The feasibility of meeting SDTs in the agreed time is in doubt, considering projected population growth and growing pressures on ecosystems stemming from current limitations in technological/environmental possibilities and, in particular, from limits to intensification of agricultural production. The quantitative estimates (World Wide Fund for Nature and International Institute for Applied Systems Analysis, 2015) carried out within a similar context are already vividly showing the infeasibility of zero net deforestation and biodiversity targets in 2030-2050, unless new technologies emerge that would provide additional sources of (substitutes for) animal protein, or traditional food consumption patterns shift substantially (i.e., less future demand for animal calories). This consideration directly links to SDG 12 on sustainable consumption and production patterns. The analysis of the SDG framework presents further detail on how coherent policy combinations can manage trade-offs among environmental conservation initiatives and food prices, concluding that investments in resilient and high-intensity production systems, waste reduction, and reduced meat consumption can reduce pressures by improving resource-use efficiency (Obersteiner and others, 2016). Hence, behavioural change (food consumption patterns) and new emerging and revolutionary technologies are likely to be an important part of the solution.

## IV. Conclusion and suggestions for a way forward

Based on the analysis presented in this document, a few aspects crucial to the achievement of SDG 15 become quite prominent. We have seen the importance of the legal context created by binding agreements at various levels. Regarding payment for performance, a quantification based on a set of biophysical and socioeconomic indicators is a prerequisite.

These are necessary elements for creating market incentives that attract private finance. This source of finance seems to be a promising solution for improving socioeconomic situations and securing long-term funding (which is key to many SDTs of SDG 15), as compared to endowments-based funding, which has obvious limits in upscaling. This is supported by the fact that, in many cases, under a business-as-usual scenario, there is a clear trade-off between environment and economics.

Because of the high complexity of the problem (location-specific, complex interactions between subsystems, inherent to ecosystems), there are many gaps regarding scientific and economic assessments. These gaps can serve as a starting point in solving existing issues and therefore be a primary target for funding.

Cost-efficient, large-scale monitoring technologies (remote sensing) still have limits in accuracy and supplied indicators, implying the need for costly in-situ measurements, The emergence of a global carbon market could foster valuing ecosystems via REDD and create financial inflow to support actions that lead to the achievement of SDG 15. However, actual costs and environmental benefits of REDD are uncertain. Nevertheless, the approach can serve the purposes of linking national and international levels in order to allow more flexibility in finance.

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## Annex I

SDG 15 and its targets

| **SDG 15** | **Targets** |
|---|---|
| Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss | 15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements<br>15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally<br>15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world<br>15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development<br>15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species<br>15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed<br>15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products<br>15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species<br>15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts<br>15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems<br>15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation<br>15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities |

## Annex II

**Mind map of SDG 15**