UNIVERSITÀ DEGLI STUDI DI PADOVA
Department of Land, Environment Agriculture and Forestry

Second Cycle Degree (MSc)
in Forest Science

# How much do forest certification standards address biodiversity dimensions? A comparative assessment of selected standards worldwide.

Supervisor
Prof. Mauro Masiero

Co-Supervisor:
Alex Pra

Submitted by:

Maria Alejandra
Lizcano Solano

Student no.
002038554

ACADEMIC YEAR 2021 – 2022

**Index**

## List of figures



## List of tables

**Abbreviations and acronyms**

| | |
|---|---|
| CBD | Convention on Biological Diversity |
| ES | Ecosystem Services |
| FSC® | Forest Stewardship Council |
| IGIs | International Generic Indicators |
| ITTO | International Tropical Timber Organization |
| MBI | Market Based Instruments |
| P, C & I | Principles, Criteria, and Indicators |
| PEFC | Programme for the Endorsement of Forest Certification |
| SFI | Sustainable Forest Initiative |
| SFM | Sustainable Forest Management |

## Acknowledgement

I would like first to express my gratitude to my supervisor and co-supervisor prof. Mauro Masiero and Alex Pra. Thank you for your patience, your guidance, knowledge-sharing, and support in the conception of this document.

I would like to thank Wesley, my colleague and friend. His support throughout the process not only professionally but personally was key to successfully developing this thesis. I'm also very grateful with the Etifor team for the support, the help when I was stuck, and the opportunity to learn from each person that substantially improved the content of this thesis.

Quiero agradecer a mi mami, a mi papi, a Sugey, a mis abuelitos, a toda mi familia y a la familia Montes, que ha estado desde el momento cero apoyándome y alentándome para cumplir este sueño que ha sido hacer este máster. A mis amigas y amigos de vieja data y más recientes que fueron una red de apoyo e inspiración para mantenerme firme. A la familia Beck Velasco por abrirme sus puertas estos dos años en su hogar y darme el calor familiar que tanto me hacía falta.

A mis amigos padovanos, por aguantarme quejándome mientras escribí esta tesis y siempre estar ahí dándome su cariño y apoyo.

Por último, pero no menos importante, a mi esposo, Sebas, tu apoyo y amor incondicional me ayudó en los momentos más difíciles de este proceso. Mi agradecimiento infinito a ti por tu amor y paciencia en todas las veces que sentí perder la cabeza. Te amo con el alma.

**Summary**

The recent global ecological crises (i.e., climate, biodiversity, plastic, resources, pollution, land use, etc.) have led the world towards a more and more urgent need for the sustainable use of natural resources. While ceasing the use of some resources seems unfeasible, the responsible use and management of social and natural assets portray an opportunity to contribute to building a more resilient, equitable, and endurable future to embrace the foreseen consequences of these global crises. As for biodiversity, the current crisis has gained much attention in the last decades. Several sectors such as academia, non-profit organizations, the financial and private sector, public bodies, and organizations have placed multiple efforts to assemble a solution that meets the critical demands at several scales of the biodiversity crisis. Nonetheless, biodiversity is context-dependent, multi-scale, complex, and underpins multiple dimensions. This study pretended to, first through experts' consultation, identify and build a meta-standard containing key criteria and indicators focused on biodiversity maintenance, protection, enhancement, and conservation. Second, from the reference standard, develop a comparative assessment of the extent to which selected forest certification standards address the multiple aspects related to biodiversity and third, to provide lessons learned and inputs on the least covered topics with the aim to contribute to future development and improvement of forest certification schemes. The results show that most of the standards had a strong focus on protecting threatened and endangered species, high conservation value areas, and water bodies. Moreover, the prioritization of connectivity and complexity of the forest addressed landscape biodiversity issues stressed in previous studies to be lacking in forest certification standards, seems to be a widely covered topic in the assessed standards. In contrast, while many biological and ecosystemic problems are widely discussed, critical aspects intrinsically connected to biodiversity are still overlooked. Climate change mitigation, adaptation, and resilience development, research, education, and capacity-building programs oriented to strengthen the acknowledgement, governance, and sensitivity toward biodiversity are poorly addressed topics in most of the standards.

# 1. Introduction

Human Development in the last decades has led to alarming biodiversity loss rates (IPBES 2019a; Sun et al. 2022). Biodiversity loss has been linked to the reduced provision in quality and quantity of essential resources, such as net primary production and carbon sequestration; instability of ecosystem functions, like water filtration or soil formation, and decreased delivery of provisioning and regulating ecosystem services, like climate regulation and pollination (Cardinale et al. 2012; IPBES 2019a; Korn et al. 2019; Pörtner et al. 2021), ultimately affecting human welfare.

Biodiversity has been widely defined in papers and grey literature from a biological perspective (UNEP and CBD 1994; Putz et al. 2000; Magurran 2004; CBD 2013; WWF 2018; TNC 2022). The social, cultural, and economic intrinsic value of biodiversity besides the biological denotation has been more marginally addressed, though in the last 15 years it has started to be broadly recognised in several contexts (MEA 2005; UNESCO and CBD 2010; Schneiders et al. 2012; Gregory et al. 2013; Laurila-Pant et al. 2015).

Biodiversity collapse has been classified as a top risk in terms of impact and likelihood of happening in the next five to ten years (World Economic Forum 2021) and shall not be overlooked; stopping it is a significant concern among governments, the private sector, non-governmental organisations, and civil society at large. Biodiversity-associated issues are now starting to be considered also from social, cultural and economic perspectives (IPBES 2019a; Pörtner et al. 2021; FC4S and UNDP 2022). As a result, many regulations, approaches, and tools to reconcile human development and the environment have arisen.

Among the formers, market-based instruments (MBIs) have been booming in the past few years to promote sustainable management of resources through incentives to profitable businesses (Lapeyre and Pirard 2013). MBIs function as a comprehensive set of tools with a price component and a place in the market (Pirard 2012). Among the assemble of instruments comprised by MBIs, “voluntary price signals” emerge in the form of certifications, standards, and guidelines where producers, through the completion of specific benchmarks, claim particular impacts on the environment to obtain a price premium for their products (Pirard 2012; Thorsen et al. 2014).

Several certification systems dealing with biodiversity can be found in the market. Some of them are designed to operate in multiple sectors, while others are designed for specific sectors. These address biodiversity aspects concerning a single economic sector, such as fisheries and aquaculture, agriculture and food, finance, mining, carbon offsets, tourism, and others (UNEP-WCMC 2011). With specific reference to the forest sector, there are certification schemes, standards and guidelines that promote sustainable forest management (even though some of them do not deliver a certification label), such as the Forest Stewardship Council® (FSC®), the umbrella scheme of the Programme for the Endorsement of Forest Certification (PEFC), the International Tropical Timber Organization (ITTO), among others. In 2004, Holvoet and Muys (2004) identified nearly 164 sustainable forest management (SFM) standards. However, a common understanding of how criteria and indicators from different standards interact was still unexplored. Masiero et al. (2015) provided a complete analysis of how sustainability standards and guidelines follow reference principles and their relationship with the criteria and indicators, specifically for forest plantations. As for biodiversity issues, the authors found both profound gaps and overlapping in the certification criteria across different standards and guidelines.

Similarly to the purpose of this thesis, Englund and Berndes (2015) explored to which extent sustainable standards considered biodiversity aspects within their criteria and indicators. Existing literature focused on biodiversity assessment within existing sustainability standards and, particularly in forest certification schemes, poorly covers biodiversity's social, cultural, and

economic aspects. This might be linked to the fact that solid empirical evidence of social and institutional impacts of certification is still missing and existing literature still shows conflicting results (Doremus 2003; Blackman et al. 2017; Cerutti et al. 2017). In other terms, the environmental impacts of forest certification are more studied than social, cultural, and economic ones.

Henceforth, to establish a comprehensive understanding of the more meaningful criteria and indicators regarding biodiversity from a holistic perspective and therefore address the current biodiversity issues, a critical review and comparison of standards and guidelines for forest certification against a reference standard portray an opportunity for further research.

Even though previous studies have been conducted on guidelines and standards overall, this thesis will specifically focus on the standards that lead to a certification in the forestry sector. This is linked to two main objectives: first, to provide an insight into the extent biodiversity is addressed in the current certification schemes within the forest sector; and second, to contribute to the continuous enhancement of forest certification standards, particularly concerning a more holistic definition of biodiversity aspects.

# 2. Theoretical background

The theoretical background section will address the relevant contextual helpful information to understand the concepts within the thesis. First, it is presented an overview of the comprehensive definition of biodiversity (2.1). This is followed by sub-section 2.2, which addresses key aspects for preservation, conservation, enhancement, and valuing biodiversity, the ecosystem services cascade approach, and the main drivers of biodiversity loss. Sub-sections 2.3 and 2.4 address policy tools, market-based instruments, and certification systems. In 2.3, is presented of a summary containing the definition of policy tools, their causes, and their uses. Whereas sub-section 2.4 gets deeper into the policy tool, this thesis will focus on market-based instruments and certification systems. Sub-section 2.5 narrows the narrative into the certification in the forestry sector and presents the central structure of certification systems —finally, provision of previous studies and similar comparative assessments in the matter.

## 2.1. What is biodiversity

Several definitions of biodiversity have been discussed over time. WWF (2018) defined it as "*all the varieties of life that can be found on Earth and their relationships to each other*" (p. 110). The Nature Conservancy (2022) described it as "*essentially, everything that makes Earth inhabitable*". In Measuring Biological Diversity, Magurran (2004) defined it as "*The variety and abundance of species in a designated unit of study*" (p. 6).

However, the most widely accepted and comprehensive definition according to the Convention on Biological Diversity (CBD), biodiversity is conceived as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*" (UNEP and CBD 1994). Biodiversity is then defined in three principal dimensions: ecosystems, species, and genes. The variations within these dimensions are described by specific concepts such as species richness, abundance, and function (CBD 2013; Englund and Berndes 2015).

Biodiversity loss, on the other hand, is not explicitly defined. However, it is interpreted as a "*concept that reaches beyond extinction, with spatial and temporal dimensions, covering, inter alia:*

a. *The decline in extent, condition, or sustainable productivity of ecosystems.*
b. *The decline in abundance, distribution or sustainable use of populations, and species extinctions.*
c. *Genetic erosion."* (CBD 2013)

For a better understanding of the biodiversity concept as reported by the CBD, Table 1 presents the disaggregation of biodiversity into several components, according to Putz et al. (2000). Although the landscape is not explicitly named as a component in the CBD definition, the interaction among ecosystems and ecological fluxes can be understood as such. Landscape and ecosystems' biophysical features and functionality are essential to species permanence and adaptability (Schmitz et al. 2015) and therefore they need to be considered.

**Table 1. Components and attributes of biodiversity according to Putz et al. (2000)**

| | Attributes | | |
|---|---|---|---|
| **Components** | **Structure** | **Composition** | **Function** |
| **Landscape** | Size and spatial distribution of habitat patches (e.g., seral stage diversity and area); physiognomy; perimeter area relations; patch juxtaposition and connectivity; fragmentation | Identity, distribution and proportion of habitat types and multi-habitat landscape types; collective pattern of Species distributions. | Habitat patch persistence and turnover rates; energy flow rates; disturbance processes (e.g., extent, frequency, and intensity of fires); human land use trends; erosion rates; geomorphic and hydrologic processes |
| **Ecosystem** | Soil (substrate) characteristics; vegetation biomass; basal area and vertical complexity; density and distribution of snags and fallen logs | Biogeochemical stocks; lifeform proportions | Biogeochemical and hydrological cycling; energy flux; productivity; flows of species between patches; local climate impacts |
| **Community** | Foliage density and layering; canopy openness and gap proportions; trophic and food web structures | Relative abundance of species and guilds; richness and diversity indices; proportions of endemic, exotic, threatened, and endangered species; proportions of specialists' vs generalists | Patch dynamics and other successional processes; colonization and extinction rates; pollination, herbivory, parasitism, seed dispersal, and predation rates; phenology |
| **Species/ population** | Sex and age/size ratios; range and dispersion | Species abundance distributions, biomass, or density; frequency; importance or cover value | Demographic processes (e.g., survivorship, fertility, recruitment, and dispersal); growth rates; phenology |
| **Genetic** | Effective population size; depression; heterozygosity; polymorphisms; generation overlap; heritability | Allelic diversity; presence of rare alleles; frequency of deleterious alleles | Gene flow; inbreeding depression; rates of outbreeding; genetic drift and mutation; selection intensity; dysgenic selection |

So far, the CBD has defined biodiversity and its loss as a mere biological definition setting aside the interactions and the stretch relationship between biodiversity and the socio-economic aspects. The Millennium Ecosystem Assessment (MEA 2005) and several other studies (UNESCO and CBD 2010; Schneiders et al. 2012; Gregory et al. 2013; Laurila-Pant et al. 2015) have recognised the social and cultural, and economic intrinsic value of biodiversity besides the biological denotation. Indeed, a more comprehensive description of biodiversity recognizes the multi-scale and multi-dimensional interactions of the social, cultural, and economic elements that directly or indirectly affect the variability of the biodiversity (Schneiders et al. 2012; Laurila-Pant et al. 2015). Yet, in 2010 the CBD released the Aichi Biodiversity Targets, whose main purpose is to set measurable objectives to save biodiversity and enhance its benefits for people (CBD 2010). The targets are composed of five strategic goals and twenty targets, including the "*Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use*". Hence, biodiversity-associated aspects represent both an ecological and a social and economic issue (IPBES 2019a; Pörtner et al. 2021; FC4S and UNDP 2022).

Sustainable development has been defined as the development that meets present needs without compromising future generations' resources (UN 2015). The CBD stated that a practical way to make progress toward the Aichi Biodiversity Targets (CBD 2016) is "*promoting the use and development of scenarios that integrate biodiversity considerations with other societal and cultural objectives… which consider multiple direct and indirect drivers of biodiversity loss and better reflect ecosystem functions and services*" (CBD 2019). The sustainable use of biodiversity can be considered a strategy to avoid and reduce the impacts on biological resources (CBD 2004; Paluš et al. 2021). To this aim, the CBD developed the Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity. These assume that biological diversity resources can be used sustainably, and that sustainable development requires the responsible use of biological resources going beyond mere preservation. To this aim, 14 principles are recommended for any use of biological diversity. These principles are formulated to be implemented by different types of actors, including forest managers, governments, and policymakers. This means that some of the principles might be out of influence or decision-making capacity by the forest managers. Table 2 displays the 14 Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity (CBD 2004).

**Table 2. Addis Ababa Principles for the Sustainable Use of Biodiversity**

| | **Description** |
|---|---|
| Practical principle 1 | Supportive policies, laws, and institutions are in place at all levels of governance, and there are effective linkages between these levels. |
| Practical principle 2 | Recognizing the need for a governing framework consistent with international, national laws, local users of biodiversity components should be sufficiently empowered and supported by rights to be responsible and accountable for the use of the resources concerned. |
| Practical principle 3 | International, national policies, laws and regulations that distort markets which contribute to habitat degradation or otherwise generate perverse incentives that undermine conservation and sustainable use of biodiversity should be identified and removed or mitigated. |
| Practical principle 4 | Adaptive management should be practiced based on science and traditional and local knowledge; iterative, timely and transparent feedback derived from monitoring the use, environmental, socio-economic impacts, and the status of the resource being used; and adjusting management based on timely feedback from the monitoring procedures. |
| Practical principle 5 | Sustainable use management goals and practices should avoid or minimize adverse impacts on ecosystem services, structure, and functions as well as other components of ecosystems. |
| Practical principle 6 | Interdisciplinary research into all aspects of the use and conservation of biological diversity should be promoted and supported. |
| Practical principle 7 | The spatial and temporal scale of management should be compatible with the ecological and socio-economic scales of the use and its impact. |
| Practical principle 8 | There should be arrangements for international cooperation where multinational decision-making and coordination are needed. |
| Practical principle 9 | An interdisciplinary, participatory approach should be applied at the appropriate levels of management and governance related to the use. |
| Practical principle 10 | International, national policies should consider current and potential values derived from the use of biological diversity, intrinsic and other non-economic values of biological diversity and market forces affecting the values and use. |

| | |
|---|---|
| Practical principle 11 | Users of biodiversity components should seek to minimize waste and adverse environmental impact and optimize benefits from uses. |
| Practical principle 12 | The needs of indigenous and local communities who live with and are affected by the use and conservation of biological diversity, along with their contributions to its conservation and sustainable use, should be reflected in the equitable distribution of the benefits from using those resources. |
| Practical principle 13 | The costs of management and conservation of biological diversity should be internalized within the management area and reflected in the distribution of the benefits from the use. |
| Practical principle 14 | Education and public awareness programs on conservation and sustainable use should be implemented, and more effective methods of communication should be developed between and among stakeholders and managers. |

In this thesis, biodiversity will be defined using the biological components suggested by the CBD and Englund and Berndes (2015): species diversity, ecosystem diversity, genetic diversity, and functional diversity. Additionally, it will consider social, cultural, and economic aspects suggested by the Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity reachable under forest managers' influence and appropriate for the scope of the objectives. The criteria and indicators will be selected to develop the study following these definitions.

## 2.2. Key aspects for preservation, conservation, enhancement, and valuing of biodiversity

To first understand the importance and critical aspects of preserving, enhancing, and valuing biodiversity, it is fundamental to comprehend that biodiversity is not an ecosystem service (ES) per se, but rather the presence of living organisms on the planet, and the ES are a consequence of their existence, structures, and interactions with abiotic components (Haines-Young and Potschin 2010). Henceforth, ES depend essentially on biodiversity as a key contribution to ecosystem structures and processes. The latter can be considered as underlying functions of ecological systems which are prior to functions and ES. Turner (2010) calls them ‘primary values’: they are essentially the system characteristics upon which all ecological functions are contingent. In this perspective, biodiversity is regarded as a glue holding ecosystem functions and ES together (Pearce and Moran 1994). Haines-Young and Potschin (2010) proposed the first ES cascade to explain the relationship between the components of ES with human-wellbeing (Haines-Young and Potschin 2010; Zhang et al. 2022). The cascade (Figure 1) differentiates on the one hand the ecosystem structures, processes, and functions, generating supporting intermediate ES (e.g., habitat provision, biomass production, water cycling etc.), and on the other hand, the final services and, in connection to them, the benefits people will derive from ES. In this sense, ES can only be considered as such when they represent a benefit to society. This view implies an anthropocentric perspective to ES and their value, and a utilitarian approach to them, as opposed to more biocentric positions (Goulder and Kennedy 1997).

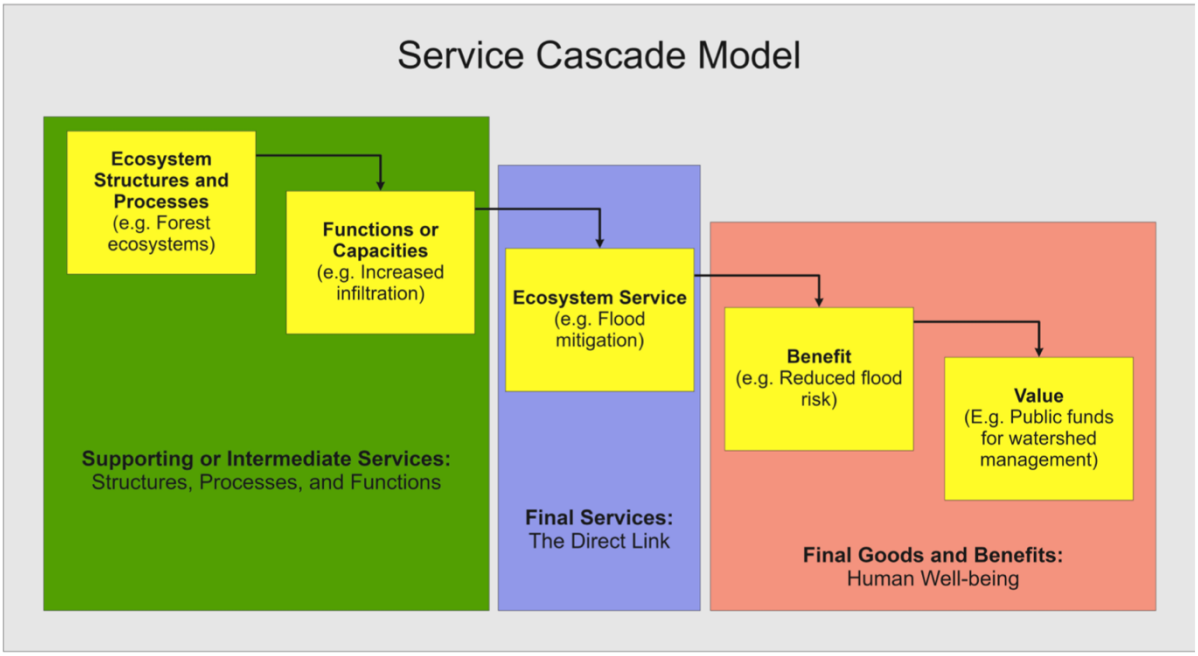



**Figure 1. Ecosystem services cascade. Adapted from Haines-Young and Potschin (2010)**

Once the importance of biodiversity has been understood to guarantee the benefits provided by the ES, the drivers threatening biodiversity are to be explored. According to the MEA (2003) and IPBES (2019), the drivers threatening biological diversity can be divided into two categories: direct and indirect (Figure 2). **Direct** (or **proximate**) drivers directly impact biodiversity and cause biodiversity losses. They include (1) overexploitation of resources (e.g. massive and intense aquaculture, agriculture, forestry, harvest, hunting, mining, intense tourism, illegal activities, etc.); (2) habitat, landscape/seascape destruction, fragmentation and degradation (e.g. urban and agricultural expansion, management intensification, land degradation, etc.); (3) pollution (atmosphere emissions, water contaminants, solids disposal); (4) introduction of invasive alien species; and (5) climate change (sea-level rise, ocean acidification, biogeochemical cycle alteration). **Indirect** (or **underlying**) drivers are complex interactions of different processes (social, economic, political, cultural, and technological ones) that affect the proximate drivers and their capacity to impact biodiversity. They include (1) values assigned by people (related to the attributes of environmental resources, such as the public good nature, externalities and ultimately, market failure); (2) demographic changes (population growth, migrations, urbanization, changes in human capital); (3) technological changes (indigenous and local knowledge loss, technification of primary sectors); (4) economic aspects (structural transition, concentrated production and financial flows); and (5) governance and market interactions, local community, states and global coordination.

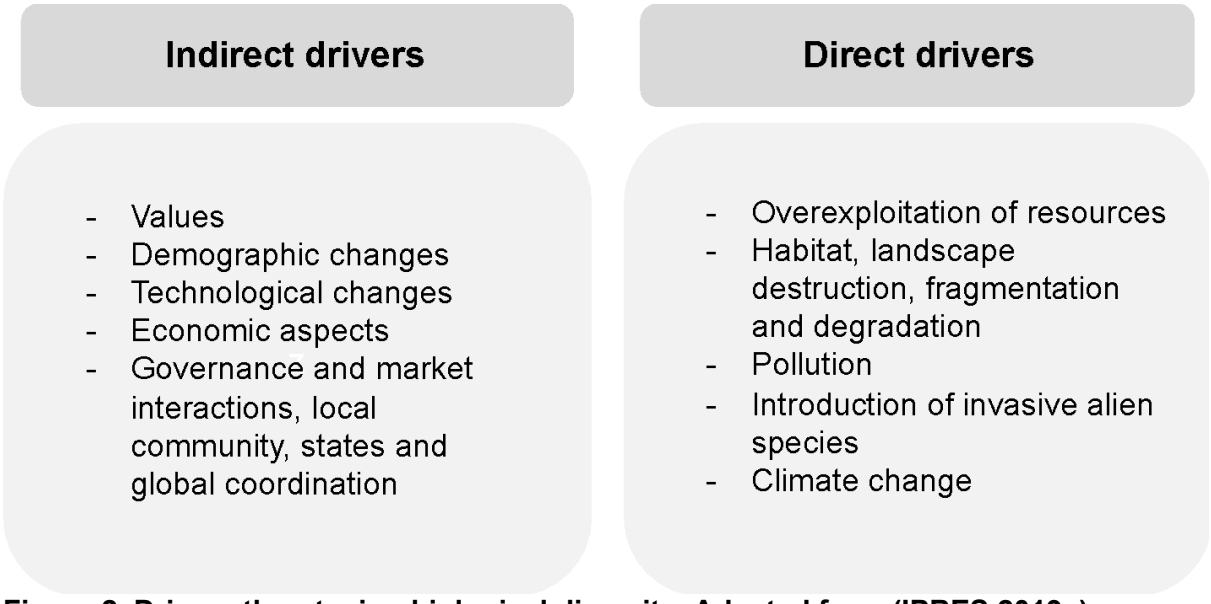



**Figure 2. Drivers threatening biological diversity. Adapted from (IPBES 2019a).**

Considering the diversity of drivers presented above and their interactions, biodiversity conservation requires a series of actions to mitigate the threats. The Society for Conservation Biology (Trombulak et al. 2004) suggested approaching them based on protecting and restoring biological diversity, ecological integrity, and ecological health. Nine principles should guide the efforts to: *"(1) protect species at risk of extinction; (2) designate ecological reserves; (3) lessen the human impact on natural systems; (4) restore ecosystems that have been degraded; (5) augment populations with individuals raised in cultivation or captivity; (6) control the number of individuals harvested in nature; (7) prevent the establishment of non-native species and eliminate non-native species that have become established; (8) understand and participate in the policy-making process; and (9) educate others about the importance of conservation".*

Moreover, as explained above, biodiversity underpins several ES. The loss of biodiversity carries ecosystem consequences such as a reduction in the number and diversity of species, loss of ecosystem structure and complexity, resilience, ecosystem function, and habitat suitability, among others (Cardinale et al. 2012; IPBES 2019a, b; Korn et al. 2019; Pörtner et al. 2021). Table 3 shows the relationship between biodiversity and several ES.

**Table 3. Ecosystem services and biodiversity provider. Adapted from Haines-Young and Potschin (2011)**

| Ecosystem service | Ecosystem service provider |
|---|---|
| Aesthetic, cultural | All biodiversity |
| Religious and spiritual experiences | All biodiversity |
| Healing, recreational and relaxation activities | All biodiversity |
| Ecosystem goods | Diverse species |
| UV protection | Biogeochemical cycles, micro-organisms, plants |
| Purification of air | Micro-organisms, plants |
| Flood mitigation | Vegetation |
| Drought mitigation | Vegetation |
| Climate stability | Vegetation |

| Ecosystem service | Ecosystem service provider |
|---|---|
| Pollination | Insects, birds, mammals |
| Pest control | Invertebrate parasitoids and predators and vertebrate predators |
| Purification of water | Vegetation, soil micro-organisms, aquatic micro-organisms, aquatic invertebrates |
| Detoxification and decomposition of wastes | Leaf litter and soil vertebrates, soil micro-organisms, aquatic micro-organisms |
| Soil generation and soil fertility | Leaf litter and soil invertebrates, soil micro-organisms, nitrogen-fixing plants, fungi, plant, and animal production of waste products |
| Seed dispersal | Ants, birds, mammals |
| Medicinal compounds | All biodiversity |
| Net primary production | Vegetation, algae and aquatic plants and micro-organisms |
| Carbon storage | Vegetation |
| Raw material | Plants, vegetation, fungi |

## 2.3. Policy tools

According to environmental economics, market failure is defined as the failure of the market when avoiding free-riding of resources and inefficient allocation of themselves (Randall 1983; Bougherara and Grolleau 2005). Authors argue that market failure is mainly caused by externalities, public good attributes of nature, and the tragedy of commons (Randall 1983; Thorsen et al. 2014). When valuing nature, ES are commonly referred to since, as explained above, they represent the tangible or intangible outcome humans can benefit from. Thereafter, when assigning a value to ecological resources, including biodiversity, in the past decades the market has developed some strategies to "correct" the failures, internalize externalities, and protect the resources.

From "stick" tools, i.e., command and control regulations, "carrots", mainly in the form of Market Based Instruments (MBIs), and "sermons", a growing set of alternatives is now setting a direction to correct market failures associated with the delivery of ecosystem services (ES), thus trying to secure ES without sacrificing economic development. Differences among the "stick" tools or command and control, "carrots" or economic instruments and "sermons" or information and education vary according to the state control they exert, direct and transaction costs, and the actors involved (Thorsen et al. 2014).

Command and control tools include direct regulation or state control, meaning these instruments are usually compulsory or imposed by the state or other public entity (Thorsen et al. 2014; Morgan et al. 2022). However, command and control tools have been argued to be insufficient, primarily due to the lack of improvement and long-term permanence conditions once the regulatory requirements are met ( Greenlaw et al. 2017 in Makrickiene et al. 2019). In forest policy, the primary duty of these tools is related to the enforcement of legal and compulsory frameworks (Brukas and Sallnäs 2012).

Carrots, i.e. incentives, which include (but are not limited to) MBIs, are part of a set of policy measures and tools to correct the market failure (Thorsen et al. 2014), which is caused mainly by externalities, asymmetric information, non-exclusion and the non-rivalry nature of some forest-based ES (Sterner and Coria 2013). MBIs work by inciting and supporting a wanted behavior towards a good while avoiding the coercion of direct regulation (Thorsen et al. 2014). They encourage and reward a change of behavior (Rissman et al. 2017) and allow governance to some degree to the subjects to take action or not (Bemelmans-Videc et al. 1998). Within MBIs, certification systems are found to be voluntary instruments and are characterized by offering a price premium for differentiated products that meet specific production processes and impact standards (Bemelmans-Videc et al. 1998; Pirard 2012; Thorsen et al. 2014); these processes and standards are then assessed by a third party who gives an assurance of compliance (Villalobos et al. 2018).

The last policy/instrument category, “sermons”, or information and education, attempts to influence behavior change through persuasion and knowledge transfer. This tool provides information on the issues, how to handle them, measures and reasons for the steps to be adopted (Bemelmans-Videc et al. 1998). This category includes several strategies, i.e., communication campaigns, advertising, training programs, educational efforts and capacity building (Bemelmans-Videc et al. 1998; Thorsen et al. 2014). The main difference between carrots and sermons is that sermons do not provide economic benefits, such as premium prices, subsidies, or tax exemptions. Sermons aim to induce the execution of an activity or divert the user from performing it (Bemelmans-Videc et al. 1998).

## 2.4. Market-based instruments and certification systems

Certification systems are part of the MBI tools to address sustainability gaps that regulatory processes have not been (entirely) able to tackle (Tröster and Hiete 2018). As a result, voluntary and independent certification systems emerged as the result of international/national, private, and non-governmental organizations’ efforts to standardize and stress sustainable practices of corporations besides or in addition to the mandatory legal requirements (Holvoet and Muys 2004; Mena and Palazzo 2012; Tröster and Hiete 2018).

Many economic sectors have now adopted a wide range of standards to improve their sustainability performances in environmental and/or socio-economic terms (UNEP-WCMC 2011). Standards also require standardization to measure progress towards goals (Linser et al. 2018) regardless of their economic sector.

The most popular certification schemes operating in the market are organized according to a hierarchical structure and developed following the logic proposed in the Tropenbos Hierarchical Framework, which was initially designed to promote, monitor, and report Sustainable Forest Management (SFM). This framework has encouraged the development of other private sector and private-public initiatives within the framework of the MBIs (Linser et al. 2018). The framework consists of three pillars, i.e., principles, criteria, and indicators (PC&I) which are then integrated by additional components such as norms and verifiers (figure 3) (Lammerts van Bueren and Blom 1997). The framework is designed to guide inputs, e.g., intention, object, and capacity, management process and outcomes, e.g., performance or outputs. The expected result from these is often used as a reference for defining the standards (Kuijk et al. 2009; Morgan et al. 2022). For example, the inputs will guide the principles at the top of the hierarchy, the management process will guide the criteria, and the outcomes will guide the indicators.

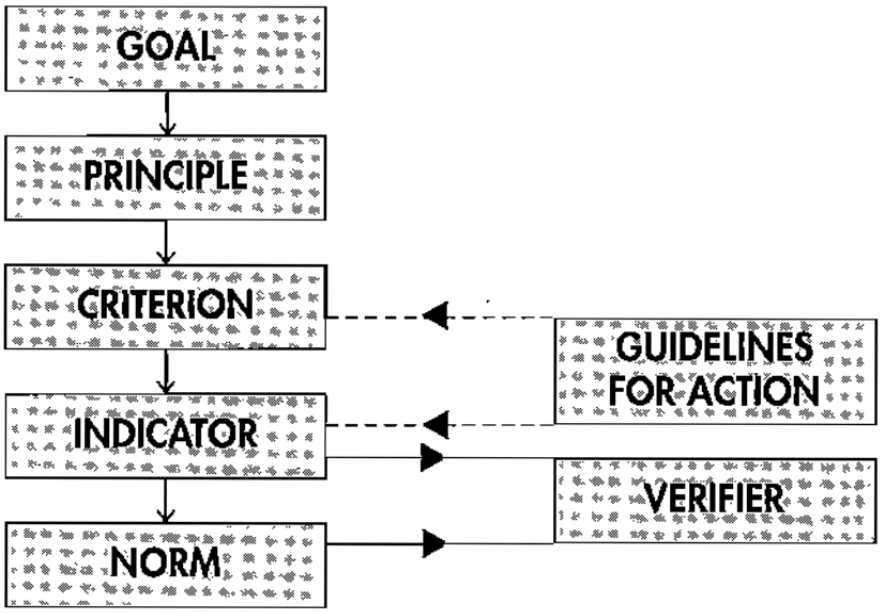



**Figure 3. Tropenbos Hierarchical Framework. Source: (Lammerts van Bueren and Blom 1997)**

To start with, the framework pursues one goal, for example, in this case: to promote SFM. Principles disaggregate from the goal, e.g., in the case of FSC (2015), as "*essential rules or elements of environmentally appropriate, socially beneficial and economically viable forest management"*. The principles are theoretical and non-measurable statements that intend to justify the actions to achieve a certain goal (in our case, SFM) as described by the criteria and indicators (Morgan et al. 2022). Principles are connected to a particular forest ecosystem function or a social feature that interacts with the ecosystem; they describe specific elements the goal aspires to achieve (Lammerts van Bueren and Blom 1997).

Criteria are next in the hierarchical framework; they aim to outline the state or the aspects of a dynamic forest ecosystem process without explaining how to achieve the state or implying the achievement of it (Lammerts van Bueren and Blom 1997). Criteria are non-measurable, yet they can be considered as a set of parameters that, when met, can demonstrate some degree of compliance with the principle they belong to. Criteria should not add requirements outside the principles' scope and should be aligned and consequent within them (Lammerts van Bueren and Blom 1997; FSC 2015; Morgan et al. 2022).

Indicators are a practical resource used to monitor and report the fulfilment of the principles and criteria. They establish the requirements and conditions to meet either in qualitative or quantitative terms. Indicators should objectively and unambiguously describe the features of the ecosystem and social system that principles and criteria could not measure by themselves. The results from the indicators should simplify the communication of the information to the involved parties (Lammerts van Bueren and Blom 1997; Morgan et al. 2022).

According to Lammerts van Bueren and Blom (1997), indicators can be divided into two categories according to their type: (i) quantitative/qualitative or (ii) input/process/outcome. As for the first type, quantitative Indicators allow quantitative measures of something being expressed as an amount, numbers, volume, etc., whereas the qualitative ones describe situations, objects, or processes without strictly involving enumeration and measurement. The second type of Indicator reports an actual condition or state of an aspect of an ecosystem or social system.

Indicators are the measurable step to allow checking the compliance with the corresponding criteria, and ultimately, principles. Given this, in their formulation Indicators must be consistent with the principles and criteria they are linked to.

The Tropenbos Hierarchical Framework has been considered an essential handbook for the development of SFM standards because it shifted the sustainable yield vision of SFM to a more comprehensive and complete picture of SFM, including broader ecosystem, social and financial aspects that are incorporated by most of the existing SFM certification systems and their standards (Lammerts van Bueren and Blom 1997; Holvoet and Muys 2004; Linser et al. 2018).

## 2.5. Certification in the forestry sector

In the forestry sector, certification systems originally arose intending to address deforestation in tropical countries by promoting SFM practices (Paluš et al. 2019). Forest certification systems have been developed in two main categories: (i) international (or supranational) and (ii) national schemes. In some cases, national schemes are endorsed by international bodies. These systems share the same general goal: the sustainable management of forest resources by complying with ecological, social, and economic values and principles. Nonetheless, the main difference lays in the vision of each certification scheme of these values and regulations and the capacity to adapt and comply with them according to their diverse socioeconomic settings and ecosystems (Angelstam et al. 2004; Paluš et al. 2021).

Nowadays, certification is considered a valuable method for implementing SFM (Masiero et al., 2015) because it addresses social, environmental and economic issues linked to forest management (Paluš et al. 2019; Garzon et al. 2020). Forest certification has become a powerful tool also to manage risks, enhance the public image and access to markets, showing signals of pro-environmental, ethical and moral behavior, which leads to providing enough incentives for suppliers to bear the costs of certification for companies (Owari et al. 2006; Galati et al. 2017; Paluš et al. 2019; Garzon et al. 2020). Although forest certification is classified as a carrot tool, authors have described certification practices also as a “sermon” by providing guidance and inciting other forest managers to become certified as a desirable behavior (Brukas and Sallnäs 2012).

Several studies across the world have had tried to assess the impact of certification practices on biodiversity (Owari et al. 2006; Kuijk et al. 2009; Kukkonen and Hohnwald 2009; Rayamajhi et al. 2012; Elbakidze et al. 2016, 2022; Kalonga et al. 2016; Galati et al. 2017; Di Girolami and Arts 2018; Campos-Cerqueira et al. 2020; Lehtonen et al. 2021). A number of studies show that SFM practices and certification can significantly contribute to biodiversity conservation (Kuijk et al. 2009; Oettel and Lapin 2021). Positive biodiversity impacts reported for certified forests include higher tree species richness, diversity, and density in Tanzania (Kalonga et al. 2016), reduced forest loss compared to non-certified forests in Bolivia (Sheil et al. 2010), improvement of community forest structure, composition and diversity after including forest certification practices in Indonesia (Arbainsyah et al. 2014). A case in Peru shows that certified forests have a higher richness of acoustically active bird species (Campos-Cerqueira et al. 2020). In temperate forest ecosystems, certified forests positively impact the fauna, flora, and ecosystem services (Di Girolami and Arts 2018; Lehtonen et al. 2021). As an example, Dias et al. (2013) found that the relative richness of species of birds, reptiles and amphibians is higher in certified forest areas than in non-certified ones.

Nevertheless, forest certification systems have also been found to “fall short” of including necessary actions to assess biodiversity (Elbakidze et al. 2022). In some cases, certification

systems include vague requirements regarding biodiversity, leading to confusion in the implementation and evaluation of their impacts (Lehtonen et al. 2021). Similarly, it has been identified that the indicators evaluating biodiversity conservation are merely indirect measurements (Kuijk et al. 2009; Campos-Cerqueira et al. 2020). Elbakidze et al. (2016) found that certified forests in Lithuania had several benefits for the ecosystems. Still, they could not always maintain structural and functional connectivity for forest species at a landscape level, as was identified in a comparison study between certified and non-certified forests in Honduras (Kukkonen and Hohnwald 2009).

Regarding social and cultural issues, studies have found that, in some cases, certified forests have positively impacted the relationships between the forest companies and the local communities (Dare et al. 2011; Tsanga et al. 2014). Even though direct evidence could not be assessed in some cases, some studies report that current practices create a cumulative effect and move towards a change in how communities engage with the companies and plantations managers (Dare et al. 2011). One of the main reasons why certified forests offer this opportunity is the continual improvement results and audits by the certification schemes and bodies (Dare et al. 2011). Another study found that, particularly in FSC certified forests, the requirements for stakeholders' involvement lead to an enhanced social exchange and thus contributed to reducing conflicting relationships between the local communities and forest managers (Tsanga et al. 2014). The same study found that the benefit-sharing was more transparent, accountable, and equitable in certified forests.

On the other hand, a review made by Blackman et al. (2017) found that most of the complaints and corrective action requests made by certification bodies in Latin America were related to social and cultural issues related to forest management. In the Congo Basin, a study carried out by Cerutti et al. (2017) identified that in some cases, the principles of certification schemes might be discordant when enforced in culture-rich countries with diverse indigenous and native communities. For example, the hunting and customary uses of forest resources and non-timber forest products (NTFP) for cultural and traditional reasons, even though they may be illegal, make part of the livelihoods and subsistence means of indigenous and native communities present in the certified forests units.

Hence, while law enforcement is usually a certification requirement, enforcing the law should not, thereby it can create a situation that may lead to conflicts with local communities making use of local resources and depending on them for their livelihoods. Nonetheless, when conflicts arise, they shall be properly identified, reported, and managed by the companies. Consequently, social acceptance of the company and its practices might be triggered among the forest managers and the local communities (Cerutti et al. 2017). This might be perceived as a violation of their traditional rights. Cerutti et al. (2017) also found that opportunistic hunters might find the harvesting periods an opportunity to hunt bushmeat, jeopardizing the biodiversity efforts made by the forest managers.

## 2.6. Previous comparative studies on certification standards

A few studies have been carried out with a focus and a scope similar to those addressed in this thesis. Overall, studies have been mainly conducted to confront sustainability standards in specific productive sectors or across multiple sectors involved with the use of biodiversity (Holvoet and Muys 2004; Hennenberg et al. 2010; Doswald et al. 2012; Englund and Berndes 2015; Masiero et al. 2015; Tayleur et al. 2017; Fransen et al. 2018; Tröster and Hiete 2018; Garzon et al. 2020; Elbakidze et al. 2022).

The agricultural sector is one of the most investigated. In particular, it has been explored by comparing voluntary and compulsory standards against a series of indicators or exploring the extent to which these standards include actions to protect biodiversity (Tayleur et al. 2017; Fransen et al. 2018). In contrast, other sectors like bioenergy and finance have been somewhat less studied and only a few papers can be found. For example, Hennenberg et al. (2010) compared bioenergy standards to a reference standard based on European legislation to protect biodiversity, while Doswald et al. (2012) reviewed the compulsory and voluntary standards for financial institutions with a biodiversity outlook.

Other initiatives and authors have explored the extent to which biodiversity is being addressed in guidelines, standards, and certification schemes across several sectors. The UNEP-WCMC (2011) developed a review on how specific certification standards in several sectors cover selected biodiversity components, address the threats to biodiversity, and whether they are aligned to international environmental policies and commitments like the Kyoto Protocol, the Paris Agreement etc. Similarly, Englund and Berndes (2015) developed a benchmark set of principles and criteria based on the CBD definition of biodiversity. They conducted a study to assess several standards (not only intended for certification) against this benchmark and verify the extent to which these standards cover the biodiversity concept.

Specifically for the forest sector, Holvoet and Muys (2004) undertook the most extensive and general review, reviewing 164 SFM standards against a reference standard and comparing the most common aspects of forest standards and guidelines. The main differences found by the authors consist in the fact that the global South-oriented standards have more emphasis and focus on social and economic aspects rather than ecological and research-based ones. Similarly, Masiero et al. (2015) developed their study on evaluating the extent to which forest standards and guidelines cover forest plantation-related issues and the possible improvement areas against a reference standard built and enriched from the one developed by Holvoet and Muys (2004).

More detailed studies have analyzed specific certification schemes, such as the Forest Stewardship Council (FSC), and their possible divergences across different countries. For instance, Elbakidze et al. (2022) assessed how FSC standards contribute to biodiversity conservation in selected countries hosting some of the most extensive certified forests, such as Sweden, Russia, and Canada. The main findings point out the need for continuous improvement and update of the agreements related to biodiversity conservation, as the endogenous and exogenous factors affecting it change over time and space. Likewise, Garzon et al. (2020) compared three certification standards and two independent national countries' certification standards regarding forest health and socio-economic viability.

The studies mentioned above did not consider a holistic and broader definition of biodiversity in forest certification standards, not linking the ecological dimension of biodiversity with the socio-economic one. This study aims to contribute to filling this gap by analyzing the extent to which biodiversity - in a broad understanding - is addressed in forest certification schemes and identifying existing gaps and opportunities, and areas for improvement.

# 3. Problem statement

In recent years biodiversity has been gaining much attention in the international policy arena as well as in the private and financial sectors. As for the latter, the 2022 report by the Financial Centre for Sustainability (FC4S and UNDP 2022) urged businesses to address biodiversity-related risks. Similarly, FAO and UNEP (2020) reported that to achieve the global biodiversity goals, technically, economically, and socially viable criteria and indicators for SFM must be defined at several scales. An international comparative study carried out by Masiero et al. (2015) found that,

even though SFM standard principles regarding biodiversity have a higher number of criteria and indicators compared to other domains, they also show the highest number of gaps compared to reference standards.

Certification systems can cover many biodiversity issues at the forest management unit level; however, biodiversity is still falling short at a landscape level and at defining proper measurement indicators mainly due to some difficulties in defining and scoping biodiversity within the framework of forest certification systems (Elbakidze et al. 2022). Moreover, other authors have pointed out the urgency that certification schemes promote the management of diverse and mixed landscapes that supports and encourage the co-benefits of conserving biodiversity (Englund and Berndes 2015). These remarks stress the importance of considering biodiversity in a holistic and more comprehensive understanding than the ones considered so far by existing certification initiatives.

The interest in biodiversity is indirectly confirmed by the fact that well-known national and international standard-setting bodies, like the British Standards Institution (BSI) and the International Organization for Standardization ISO, have started developing specific standards to address biodiversity issues. In this sense, the development of this thesis is propitious to provide insights on the topic. Biodiversity conservation and management underpin solutions to other complex targets, like climate change; thus, tackling biodiversity issues can support environmental goals like carbon neutrality and support a broad range of forest-based ecosystem services, ultimately contributing to people's wellbeing and health.

# 4. Objectives

The overall objective is this thesis is to contribute to comparing how biodiversity is addressed in international and national forest certification standards.

## 4.1. Specific objectives

1. Identify and collect from international and national (internationally endorsed) forest certification standards criteria and indicators focused on biodiversity maintenance, protection, enhancement, and conservation.
2. Describe and frame the most relevant principles, criteria, and indicators through a reference meta-standard.
3. Produce a comparative assessment of the most and the least covered criteria and indicators regarding biodiversity within the selected standards.
4. Provide lessons learned and inputs for future developments in forest certification schemes concerning biodiversity.

# 5. Research methodology

This section addresses the research approach and methodology to accomplish each specific objective as well as the criteria adopted for their selection. The first part introduces the research approach, methods used, the steps taken and their development. It also includes the criteria used for data collection. Sub-section 5.2 contains the data collection methods and sources and explains the statistical analysis. This section also covers the constraints and limitations of this study (5.3). Supplementary information about methodological aspects is provided within the annexes.

## 5.1. Research approach

The methodologies used to accomplish the objectives of this thesis build on qualitative data using several sources of information and techniques.

1. To address specific objective one – i.e., (1) *Identify and collect from international and national (internationally endorsed) forest certification standards criteria and indicators focused on biodiversity maintenance, protection, enhancement, and conservation* – the following methodologies have been used:

- Developing an extensive review of scientific and grey literature, databases, websites, reports, and official sources regarding sustainability certification standards.
- Developing a consistency assessment of the current and outdated certification schemes based on literature sources and data available.
- Selecting from the assessed certification schemes the principles, criteria, and indicators aligned with the CBD definition, IPBES's main drivers of biodiversity loss (IPBES 2019a) and relevant literature.

Due to the high volume of certification standards (Annex 3), some criteria are applied to select the standards to be compared. The criteria are:

- Standards applicable at a global geographical scale, either internationally or nationally applicable but internationally endorsed.

- Among the standards identified via the last criterion are those with the largest certified area (number of hectares) per continent or region (namely: Africa, Asia – Pacific, Europe, North America, South America, Central America, and West Europe). This is to create a representative sample of the various regions worldwide. The European region has been split into East Europe and Central–Western Europe due to the large extension of the certified area in these two sub-regions. In contrast, the Asia-Pacific region has been kept as one due to the limited areas and countries participating in these schemes. The countries considered as East Europe are Russia, Turkey, Poland, Ukraine, Romania, Bulgaria, Croatia, Bosnia and Herzegovina, Austria, Lithuania, Estonia, Latvia, Serbia, Hungary, Slovakia, Slovenia, Czech Republic, Romania, and Belarus. On the other hand, the countries considered Central–Western Europe are Sweden, Finland, United Kingdom, Germany, Norway, Switzerland, Portugal, Ireland, Spain, Denmark, Netherlands, France, Italy, Belgium, and Luxembourg.

5. Regarding specific objective two – i.e., (2) *Describe and frame the most relevant principles, criteria, and indicators through a reference meta-standard* – a Delphi survey has been carried out. The Delphi method selects a panel of experts to express their opinion on a pre-defined reference standard to enable the convergence of views.

To achieve specific objectives three and four – i.e., (3) *Produce a comparative assessment of the most and the least covered criteria and indicators regarding biodiversity within the selected standards* and (4) *Provide lessons learned and inputs for future developments in forest certification schemes concerning biodiversity*– First, a comparison and a gap analysis were carried out. With the results from the gap analysis, descriptive statistics to measure the frequency and extent of the selected forest standards, as well as radar charts, were used.

The results from the statistical analysis allow identifying key aspects regarding biodiversity most covered or left behind in forest certification standards. A diagnosis and classification of these aspects compared to relevant literature and studies on biodiversity allowed fulfilling specific objective three.

## 5.2. Data sources and methodologies

### 5.2.1. Literature review and certification standards selection

A comprehensive literature review was carried out at the beginning of the thesis. The review included scientific papers, grey literature, databases from certification standards, websites, official reports, and sources to collect as many certification standards in the market as possible. To carry out the literature review, Google scholar search engine, Web of Science, Scopus, ResearchGate, and the online university library of the University of Copenhagen and the University of Padova. Boolean operators to carry out the review included: “biodiversity AND certification* AND forest”, “standard* OR certification* AND biodiversity”, “biodiversity AND forest certification”, and “comparison OR assessment AND biodiversity AND certification”.

Following the literature search, a consistency review was carried out to obtain the certification standards still in place and their latest versions, remove those outdated and differentiate the scale (global or national-international endorsed) from the initial list.

To establish a baseline for the reference standard, the PC&I from the selected standards and lists of PC&I used in previous studies were collected and organized in a survey questionnaire. The PC&I chosen were those aligned with the CBD definition, IPBES’s main drivers of biodiversity loss (IPBES 2019a) and relevant literature in biodiversity conservation, preservation, enhancement, and valuation.

### 5.2.2. Delphi survey questionnaire

The Delphi survey method is a widely known research technique used in the social sciences (Landeta and Barrutia 2011). It is an iterative process to collect judgement of experts about a topic in situations with incomplete or controverted information (Skulmoski et al. 2007). This technique has proved useful when the information intended to collect can benefit from collective subjective judgements or when the context dynamics entangle an active communication, e.g., distance, time differences, movement capacity (Grime and Wright 2016). The method consists of one or more rounds of experts’ consultation through feedback-controlled questionnaires. The first round is carried out individually with a panel of experts on the research topic. The answers are collected and summarized, and – if more rounds are carried out – to build the second-round questionnaire. The latter is shared once again for feedback. The researcher uses the results to form conclusions, trying to enable the convergence of experts’ opinions.

For this thesis, the survey was conducted considering a panel of nine experts operating in different fields, all with a robust professional background in biodiversity and forest certification. The Delphi

method survey consisted of two rounds. The first round was carried out from the 23rd of May to the 17th of June 2022. It aimed to collect experts' opinions, integrative comments, and suggestions on a pre-defined reference standard consisting of nine Principles, 39 Criteria and 78 Indicators (See Annex 1 and 2 for the Delphi survey questionnaire and the list of experts consulted). The feedback was collected and organized for the second round that was carried out from the 29th of June to the 10th of July. The collected information could be ranked in this round, prioritizing the experts' suggestions. Results from the second round were analyzed, producing the final reference standard used to compare the certification standards (see section 6.1).

#### 5.2.3. Gap, statistical analysis, and data visualization

A gap analysis was conducted to determine the differences and similarities between the selected standards and the reference standard agreed as a result of the Delphi survey applied in the initial stages of the study. For each forest certification standard, the sets of PC&I were compared against the reference standard.

Three matrices were developed containing the PC&I from the reference standard on the X-axis, one for each hierarchical level. The Y-axis included the name of the certification standards to be compared. The matrices were filled out with qualitative data according to the level of coverage each forest certification standard had regarding each PC&I from the reference standard. Once qualitative data was organized, in order to visualize the data, it had to be converted into quantitative categories. Table 4 clarifies the categorization used for the results:

**Table 4. Categorization of the gap analysis.**

| Qualitative | Quantitative | Meaning |
|---|---|---|
| Yes | 3 | The forest certification standard fully covers the assessed P, C, or I. |
| Partially | 2 | The forest certification standard partially covers the assessed P, C, or I. This means the assessed standard covered somewhat the reference standard, but specific aspects were missing. |
| No | 1 | The forest certification standard did not mention, cover, or include the assessed P, C, or I. |

To obtain a graphical visualization of the correlation between the assessed certification standards and the reference standard, statistical analysis of frequency, radar charts, and bar plots were used to map the results of the comparative assessment.

Microsoft Excel® was used to organize and classify the data in the first part of the analysis. Later, the software XLSTAT® free version was used to conduct the statistical analysis of frequency, radar charts, and bar plots. XLSTAT is an Excel data analysis add-on used to analyze, customize, and share results within Microsoft Excel (Addinsoft 2022).

### 5.3. Limitations and recommendations for further studies

The present study has some limitations, mainly related to the range of the forest certification standards. In this study, 160 forest certification standards were identified at several scales. The decision on which standards were selected in the study is referenced in section 6.1. The large

volume of standards and the limited time to develop this study reduced the number of chosen standards to 13. Although the standards on a global scale were prioritized, most of the selected standards are national (international endorsed standards) due to the lack of global scale forest certifications standards. As explained in the discussion of the results (section 7.1), the biophysical, social, cultural, and economic contexts shape the national standards even though these follow an international reference standard. The selection of particular national standards endorsed internationally might have influenced more / less compliant results according to the country's specific characteristics. For further studies, it is recommended to cluster the compared standards according to biodiversity social and economic indexes in order to have insights with commensurate contexts.

# 6. Results

In this chapter, the results of the data analysis are presented. Section 6.1 presents the selected standards for the gap analysis of the study. Section 6.2 presents a brief version of the reference standard resulting from the Delphi method. The complete reference standard, however, is found in annex 4. Section 6.3 presents the gap and statistical analysis, first a summary of the compliance extent for each of the standards, second for each principle overall, and third for each of the reference principles (sections 6.3.1 to 6.3.9), with its corresponding criteria and indicators. For Section 6.3, the P, C&I are presented in a table, followed by bar charts displaying the percentage of compliance of each reference C&I.

## 6.1. Selected standards

The selection of standards produced a list of 160 forest standards. The ones selected to carry out this thesis are presented in table 5. A total of 13 standards were selected, of which three are applicable on a global scale, and ten at a national scale, namely two each for North America, Asia-Pacific, South America, and Africa, and one each for Western Europe and Eastern Europe.

**Table 5. Selected standards to carry out the gap analysis.**

| Scale | Forest certification standard |
|---|---|
| Global | Forest Stewardship Council (FSC) International Generic Indicators (IGIs) |
| Global | Program for the Endorsement of Forest Certification (PEFC) International Standard |
| Global | Sustainable Forestry Initiative (SFI) |
| North America | PEFC Canada |
| Western Europe | PEFC Finland |
| Asia-Pacific | PEFC Australia |
| South America | PEFC Brazil |
| Africa | PEFC Gabon |
| Eastern Europe | FSC Russia |
| North America | FSC Canada |
| South America | FSC Brazil |
| Asia-Pacific | FSC Indonesia |
| Africa | FSC Republic of Congo |

## 6.2. Reference standard

The reference standard developed through expert's opinions collected via the Delphi survey (annex 1) contains nine principles, 41 criteria and 78 indicators and includes information related to different dimensions, such as:

1. Endangered species
2. Habitat destruction, fragmentation, and other forms of degradation
3. Habitat degradation, modification, and pollution
4. Overexploitation of resources
5. Invasive species and genetically modified organisms (GMO)

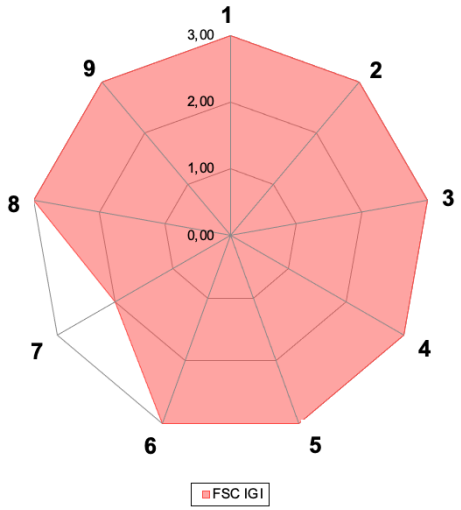
6. Climate change adaptation, resistance, and resilience
7. Research, awareness, education, and capacity building
8. Social and cultural dimensions of biodiversity
9. Economic sustainability of biodiversity.

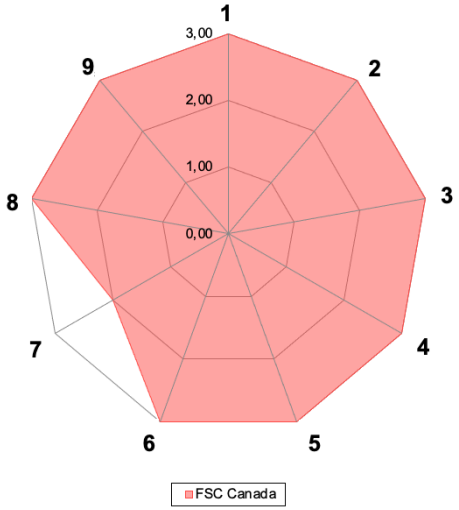
### 6.3. Gap and statistical analysis

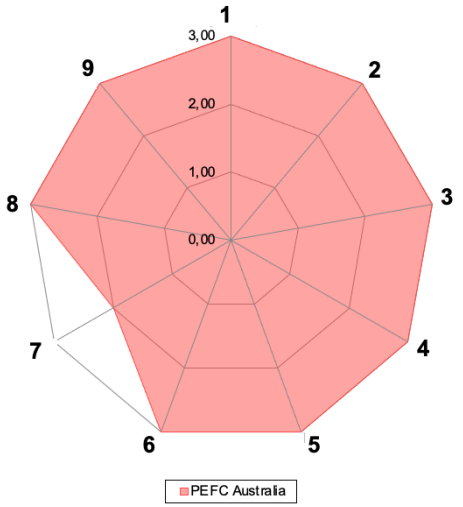
The gap analysis developed for the PC&I produced three matrixes analyzing the level of compliance as explained in section 5.2.3. The results allow identifying how forest certification standards address biodiversity issues and their dimensions to a broader extent. The results presented below are aggregated at a principle level, including the corresponding criteria and indicators.

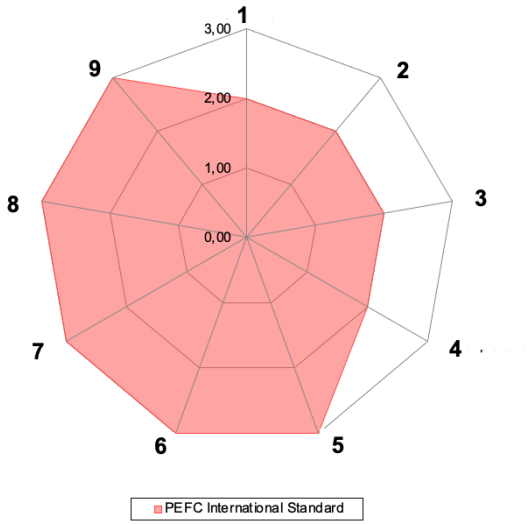
Figures 4 presents an overview of the level of compliance of each selected forest certification standard against each principle of the reference standard. They show the extent to which the selected forest standards comply with the nine reference principles. Some standards like FSC IGIs, PEFC Australia, FSC Indonesia and FSC Canada cover most of the reference standard principles, while others, like PEFC Finland and PEFC Canada, cover the least the reference standard principles. Although figures 4 and 5 provide an overview of the analyses performed, the results presented below are focused on the general gaps and strengths of the standards against the reference standard instead of per each forest certification standard.

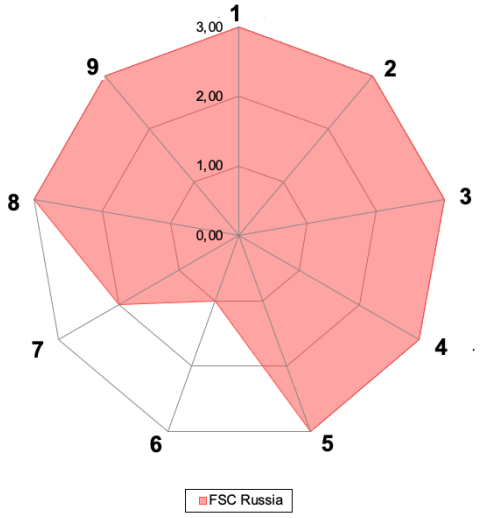
Figure 5 presents a summary of the total statistical frequencies for all selected standards against each reference principle. In general terms, the standards addressed most of the reference principles (please refer to annex 5 for details). Nevertheless, most standards show partial compliance or non-compliance with principle seven (Research, awareness, education, and capacity building). Similar situations are observed for principles three (Habitat degradation, modification and pollution are assessed, avoided, mitigated, and compensated) and six (Climate change adaptation, resistance, resilience, and mitigation measures are taken around biodiversity potential threats and synergies with other change drivers) where close to 50% of the standards are found to be partly compliant or non-compliant. Conversely, principles eight (Social and cultural dimensions of biodiversity are valued, respected, protected, maintained, and enhanced) and nine (Use of biodiversity shall be economically sustainable, improve conditions of local communities and economies and equitably distributed among local stakeholders) are widely covered by most of the standards. More details on compliance with each principle as well as with its criteria and indicators are presented below.

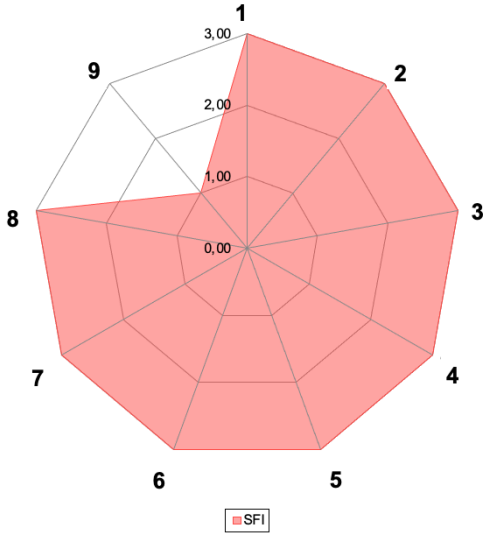

1
2
3
4
5
6
7
8
9
3,00
2,00
1,00
0,00
FSC IGI


1
2
3
4
5
6
7
8
9
3,00
2,00
1,00
0,00
FSC Canada


1
2
3
4
5
6
7
8
9
3,00
2,00
1,00
0,00
PEFC Australia


1
2
3
4
5
6
7
8
9
3,00
2,00
1,00
0,00
PEFC International Standard


1
2
3
4
5
6
7
8
9
3,00
2,00
1,00
0,00
FSC Russia


1
2
3
4
5
6
7
8
9
3,00
2,00
1,00
0,00
SFI

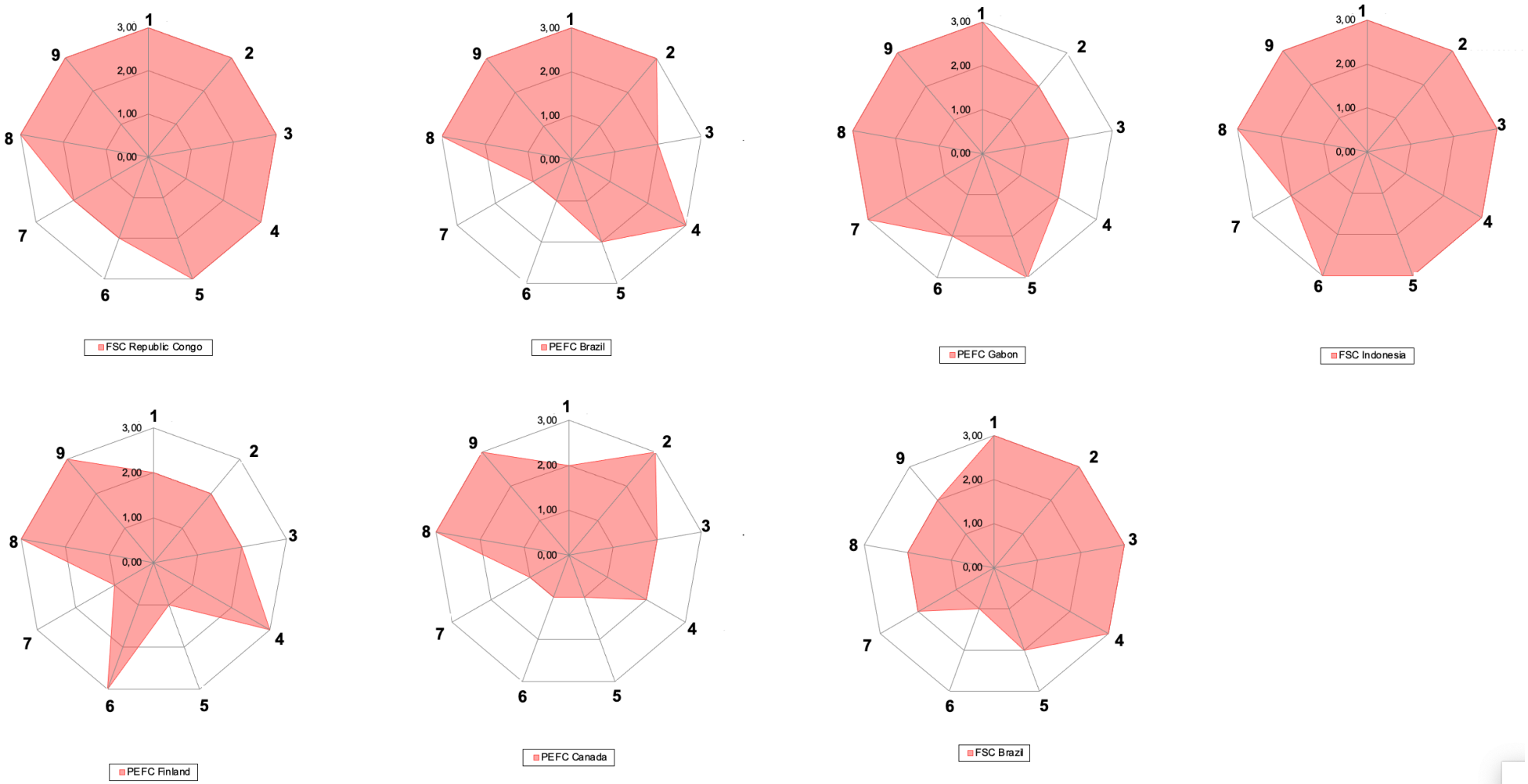



**Figure 4. Extent to which the selected forest certification standards cover the reference standard principles**

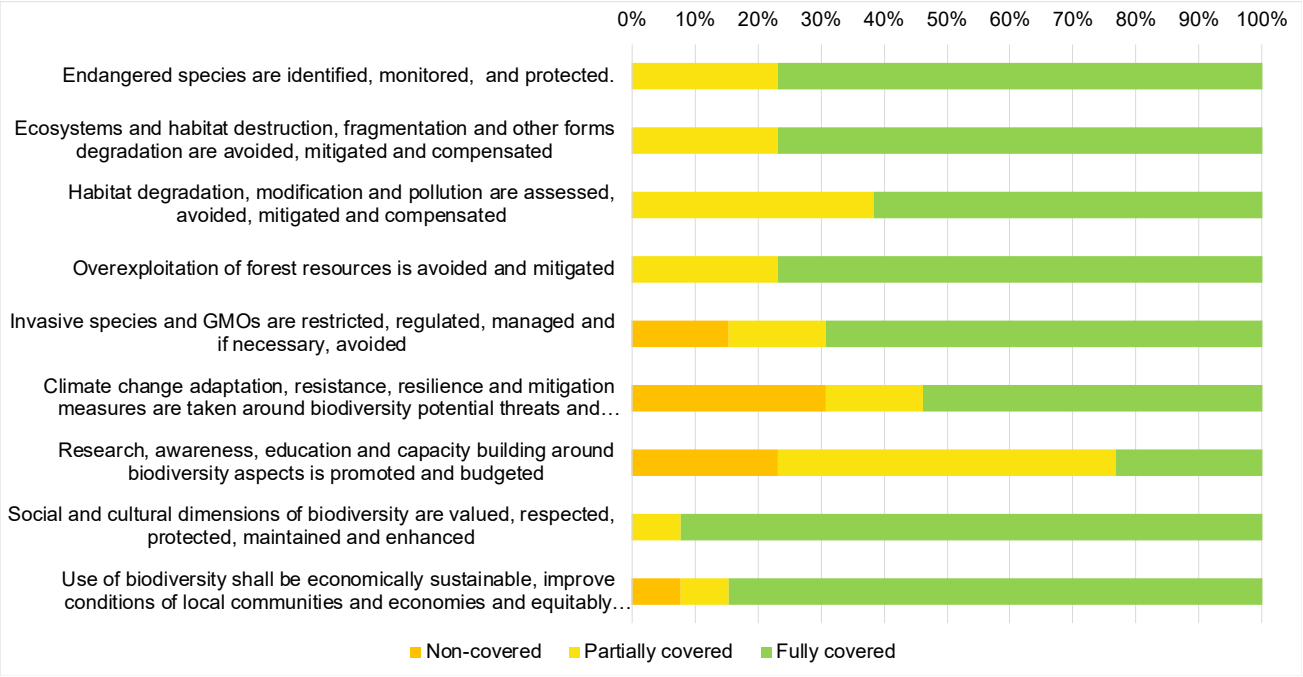



**Figure 5. Extent to which each principle is covered by the selected standards**

### 6.3.1. Reference principle 1: Endangered species are identified, monitored, and protected

PC&I 1 are reported in detail in Table 6. On average, the selected standards cover 58% of the criteria and 56% of the indicators relating to Principle 1 (Figures 6 and 7). More in detail, criteria 1,2 and 1,4, are 69% not covered within the standards being evaluated. The former is addressed by 31% of the standards, whereas the latter is partially considered by 15% of the standards and fully considered by another 15%. This reflects a gap in the species considered outside or near the production area. Indicators 1f and 1e are the less addressed by the standards. Indicator 1f, related to the number and list of species per area, is not addressed by 85% of the standards and partially addressed by 15% of them: as a consequence, none of the standards fully addresses this indicator. Indicator 1e, related to the number of functional role species, emphasizing specialist species and low population rate species, is thoroughly addressed by only 8% of the standards.
The rest of the indicators are addressed in more than 50% of the standards. More detailed information is available in annex 6.

**Table 6. Reference principle one and associated criteria and indicators**

| | |
|---|---|
| **Principle 1** | Endangered species are identified, monitored, and protected. |
| **Criteria** | |
| 1,1 | Endangered species within the production area protected |
| 1,2 | Endangered species around the production area considered |
| 1,3 | Endemic and rare species at risk within the production area are protected |
| 1,4 | Endangered, threatened, or vulnerable species within relevant proximal zone are identified and monitored |
| **Indicators** | |
| 1a | Existence of procedures for the determination of terrestrial biological diversity in several aspects (taxonomic, functional, and genetic) and its changes inside the production area |
| 1b | Percentage of land surface with protected status |
| 1c | Total number of red list species per surface area |
| 1d | Number of threatened species per surface area |

| | |
|---|---|
| 1e | Number of functional role of species per surface area, it should emphasize in specialist species and low population rate species |
| 1f | Number and list of species per surface area |
| 1g | Existence of procedures for monitoring of damage to species caused by unsustainable harvesting practices and illegal extraction of individuals (e.g., harvest rates, heavy machinery, skid trails, forest roads, light and noise pollution, soil compaction and erosion, over selection of particular species or structures) |
| 1h | Protective measures in place for the controlling and/or prevention of forest damage caused by unsustainable harvesting practices and illegal extraction of individuals (e.g., harvest rates, heavy machinery, skid trails, forest roads, light and noise pollution, soil compaction and erosion, over selection of particular species or structures) |
| 1i | Existence and implementation of measures for the protection of endangered, sensitive species (core forest species, habitat specialist species), endemic species |
| 1j | Preservation measures of remnant natural forest core habitat and ecological restoration of edges to buffer edge effects |

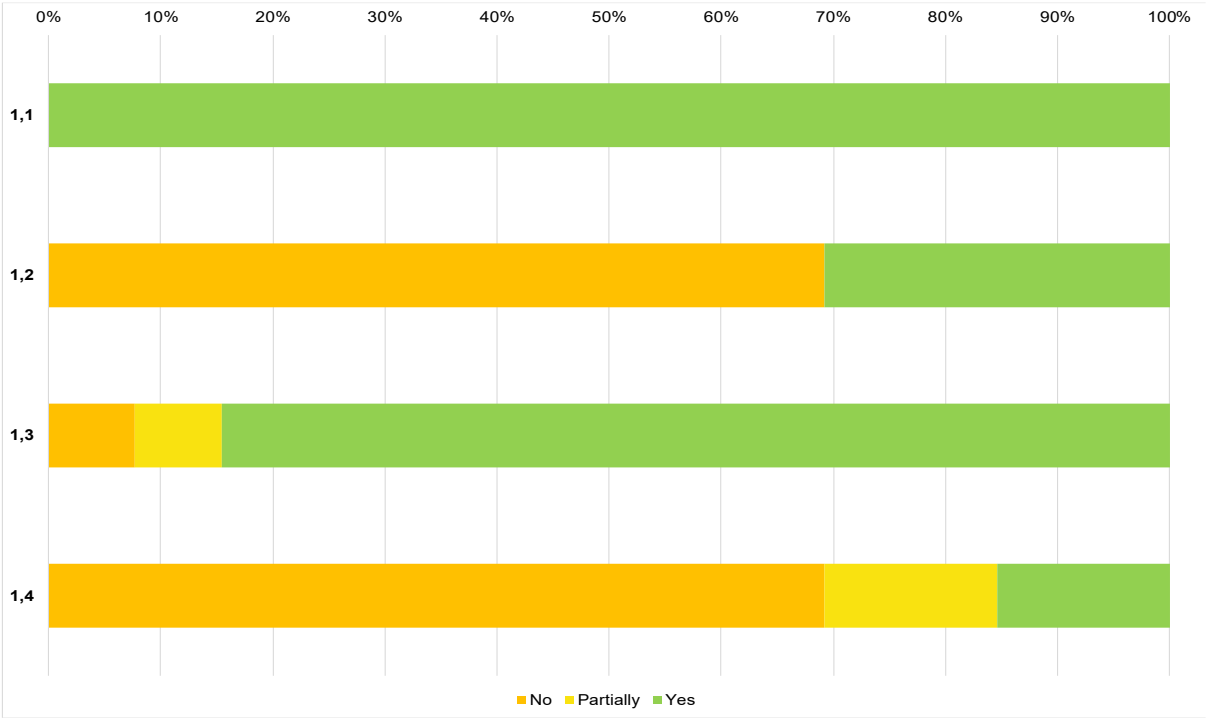



**Figure 6. Overall compliance of selected standards with criteria associated with principle one. For details about criteria see Table 6**

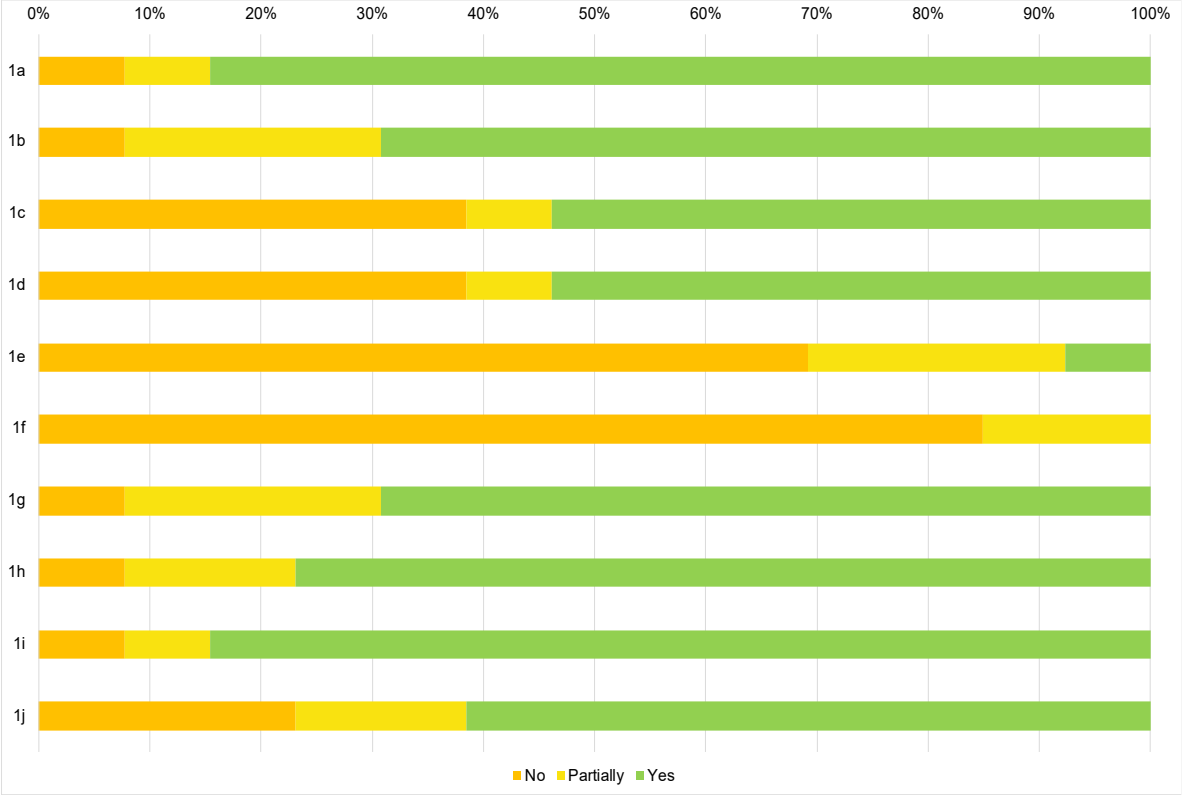



**Figure 7. Overall compliance of selected standards with indicators associated with principle one. For details about criteria see Table 6**

### 6.3.2. Reference principle 2: Ecosystems and habitat destruction, fragmentation and other forms degradation are avoided, mitigated, and compensated

Regarding PC&I 2 (table 7), related to ecosystems and habitat destruction, fragmentation, and other forms of degradation, most of the criteria and indicators are addressed by at least 50% of the standards. On average, the assessed standards covered 60% and 68% of the criteria and indicators respectively (figures 8 and 9). The least covered criterion in the standards is criterion 2,4 related to potential leakage effects that is not covered by any of the assessed standards. This suggests a clear gap in assessing the displacement of potential threats to areas adjacent to the production forest units. The least considered indicators are 2b, 2c, 2f and 2i: 54% of the standards thoroughly considered them, between 15 and 23% partially considered them and between 23 and 30% did not consider them. More detailed information is available in annex 7.

**Table 7. Reference principle two and associated criteria and indicators**

| **Principle 2:** | Ecosystems and habitat destruction, fragmentation and other forms degradation are avoided, mitigated, and compensated |
|---|---|
| **Criteria** | |
| 2,1 | Ecosystems and habitat loss and fragmentation is avoided, minimized, or mitigated |
| 2,2 | High Conservation Value areas identified and protected |
| 2,3 | Rehabilitation and restoration actions are implemented where destruction or fragmentation have occurred |
| 2,4 | Potential leakage effects of restoration assessed |

| Indicators | |
|---|---|
| 2a | Existence and implementation of measures for the protection of specific ecosystems and habitat with high biodiversity value |
| 2b | Existence of procedures for monitoring of damage to forest resources caused by encroachment (illegal settlements, illegal agricultural expansion), resource extraction and use |
| 2c | Protective measures in place for the controlling and/or prevention of forest damage caused by encroachment (illegal settlements, illegal agricultural expansion), resource extraction and use |
| 2d | Existence and implementation of measures for the conservation or improvement of ecosystems and habitat diversity |
| 2e | Existence and implementation of measures for the conservation or restoration of natural ecosystem complexity |
| 2f | Existence of data about occurring ecosystem types within the production area |
| 2g | Harvesting limited to periods and areas with little impact on fauna, flora, and soil |
| 2h | Degree of structural fragmentation or connectivity (corridor function) measured between habitat fragments |
| 2i | Existence and implementing programs for maintenance, conservation or preservation of keystone species and functional groups |
| 2k | Existence and implementation of programs for maintain key structural diversity at both landscape and stand levels |

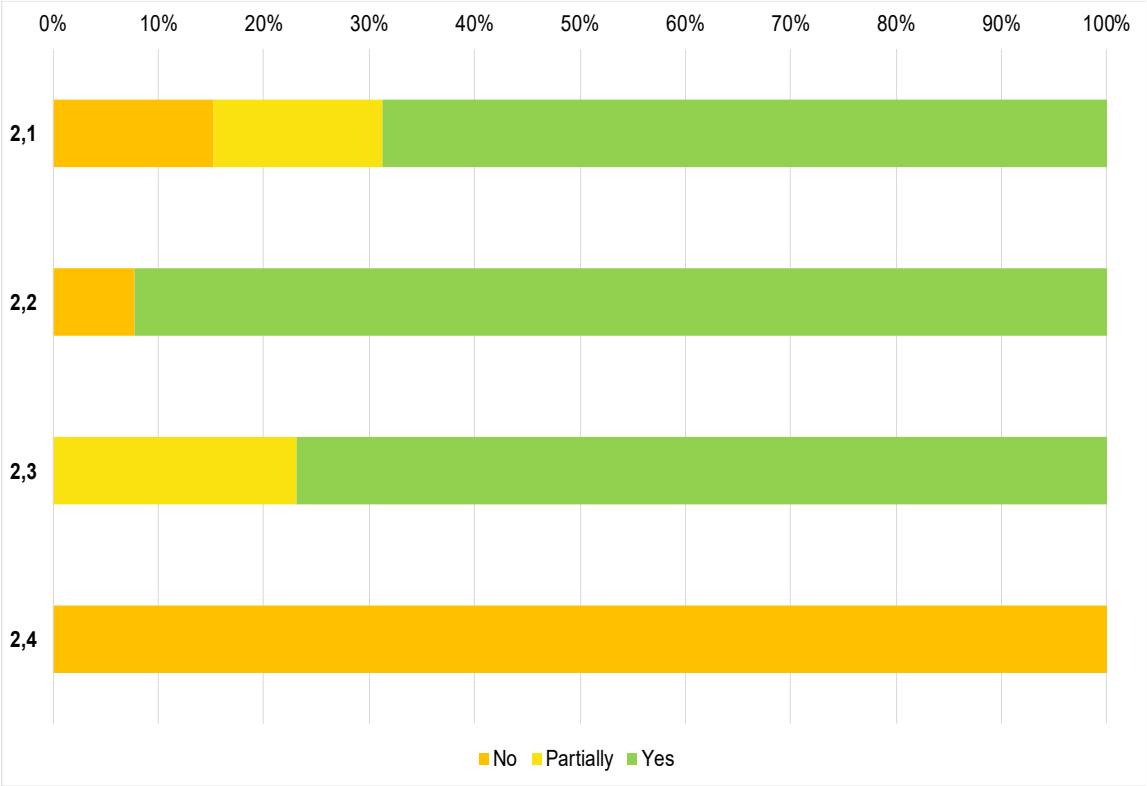



**Figure 8. Overall compliance of selected standards with criteria associated with principle two. For details about criteria see Table 7**

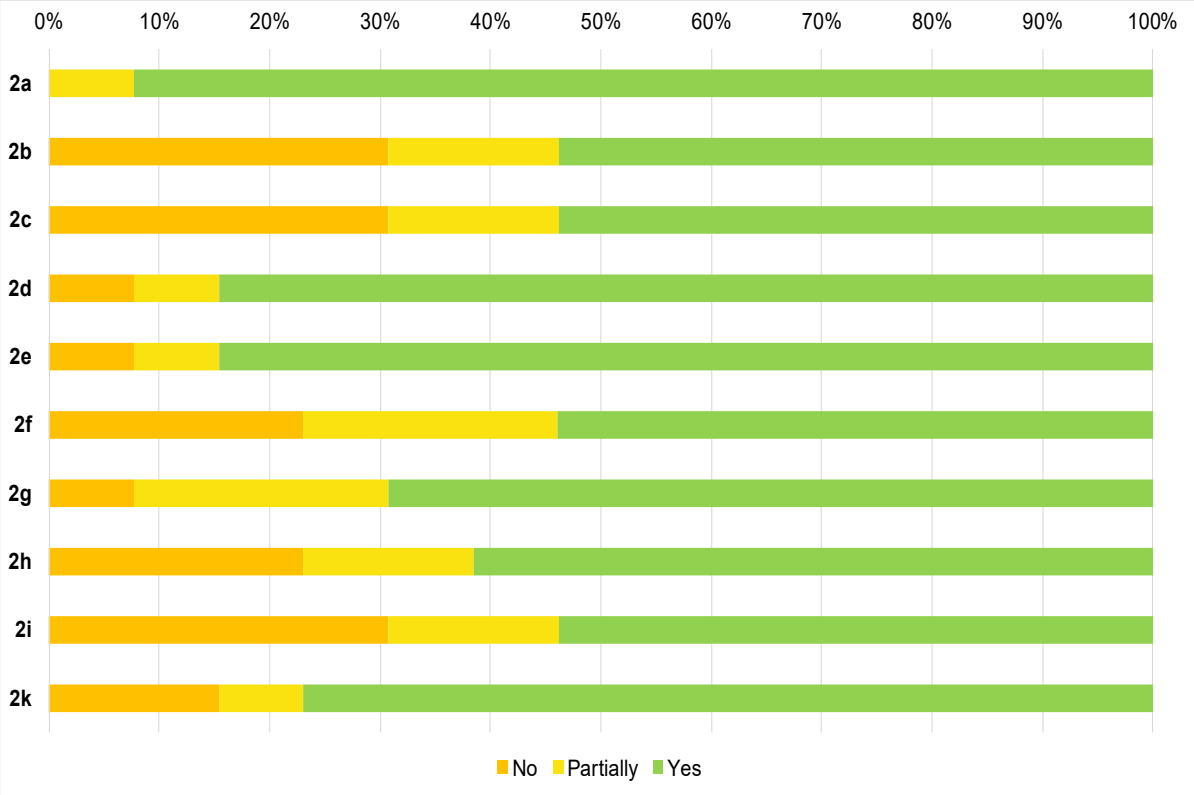



**Figure 9. Overall compliance of selected standards with indicators associated with principle two. For details about criteria see Table 7**

### 6.3.3. Reference principle 3: Habitat degradation, modification and pollution are assessed, avoided, mitigated, and compensated

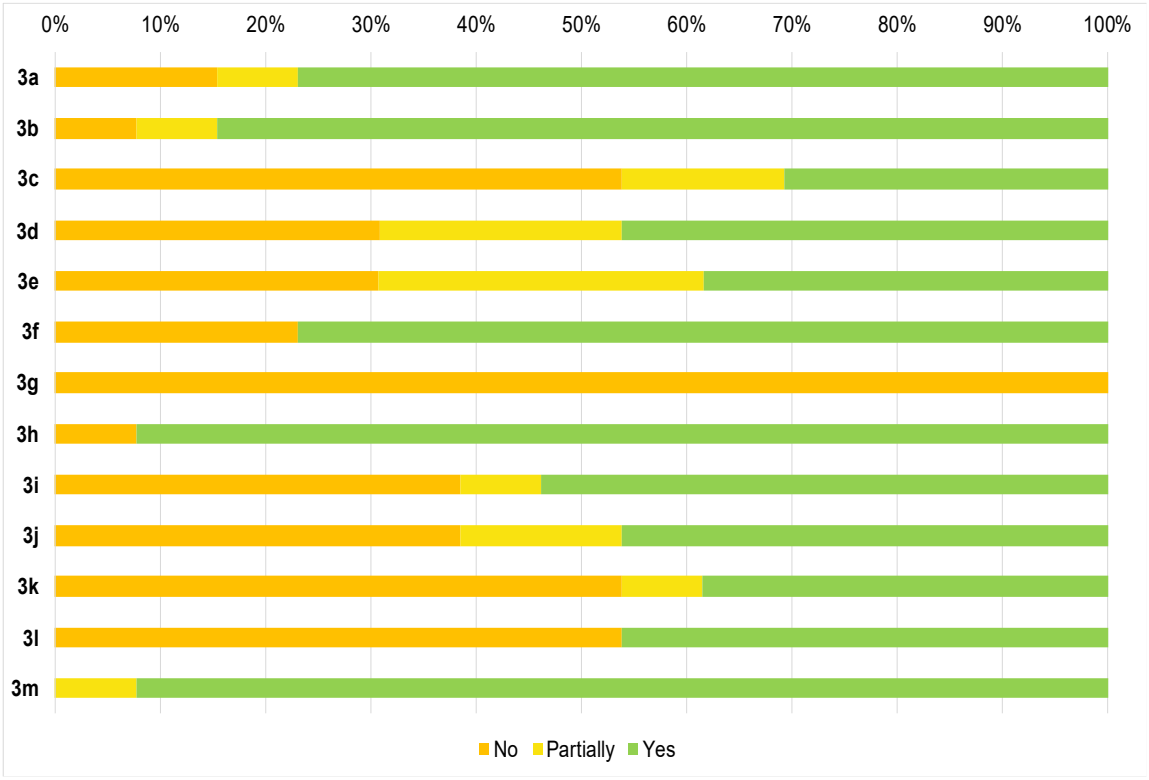
For PC&I 3 (table 8), related to habitat degradation, modification, and pollution, the standards cover 59% of the criteria. Criteria 3,6 related to soil erosion prevention is addressed by all (100%) of the selected standards. Other criteria such as 3,1 associated with pesticide use are covered by 85% of the standards; 3,5 related to the protection of water bodies is considered by 77% of the standards, and criteria 3,8 about waste management is covered by 62% of the standards. The indicators with the highest coverage by the standards are indicators 3b (minimization of negative impacts on biodiversity caused by forest management activities), 3f (measures to increase the structural complexity of the forest), 3h (regulations on the use of pesticides and biocides) and 3m (soil fertility), with 85%, 77%, and 92% for the last two respectively.

On the opposite, indicators like 3g related to the methods to remove non-indigenous harmful species are not considered in any of the standards assessed. Likewise, indicators 3c and 3k associated with the monitoring of illegal waste disposal and specificity on the amount and types of biocides and pesticides are considered partly in 15% and 38% of the standards, respectively. 54% of the standards for each criterion, did not consider these aspects. More detailed information is available in annex 8.

**Table 8. Reference principle three and associated criteria and indicators**

| | |
|---|---|
| **Principle 3** | Habitat degradation, modification and pollution are assessed, avoided, mitigated, and compensated |
| **Criteria** | |
| 3,1 | Pesticide use restricted to irreplaceable management activities that require it |
| 3,2 | Guidance for pesticide application provided |
| 3,3 | Guidance for fertilization provided to avoid nutrient leaching |
| 3,4 | Buffer zones required if adjacent to sensitive areas like core forest areas, water bodies, etc. |
| 3,5 | Water resources like springs, water bodies or wetland, are protected |
| 3,6 | Soil erosion prevented and mitigated |
| 3,7 | Soil quality maintained through actions like avoiding soil compaction, maintaining canopy cover, ground vegetation, the layer of soil organic matter, etc. |
| 3,8 | Waste management required |
| 3,9 | Management activities are designed in alignment with natural disturbance regimes with justification |
| 3,1 | Maintenance of decomposition and nutrient cycling |
| **Indicators** | |
| 3a | Existence and implementation of measures for the conservation of existing genetic diversity |
| 3b | Existence and implementation of measures for the minimization of negative impacts of forest management on biological diversity in several aspects (taxonomic, functional, and genetic) |
| 3c | Existence of procedures for monitoring of damage to forest resources caused by infringements (illegal waste disposal) |
| 3d | Protective measures for the controlling and/or prevention of forest damage caused by infringements (illegal waste disposal) |
| 3e | Existence and implementation of measures for the conservation of the litter layer |
| 3f | Existence and implementation of measures that guarantee the presence of sufficient amounts of dead wood, standing as well as lying on the forest floor according to the structural and functional characteristics of the forest |
| 3g | Preference for mechanical techniques for the removal of non-indigenous harmful species |
| 3h | Existence and implementation of regulations for the use of biocides and pesticides |
| 3i | Amounts and/or types of used biocides and pesticides |
| 3j | Existence and implementation of regulations for the use of fertilizers |
| 3k | Amounts and/or types of used fertilizers |
| 3l | Degree of use of environmentally friendly control agents |
| 3m | Existence of measures to maintain soil fertility and site productivity |

**Figure 10. Overall compliance of selected standards with criteria associated with principle three. For details about criteria see Table 8.**



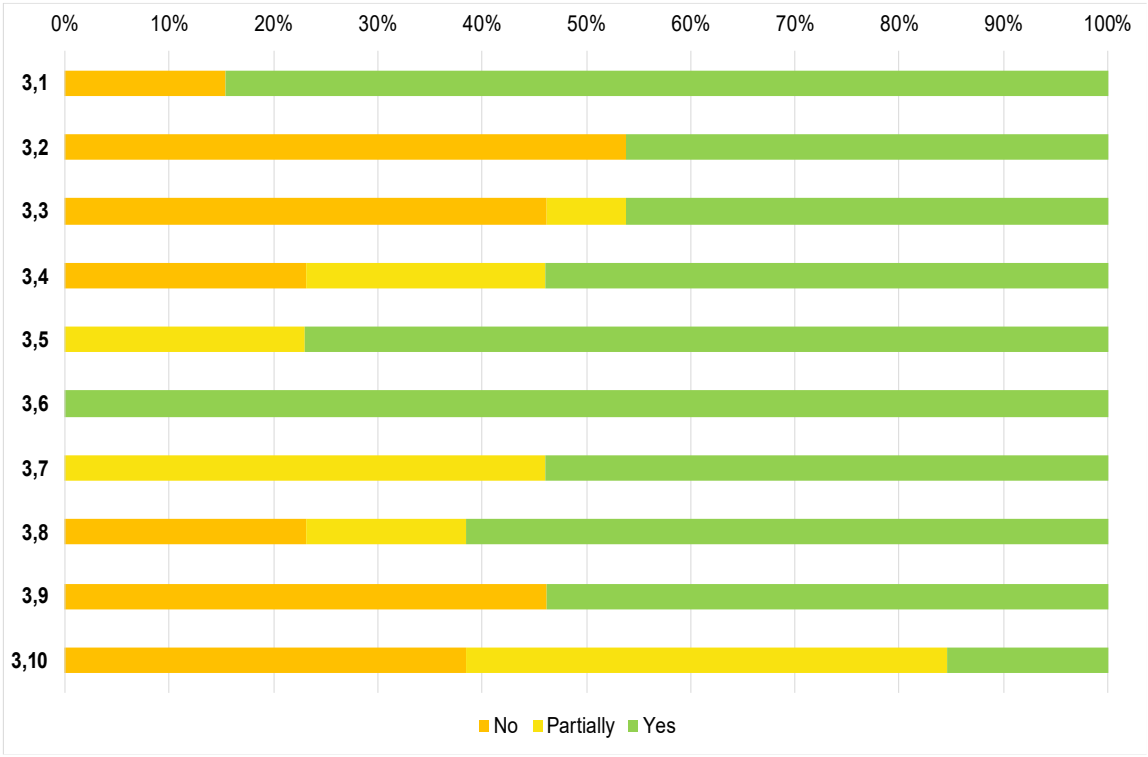




**Figure 11. Overall compliance of selected standards with indicators associated with principle two. For details about criteria see Table 8.**

### 6.3.4. Reference principle 4: Overexploitation of forest resources is avoided and mitigated

The PC&I 4 (table 9) are oriented to assess the measures taken to avoid overexploitation of resources. For this set of PC&I, 92% of the standards covered the criteria, and 76% the proposed indicators. In particular, 100% of the standards cover criterion 4,1 and 85% cover criterion 4,2. All indicators except indicator 4f are covered by the standards in a range between 77 and 92%. Indicator 4f related to the incentives for using lesser-known woody species is covered by only 23% of the standards, while 77% do not include this topic within their requirements.
More detailed information is available in annex 9.

**Table 9. Reference principle four and associated criteria and indicators**

| | |
|---|---|
| **Principle 4:** | Overexploitation of forest resources is avoided and mitigated |
| **Criteria** | |
| 4,1 | Approach for long-term sustainability in functional and structural ecosystem processes and socio-economic aspects. |
| 4,2 | Sustainable harvest rates and measures identified and applied according to the status of the extracted species |
| **Indicators** | |
| 4a | Existence of procedures for monitoring of damage to forest resources caused by harvesting practices and illegal extraction of individuals |
| 4b | Protective measures for the controlling and/or prevention of forest damage caused by harvesting practices and illegal extraction of individuals |
| 4c | Monitoring mechanisms for changes in growing stock by species and age class |
| 4d | Harvested volume by species |
| 4e | Existence and adoption of product-specific sustainable harvest levels |
| 4f | Incentives for the use of lesser-known woody forest species |
| 4g | Measures for rehabilitation or restoration and for targeted and controlled reintroductions of extracted individuals are present |
| 4h | Forest is managed using close-to-nature principles that prioritizes maintaining site conditions to allow natural regeneration over artificial planting |

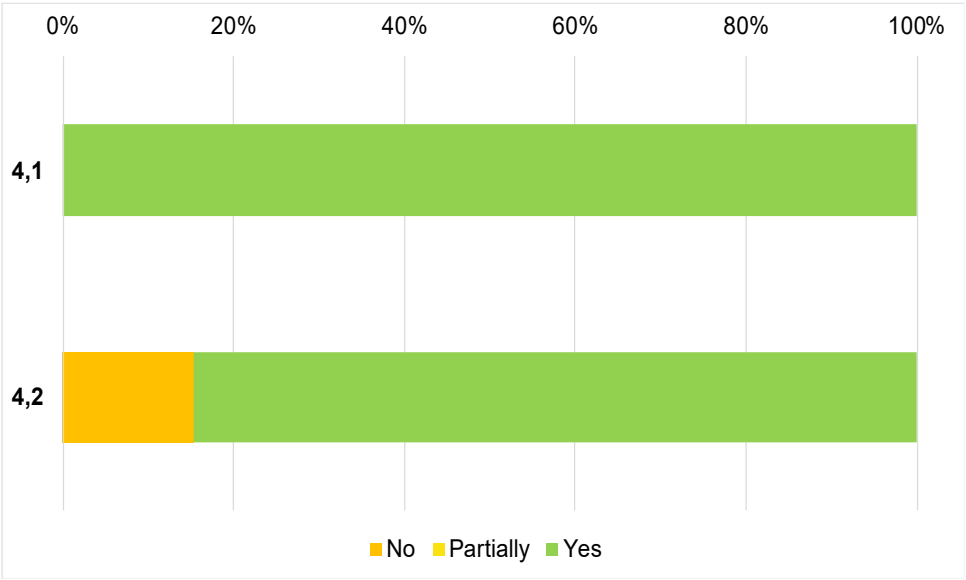



**Figure 12. Overall compliance of selected standards with criteria associated with principle four. For details about criteria see Table 9**

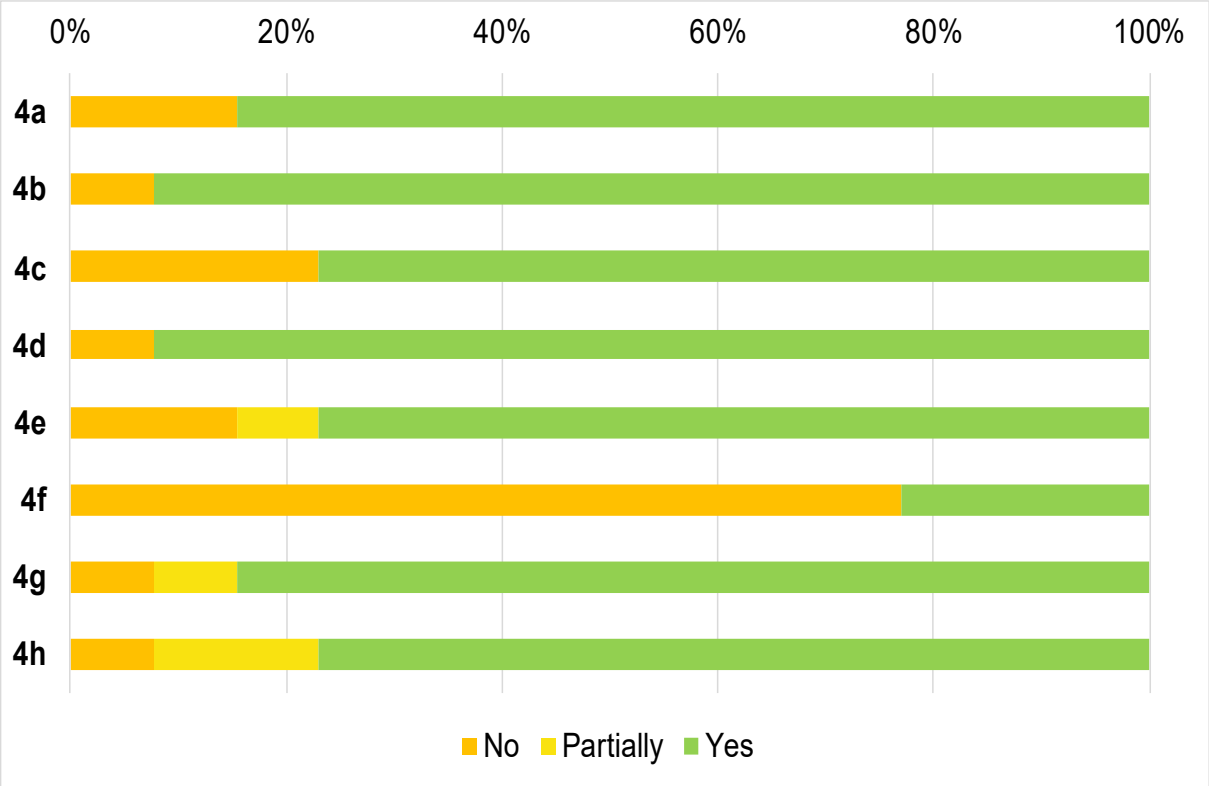



**Figure 13. Overall compliance of selected standards with indicators associated with principle four. For details about criteria see Table 9**

### 6.3.5. Reference principle 5: Invasive species and GMOs are restricted, regulated, managed and if necessary, avoided

The set of PC&I 5 (shown in table 10) concerning the restriction, regulation and management of invasive species and GMOs do not show a high coverage among the standards evaluated. On average, only 41% of the standards covered the criteria and 56% covered the indicators (figures 14 and 15). Criteria 5,3 related to systems that allow identifying invasive species sites prone is not covered by 85% of the standards. Similarly, for criteria 5,2, around 53% of the standards only partially included or did not include measures to prevent the introduction and spread of invasive species. These results also reflect on the indicators: indicators 5h and 5i are not addressed by 69% and 100% of the standards, respectively. These results evidence a gap in the control and monitoring of invasive species.

In contrast, the indicator 5c oriented to strengthening indigenous biodiversity is considered by 85% of the standards. Similarly, indicator 5d related to limitations on the use of exotic tree species for regeneration activities, is addressed by 77% of the standards. More detailed information is available in annex 10.

**Table 10. Reference principle five and associated criteria and indicators**

| **Principle 5:** | Invasive species and GMOs are restricted, regulated, managed and if necessary, avoided |
|---|---|
| **Criteria** | |
| 5,1 | Native species preferred over exotic |
| 5,2 | Measures taken to prevent introduction of invasive species |

| | |
|---|---|
| 5,3 | Generation of early warnings (spatially explicit) to identify sites vulnerable to invasion and constant monitoring for the presence of invasive species at that site. |
| **Indicators** | |
| 5a | Existence of procedures for monitoring of damage to forest resources caused by invasive alien species |
| 5b | Protective measures for the controlling and prevention of forest damage caused by invasive alien species |
| 5c | Existence and implementation of measures which protect, support, or strengthen indigenous biodiversity |
| 5d | Existence of regulations and limitations for the use of exotic tree species in regeneration activities |
| 5e | Monitoring of the use of exotic tree species and their impacts on the environment such as use, geographic distribution, competition with native species, functional degradation, and ecosystem services |
| 5f | The use of biological control agents is strictly regulated |
| 5g | Existence of regulations which prevent the introduction and spreading of non-indigenous species |
| 5h | Existence of procedures for monitoring the presence of invasive alien species |
| 5i | Total number of invasive species per area in the production area |

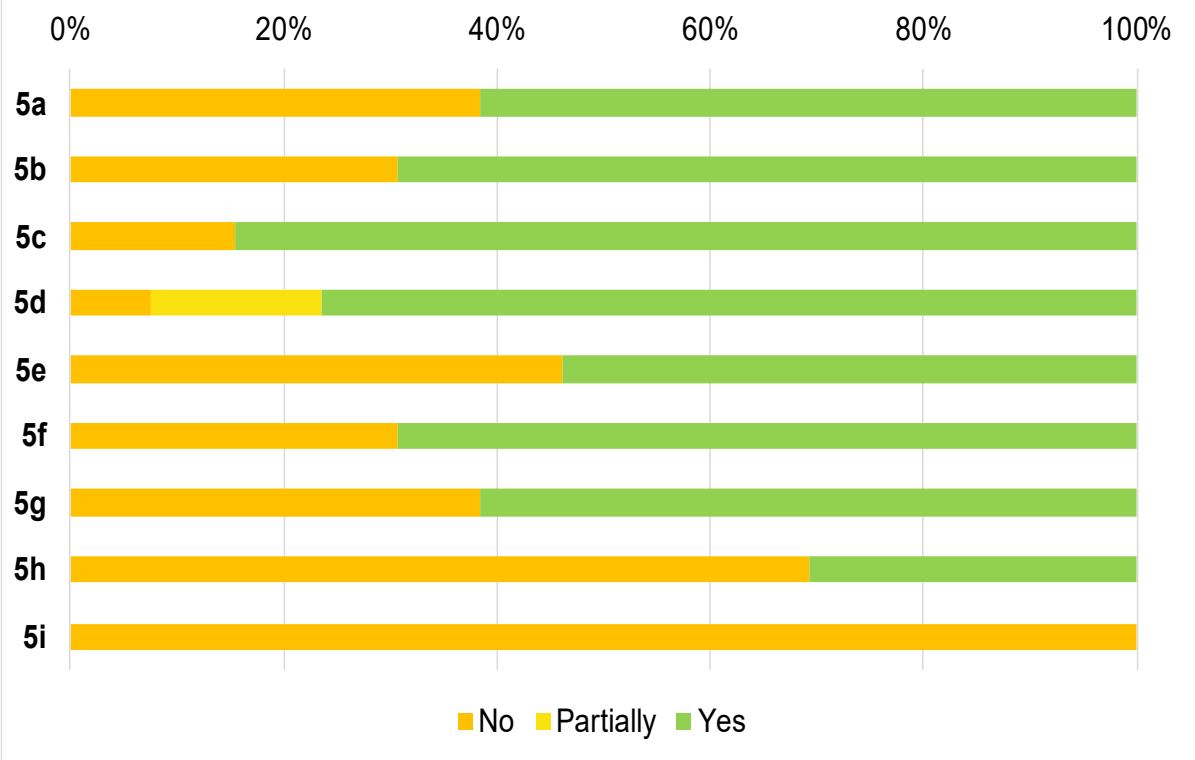



**Figure 14. Overall compliance of selected standards with indicators associated with principle five. For details about criteria see Table 10.**

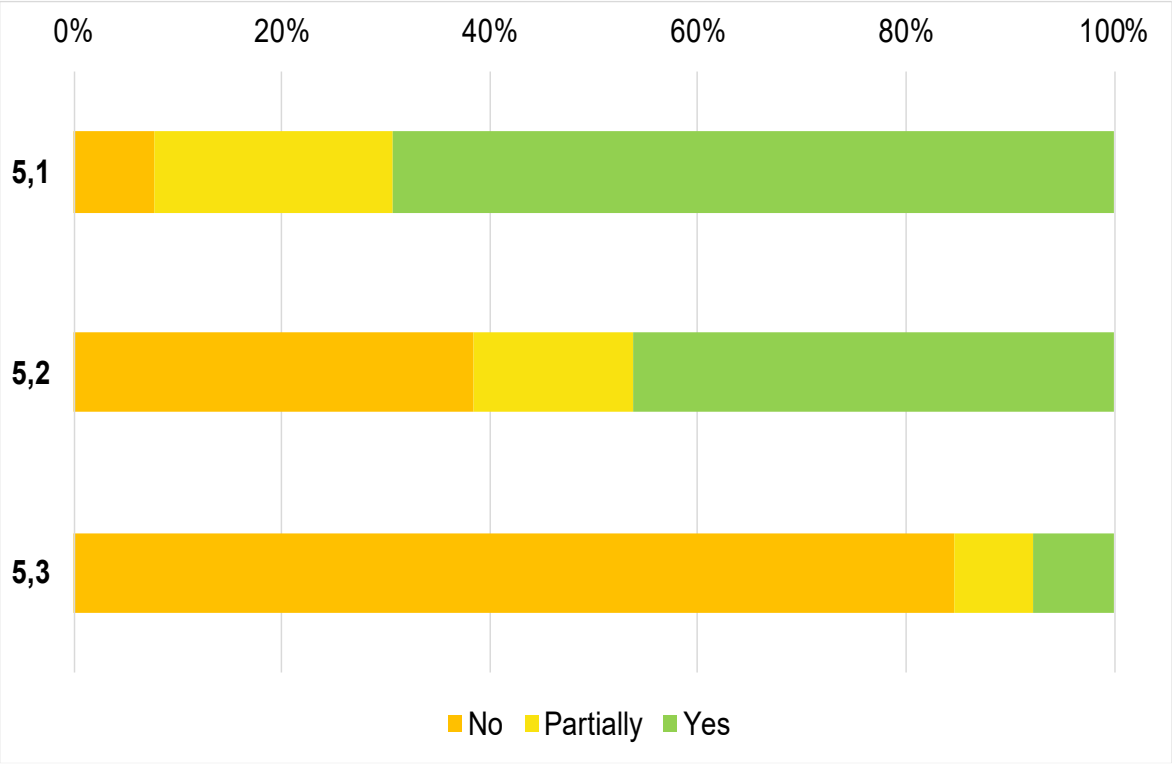



**Figure 15. Overall compliance of selected standards with criteria associated with principle five. For details about criteria see Table 10.**

### 6.3.6. Reference principle 6: Climate change adaptation, resistance, resilience, and mitigation measures are taken around biodiversity potential threats and synergies with other change drivers

PC&I 6 (table 11) correspond to climate change adaptation and mitigation procedures. This principle is one of the less addressed by the standards (figure 5). On average less than 50% of the standards cover criteria and indicators. More in detail, 42% of the standards addressed the criteria proposed and 49% of the indicators (figures 16 and 17). Criteria 6,1 and 6,2 are poorly covered; 77% of the standards do not consider measures for reducing greenhouse gasses (GHG) release and replacing fossil energy sources. Indicator 6e shows the same results, with 77% of the standards not addressing it. Factors like monitoring damage to the forest resources caused by extreme climate events are considered or not considered in equal proportions by 38% of the standards.

Conversely, criteria 6,3 related to carbon stock maintained or enhanced is handled by 69% of the standards. This is reflected in indicator 6d: 69% of the standards require considering the diameter for each species in the harvesting activities. Still, the assessment of climate change aspects needs to be addressed from sources such as GHG emissions and fossil fuel use. More detailed information is available in annex 11.

**Table 11. Reference principle six and associated criteria and indicators**

| | |
|---|---|
| **Principle 6:** | Climate change adaptation, resistance, resilience, and mitigation measures are taken around biodiversity potential threats and synergies with other change drivers. |
| **Criteria** | |
| 6,1 | Measures to reduce the release of GHG |
| 6,2 | Fossil energy and GHG avoided to the extent that there are suitable available alternatives |
| 6,3 | Carbon stock maintained or enhanced |
| 6,4 | Resilience, response of forest resources assessed and, mitigation measures are addressed |
| **Indicators** | |
| 6a | Existence of procedures for monitoring of damage to forest resources caused by climate extreme events |
| 6b | Protective measures for the controlling and/or prevention of forest damage caused by climate extreme events |
| 6c | Climate-smart forest management practices are adopted, e.g.: preference for long rotations |
| 6d | Protected and/or trees above a certain diameter for each species are identified and are not felled during harvesting |
| 6e | Existence of procedures for reducing greenhouse gas emissions from operational activities in forest management |
| 6f | Selection of durable and adapted native species resistant to drought, flooding, heat, etc. according to various climate change scenarios (e.g., high water use efficiency, toleration of anerobic conditions, etc.) |

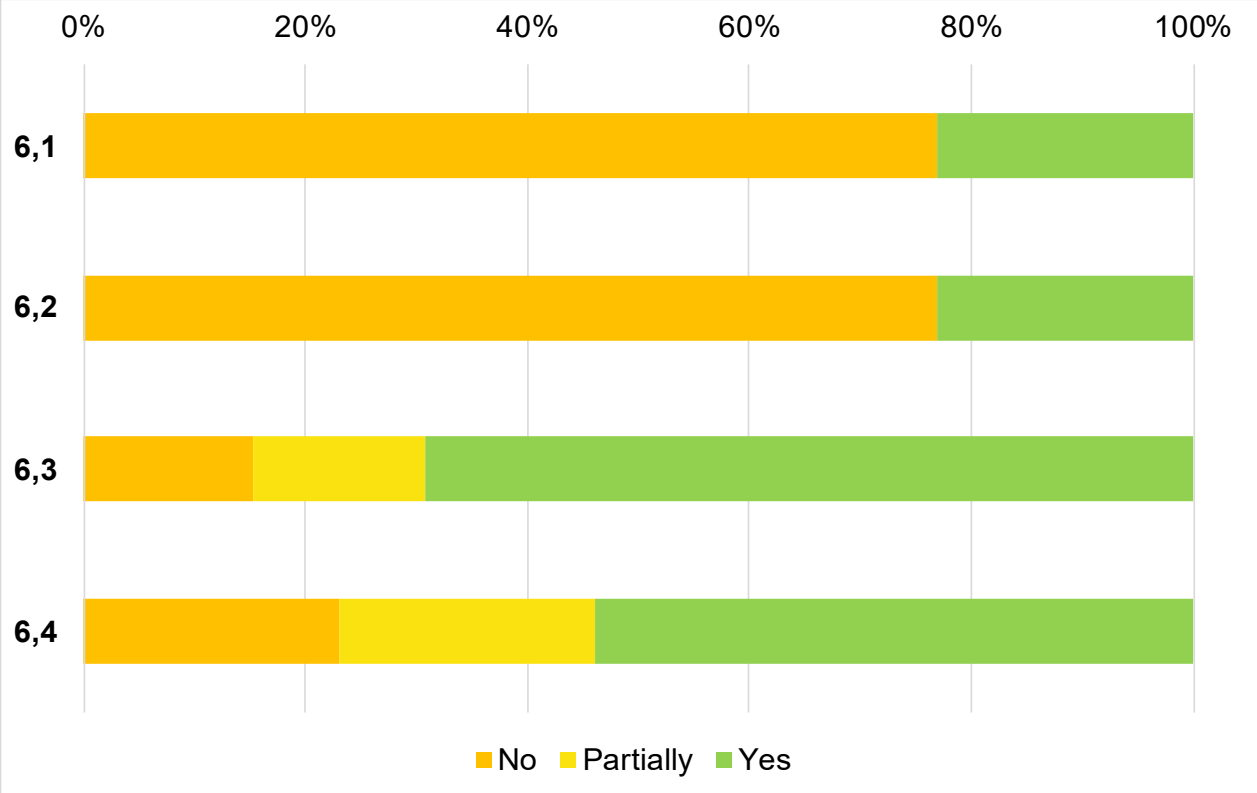



**Figure 16. Overall compliance of selected standards with criteria associated with principle six. For details about criteria see Table 11.**

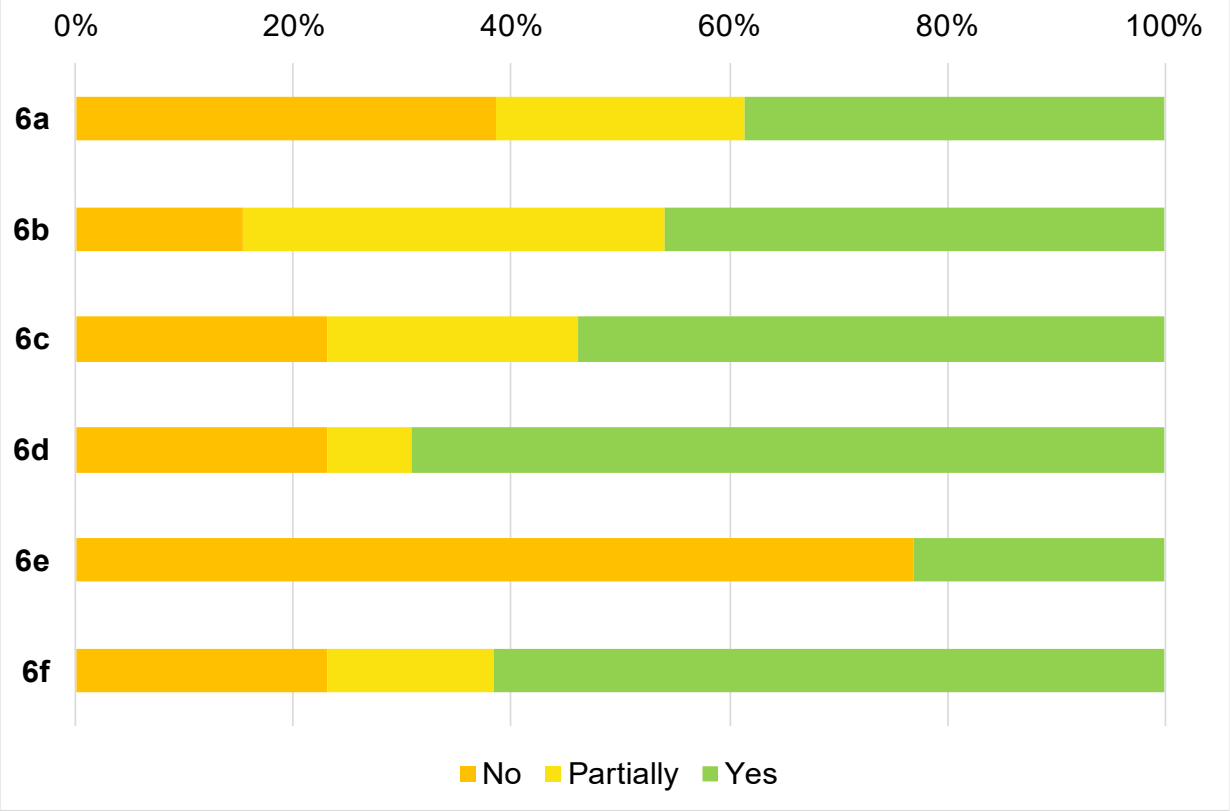



**Figure 17. Overall compliance of selected standards with indicators associated with principle six. For details about criteria see Table 11.**

### 6.3.7. Reference principle 7: Research, awareness, education, and capacity building around biodiversity aspects is promoted and budgeted

The set of PC&I (shown in table 12) corresponding to research, awareness, education, and capacity building around biodiversity is one of the less covered among the PC&I sets considered for this thesis. On average only 56% of selected standards cover criteria under Principle seven and 36% cover indicators. For instance, criteria 7,1 ad 7,2 are mentioned only in 8% of the standards. These two criteria are connected to research support, awareness spread and biodiversity appropriation. The low coverage of these topics in the standards is reflected also in the indicators, where indicators 7c, 7d and 7f are included only in 15%, 23% and 8% of the standards, respectively. A gap in research investment to improve the stakeholders' knowledge, recognition, and appreciation of the local biodiversity are outlined.

On the other hand, criteria 7,4 and 7,5 are widely included in no less than 92% of the standards. These two criteria are related to the involvement of stakeholders in the management plan and strategies to help improve local livelihoods, demonstrating an interest in local communities and stakeholders' participation. More detailed information is available in annex 12.

**Table 12. Reference principle seven and associated criteria and indicators**

| | |
|---|---|
| **Principle 7:** | Research, awareness, education, and capacity building around biodiversity aspects is promoted and budgeted |
| **Criteria** | |
| 7,1 | Research supported to all stakeholders |
| 7,2 | Awareness spread and social appropriation of biodiversity to all stakeholder |
| 7,3 | Education and capacity building to all stakeholders provided |
| 7,4 | Stakeholders' involvement in planning process is adopted |
| 7,5 | Strategies to help improve local livelihoods are adopted |
| **Indicators** | |
| 7a | Existing education, training, and capacity-building programs on biodiversity management |
| 7b | Encourage the use, if sustainable, of non-wood forest species. |
| 7c | Research activities supported related to pressures caused by humans' actions (land use change, overexploitation, etc.) on biodiversity |
| 7d | Research for possible consequences of unwanted introduction or spreading of invasive alien species |
| 7e | Availability and update of maps of the protected forest area |
| 7f | Amounts of investments in research, development and education in the topics prioritized before. |

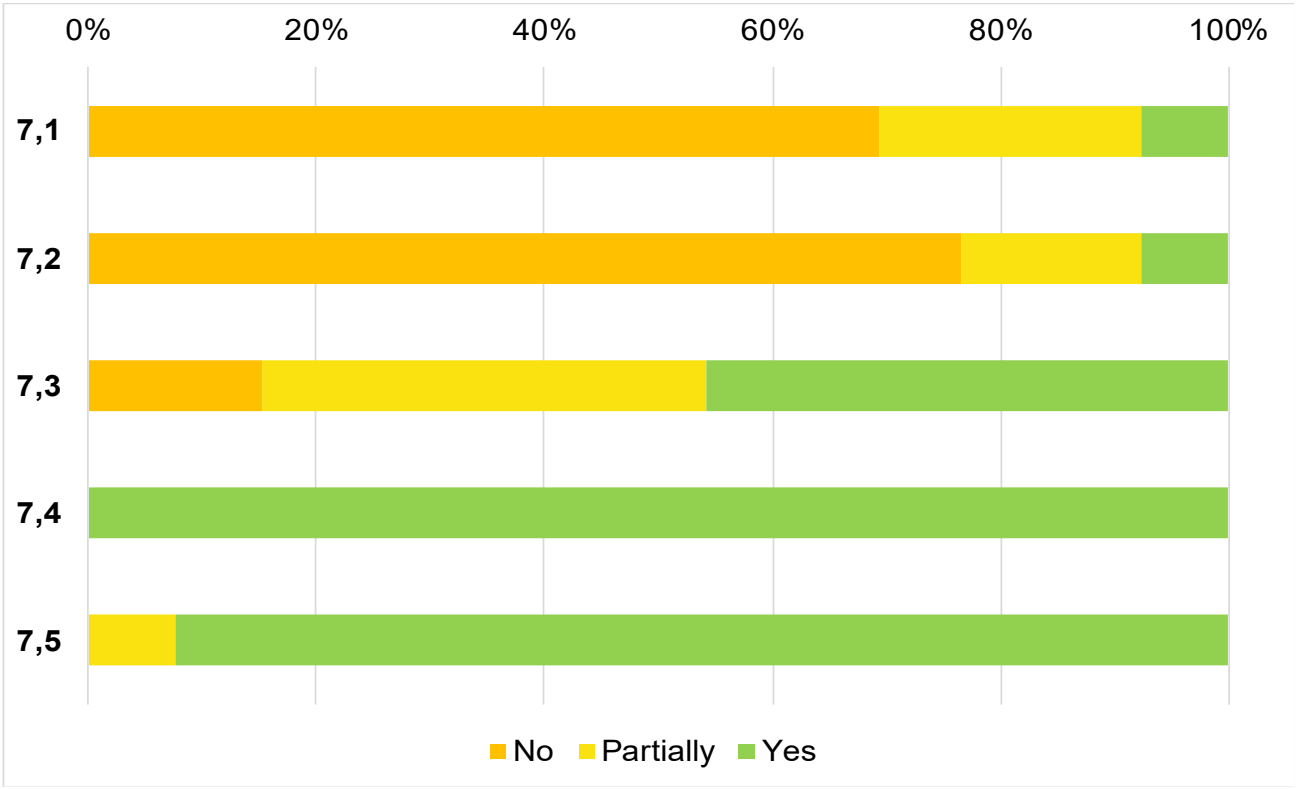



**Figure 18. Overall compliance of selected standards with criteria associated with principle seven. For details about criteria see Table 12**

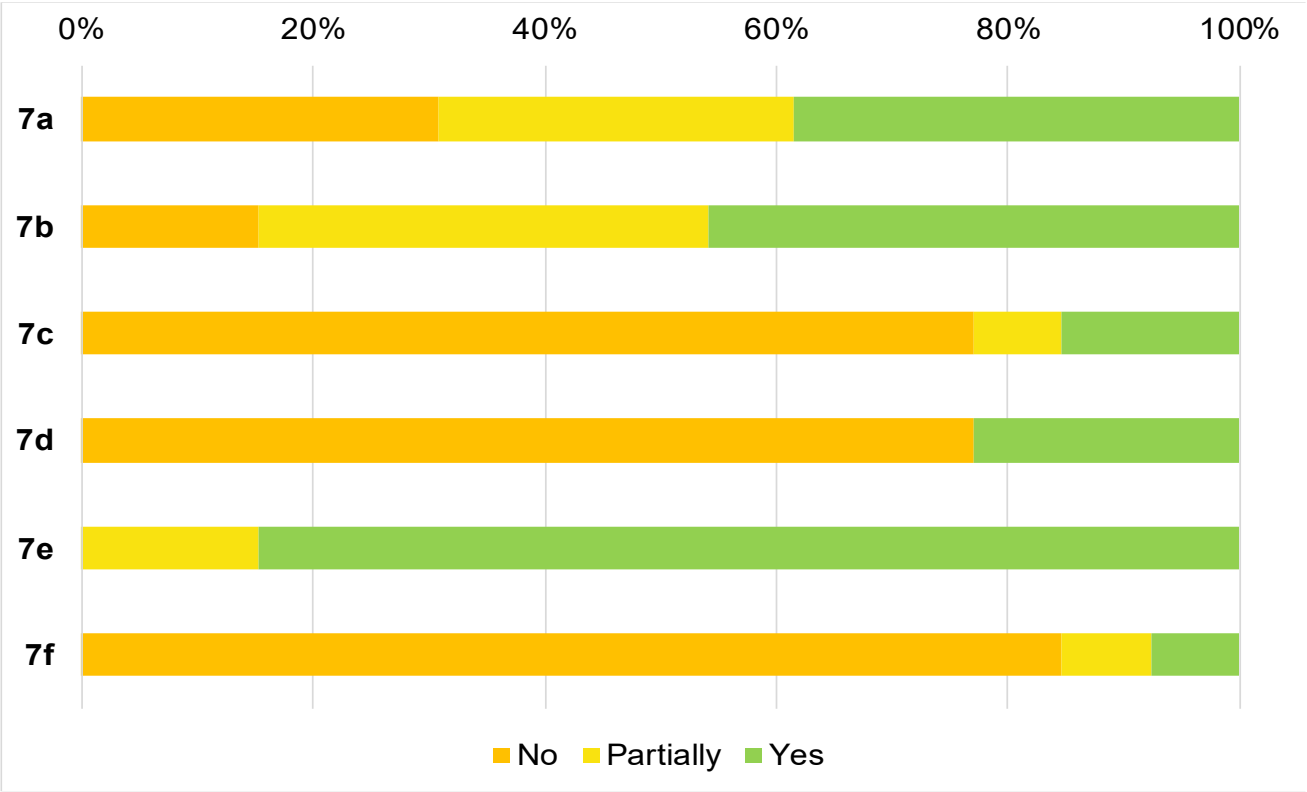



**Figure 19. Overall compliance of selected standards with indicators associated with principle seven. For details about criteria see Table 12**

### 6.3.8. Reference principle 8: Social and cultural dimensions of biodiversity are valued, respected, protected, maintained, and enhanced

PC&I 8 (table 13) are the set more widely covered by the selected standards. Criteria from 8,1 to 8,5 are 100% covered by the standards, in the same manner as indicators 8a to 8d (figures 20 and 21). Other indicators such as 8e and 8i are also widely covered by 85% of the standards. Nevertheless, some gaps in regulating the disturbance in some areas (criteria 8,6) are covered only by 15% of the standards. Other aspects that seem less relevant for the standards to consider are measures to avoid damage or degradation of recreational and cultural places by the presence of tourism in the management activities, corresponding to indicators 8j and 8k, respectively, with only 8% of the standards addressing these aspects. More detailed information is available in annex 13.

**Table 13. Reference principle eight and associated criteria and indicators**

| | |
|---|---|
| **Principle 8:** | Social and cultural dimensions of biodiversity are valued, respected, protected, maintained, and enhanced |
| **Criteria** | |
| 8,1 | Clear established indigenous and local communities' rights in the production area where relevant |
| 8,2 | Forest management plan engage indigenous communities traditional land use and forest-based ecological knowledge, where relevant |
| 8,3 | Forest community level of well-being and resilience derived from forest resources are valued, maintained, and enhanced |
| 8,4 | Forest management consider, values and protect cultural, recreational, spiritual, and archeological values |
| 8,5 | Clear and unambiguous land tenure, access, and use rights including customary rights |
| 8,6 | Disturbances are limited to a minimum and are restricted by regulations |
| **Indicators** | |
| 8a | Recognize and implement indigenous and local communities' rights where relevant |
| 8b | Areas of importance to indigenous and local communities are mapped (such as hunting and trap- ping, sacred areas, medicinal plant areas, and others). |
| 8c | Areas of importance to indigenous and local communities are safeguarded |
| 8d | Indigenous and local communities have secure access rights to areas for which they hold customary access rights |
| 8e | Forest management engages indigenous and local communities in decisions about use of forest resources from the areas but ensuring sustainability of natural capital stocks |
| 8f | Recognition and valuation of species with some degree of importance for indigenous and local communities |
| 8g | Existence and implementation of measures for the conservation of relevant human made ecosystems |
| 8h | Percentage of the whole forest reserved for recreation and tourism in consultation with indigenous communities |
| 8i | Number and/or area from the whole forests managed for the protection of cultural, archeological, social, and spiritual values in consultation with indigenous communities |
| 8j | Measures to avoid damage by recreation and tourism are in place |
| 8k | Monitoring system in place to check for signs of cultural degradation |

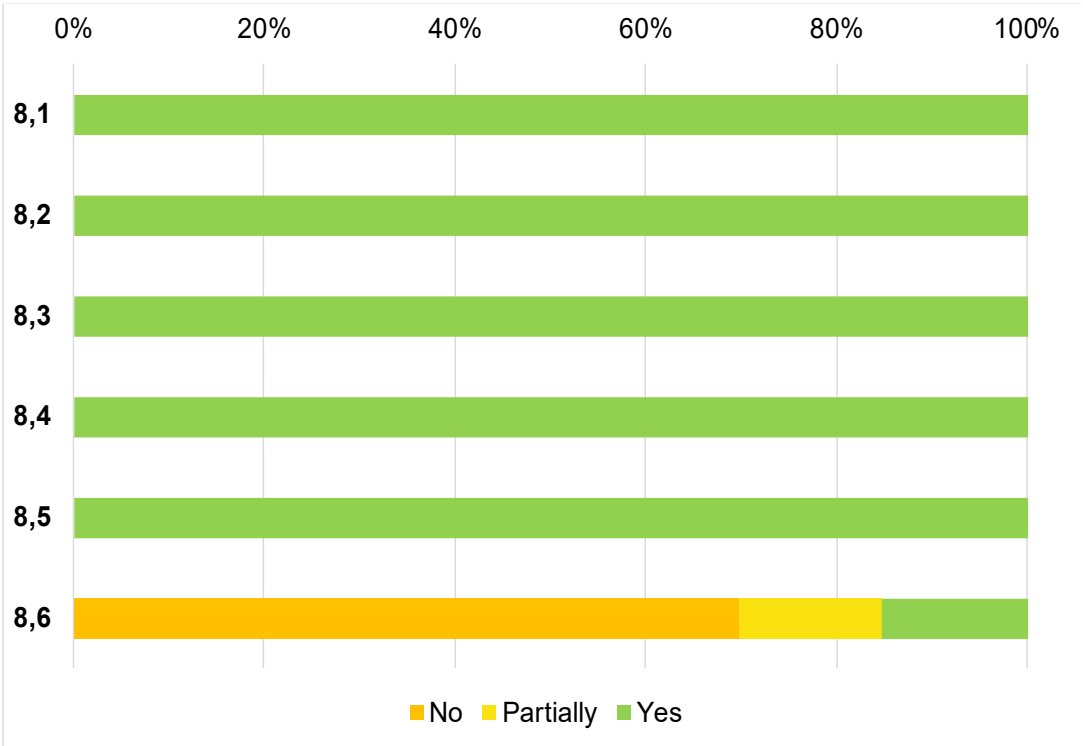



**Figure 20. Overall compliance of selected standards with criteria associated with principle eight. For details about criteria see Table 13.**

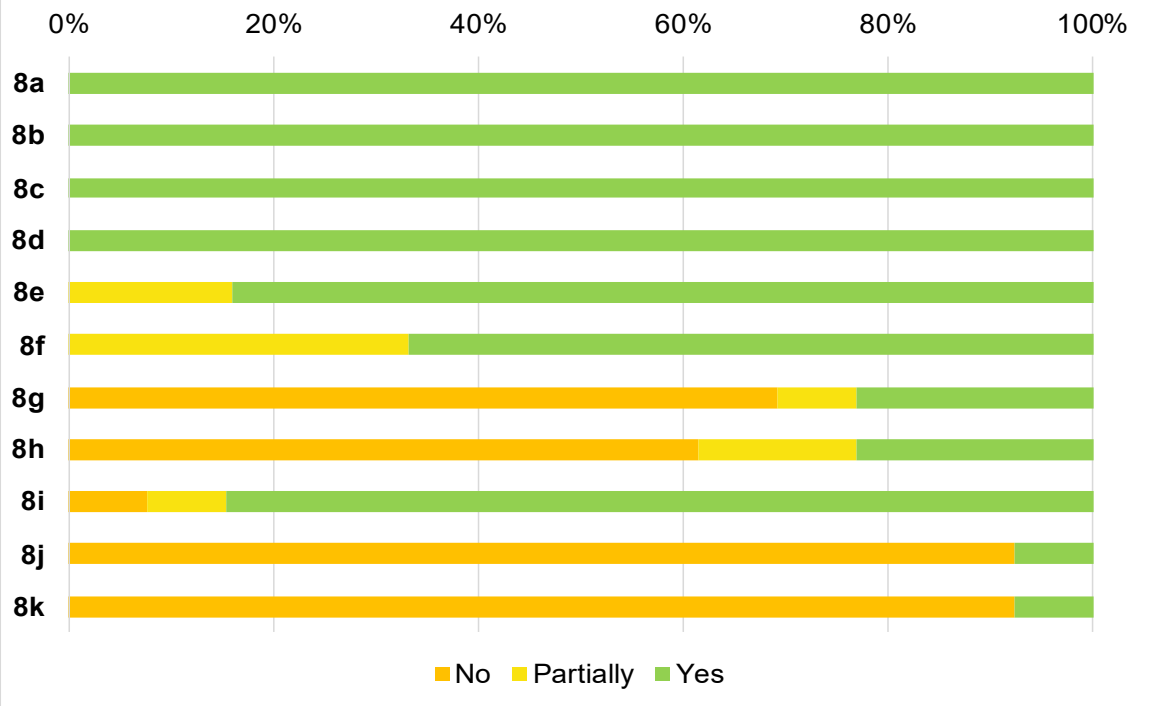



**Figure 21. Overall compliance of selected standards with indicators associated with principle eight. For details about criteria see Table 13.**

### 6.3.9. Reference principle 9: Use of biodiversity shall be economically sustainable, improve conditions of local communities and economies and equitably distributed among local stakeholders

The last set of PC&I deals with economic sustainability associated to forest management, to improve the conditions of local communities and their economies (table 14). On average, 72% of the standards cover the criteria within this set and 62% the indicators (figures 22 and 23). The economic benefits seem to be a relevant matter among the standards. As a result, the criteria, including locally sourced products and sustainability in the long term, are considered between 92% to 100% of the standards assessed. In contrast, topics like equal distribution among diverse demographics are considered only in 23% of the standards, and partially covered in 31% of them.

Regarding the indicators, those related to benefits to female employees and the identification of non-wood forest products, and their potential uses are addressed by 39% of the standards. Whereas the requirement to employ local people and fair wages according to the local context are the most widely covered, being covered by 85% of the standards. More detailed information is available in annex 14.

**Table 14. Reference principle nine and associated criteria and indicators**

| | |
|---|---|
| **Principle 9:** | Use of biodiversity shall be economically sustainable, improve conditions of local communities and economies and equitably distributed among local stakeholders |
| **Criteria** | |
| 9,1 | Economic benefits derived from the use of biodiversity are produced locally and the reporting should be timely, transparent, and easily accessible |

| | |
|---|---|
| 9,2 | Distribution of benefits derived from the use of biodiversity are equitably distributed across gender, and social groups within local communities |
| 9,3 | Benefits derived from the use of the biodiversity shall not produce any long-term impact on the resource base to guarantee sustainability |
| **Indicators** | |
| 9a | The forest management must recruit a minimum percentage from local and/or indigenous population |
| 9b | Identification of non-wood forest products and their potential uses |
| 9c | Gender and other demographics balance in employment rate, in forest-related activities and in management/decision-making positions. |
| 9d | The wages are fair in comparison to local context average |
| 9e | Benefits in place for female employees |

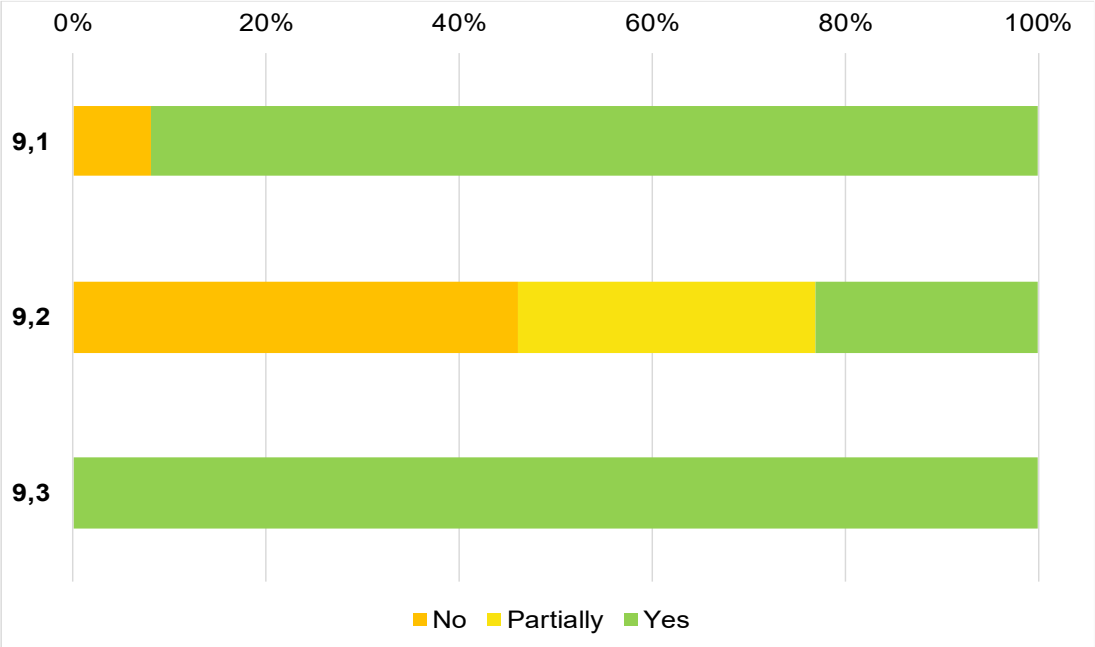



**Figure 22. Overall compliance of selected standards with criteria associated with principle nine. For details about criteria see Table 14.**

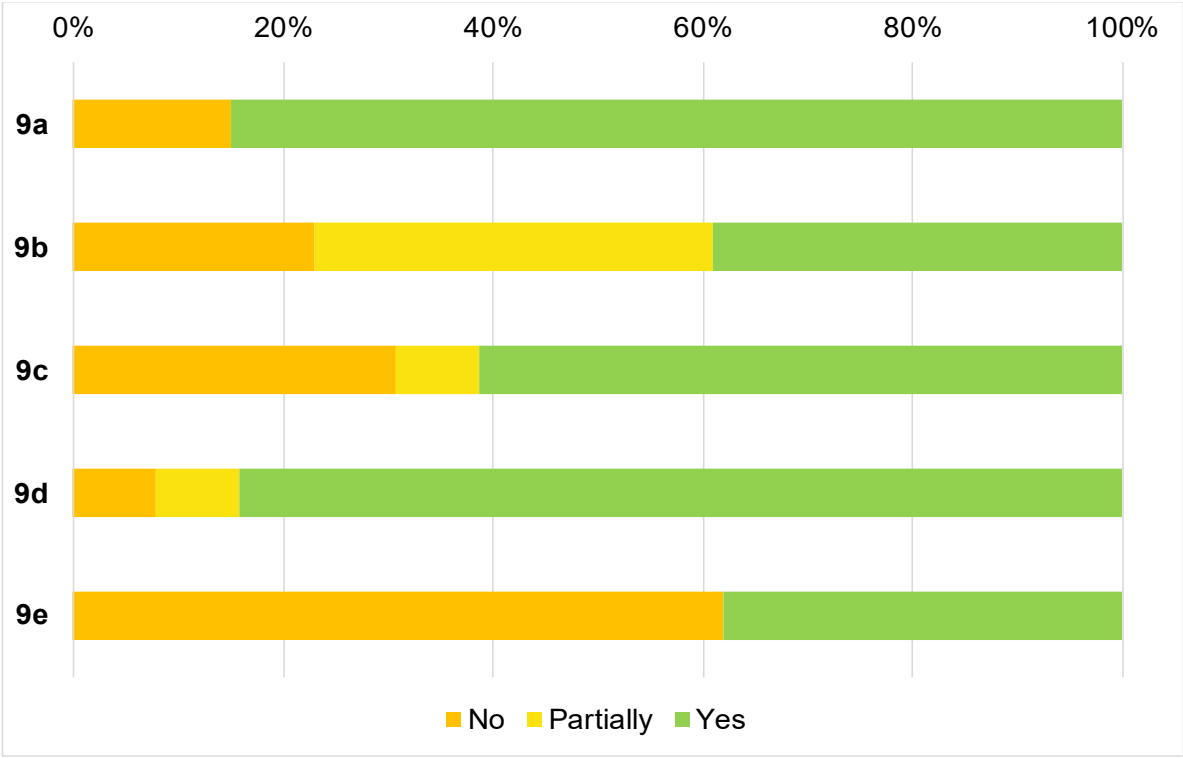



**Figure 23. Overall compliance of selected standards with indicators associated with principle nine. For details about criteria see Table 14.**

# 7. Discussion

This chapter discusses the implications of the study's findings in comparison with previous studies on the topic while also addressing the impact on management and decision-making.

## 7.1. Discussion of the results

The results from this study are aligned with previous studies on the same matter or correlated to the topics exposed before. Although not many studies have developed a reference standard to compare with the existing standards, the main gaps identified in this study are mentioned in similar papers. Englund and Berndes (2015) developed a similar methodology as this study, highlighting common gaps and affinities between a range of different standards. The authors found gaps in research, awareness, education, climate change adaptation – concerning energy use and GHG emissions – and habitat degradation related to pesticides, fertilizers, and waste management. Similar outcomes were found in Masiero et al. (2015) as well, regarding the first topic: research, awareness, and education, where according to the results of the present study, more than half of the standards partially addressed the issues proposed by the reference standard in this matter. Although anthropogenic action is widely distributed across the world with several impacts, rich biodiversity ecosystems such as forests are more exposed to suffering the consequences of it. Studies have demonstrated that research support, public awareness raising, education, and capacity-building campaigns can help people of diverse ages and social standing to sensitize and change their perception of the resources related to the biodiversity (Macharia et al. 2010; Morar and Peterlicean 2012), thus reducing the pressures and minimizing the threats over the biodiversity resources.

An interesting point is that even though the latest versions of the standards selected for this study were included, climate change adaptation seems to be a common issue missing in the standards evaluated not only in this study but in similar studies carried out in diverse countries like Turkey, Bulgaria, and United States (Englund and Berndes 2015b; Garzon et al. 2020). However, in studies on biofuel and agricultural sustainability standards, climate change and energy use are generally included (Hennenberg et al. 2010; Tayleur et al. 2017). Energy use and GHG emissions resemble overlooked issues in forestry standards. While it is true that the carbon sequestration provided by forests addresses climate change, focusing uniquely on carbon can unintendedly create a carbon tunnel vision that gives selective attention to climate change solutions (Savasta-Kennedy 2014) and ignores multiple co-benefits forests can provide to society, including biodiversity. Nonetheless, it must be highlighted that some of the standards assessed in this study are already working with certifications of these forests' co-benefits through ecosystem services certification (i.e., FSC Ecosystem Services Procedure, PEFC Ecosystem Services in Italy). These co-benefits are certified as an extra step that forest managers take to validate and verify the provision of these services derived from their regular forest management.

Moreover, forest certification standards are also partnering with other types of certification focused on carbon standards. The SFM certification, along with carbon and/or ecosystem services certifications, portrays an appealing approach for forest standards to address climate change gaps, avoid the carbon vision tunnel and enter the market with higher performance by managing externalities, reducing risk, and fostering diverse financial sources. Lastly, the ongoing development of initiatives like the regulatory framework for certifying carbon removals based on robust and transparent carbon accounting within the framework of the EU Carbon Farming Initiative may have delayed initiatives in this field since standard-setting bodies might be waiting to see developments and, in case, align their standards to the coming soon regulation.

Regarding habitat degradation, this study found that the reference principle is fully covered by 62% of the standards; however, similar gaps in the regulation of fertilizers and soil management were identified in similar studies (Englund and Berndes 2015b; Masiero et al. 2015). This study also found there is room for improving the regulations related to soil fertility, as seen in Masiero et al. (2015). Overall, soil fertility in the standards is generally addressed without going into details, regardless of the knowledge of forest management activities that can affect soil quality and fertility, such as regulating fertilizers and limiting activities such as trimming.

On the other hand, pesticides and waste management seem like topics that have been further addressed, either because of the selected standards in this study or because of updates that the standards might have carried out since previous studies were conducted. Regarding the use of invasive species and GMOs, which were topics poorly covered by the standards assessed in the studies carried out by Englund and Berndes (2015), Masiero et al. (2015), and Tayleur et al. (2017), we found that 69% of the standards included several criteria and indicators covering to these topics. The high coverage found in this thesis is mainly related to measures to strengthen indigenous biodiversity or limit the use of exotic species, which seems to be strictly regulated by most standards. While this is of significant importance, monitoring the presence and consequences of invasive species is overlooked by the standards. This was also identified as a gap in the above-mentioned literature. Early warnings to detect the presence and monitoring potential damage of invasive species are the most cost-effective procedures (Poland et al. 2022). The likelihood of modification of the ecosystem dynamics, composition, structure, function, and, consequently, local economies can be reduced through practical approaches including, but not limited to, identifying, monitoring, and managing invasive species.

Another aspect found poorly covered by Masiero et al. (2015) is natural regeneration; contrarily to this study, it has been found that 77% of the standards considered the preference of natural regeneration over artificial planting in the management. Nonetheless, it is essential to mention that Masiero's study was focused on forest plantations rather than overall forests. Moreover, other studies carried out by Hennenberg et al. (2010) and Tayleur et al. (2017), where the standards from different sectors (biofuel and agriculture) were assessed in terms of biodiversity, found that the standards for these sectors, as well as the forest sector, widely cover other issues such as endangered species protection and habitat destruction – related to high conservation value (HCV) areas and water bodies

protection – (Englund and Berndes 2015b). From a conservation point of view, the importance that standards are giving to protecting species, HCV areas, and other ecosystems can represent a significant progress in protecting biodiversity. Often, defining the species' habitat niches is difficult and costly. Prioritizing areas for conservation with high value due to the resources available, the habitat quality and suitability, landscape connectivity, and the habitat features (e.g., core forest areas), among other attributes, can be a cost-effective management solution to contribute to biodiversity protection and conservation (Wilson et al. 2011).

Finally, most standards had considerable gaps in some cultural dimensions of biodiversity. Most of the gaps are related to recreational aspects and the implications that establishing tourism and recreational sites might have on local and indigenous communities and their cultures. Nonetheless, it is clear that forest certification standards are oriented to forest operations and management. Hence, the gaps found in this study regarding the topics abovementioned in this paragraph can be covered by complementary standards specifically operating in the field of sustainable tourism. For instance, the case of the Global Sustainable Tourism Certification (GSTC) initiative – in particular their standards for tourism destinations –has been quickly growing in the last few years. Equivalent to FSC, the GSTC is a member of the International Alliance for Social and Environmental Standard Setting (ISEAL) and relies on Assurance Service International (ASI) for the international accreditation of certification bodies. These connections and complementarity might suggest synergies among different initiatives and, therefore, their capacity to complement each other, filling gaps (Masiero, M. personal communication, August 4, 2022).

Moreover, factors such as demographic balance in employment and benefits for female workers are lacking in more than half of the standards, as Masiero et al. (2015) also found in their study. Economic aspects of biodiversity, such as supporting and favoring local suppliers and workforce to strengthen the local economies and long-term sustainability, are widely addressed in the standards.

Furthermore, although this thesis's main objective is not to compare standards, the results stress particular issues regarding the coverage of standards over specific biodiversity issues addressed in the reference standard as well as consistency of standards developed under the same umbrella scheme (e.g., PEFC or FSC). At the same time, it is interesting to assess if differences among national standards reflect country-specific features in terms of biodiversity, e.g., with more biodiversity-rich countries showing more robust and complete standards with reference to biodiversity.

In addressing these aspects, first, in a general context, crucial concepts will be explained. In 2001, the CBD calculated the National Biodiversity Index (NBI) for all the countries with a land area larger than 5000 $km^2$. The index values range between 1 and 0, where 1 indicates a country is highly biodiverse according to species richness and endemism estimates in vertebrate and vascular plants, and 0 stands for very poor biodiversity-related performances (CBD 2001). On the other hand, as for social conflicts associated with the environment, the Environmental Justice Atlas (EJ Atlas), a widely used and accepted platform that projects maps of environmental conflicts along the supply chain, provides an updated overview of the

challenges and commodities leading to socio-ecological conflicts (Temper et al. 2015).

As an example of the remarks found when assessing national certification standards belonging to the same umbrella scheme, we might consider a comparison between PEFC Canada and PEFC Australia. The differences in the level of compliance is noticeable (67% of covered standards vs. 96% respectively). Even though both national standards are formulated under the same baseline (the PEFC Sustainable Forest Management standard - ST 1003, dating back to 2018), a 29% gap in compliance against the reference standard is observed among them. It might be conceivable that the divergence in the strictness of the standards for each country is given due to the stark contrast of NBI among countries where Australia is ranked as number six on the top of the most biodiverse countries with 0,59 on the index scale, whereas Canada in position number 152 with 0,20 (CBD 2001). As an additional example, a similar comparison can also be made for the national PEFC standards for Finland and Gabon. The former is ranked in position 154 regarding world biodiversity, while the latter ranks 48$^{th}$. The difference in compliance with the reference standard, though not large – 75% for PEFC Finland vs. 85% for PEFC Gabon, still opens the discussion to evaluate if there is any relationship between the biodiversity rate and the stringency that national standards are formulated. Unfortunately, few studies, besides the one by Englund and Berndes (2014), have addressed this topic.

However, opposite situations can be observed for other certification standards. So is the case for FSC Brazil and FSC Canada. As discussed in this thesis and previously explored, biodiversity is strongly linked to cultural, social, and economic dimensions. The fact that some countries have more complex cultural and socio-environmental circumstances might affect the stringency under the emerging standards. FSC Brazil complied with 78% of the reference standard, while FSC Canada with 96%.

Nonetheless, according to the portal EJ Atlas, Canada has 81 cases reported of environmental conflicts. In contrast, Brazil has 174, of which around 65 are related to land use, namely forests, agriculture, fisheries, livestock, and biodiversity conservation (Temper et al. 2015). Similarly, the Environmental Performance Index ranked Canada in position number 25 while Brazil in number 46 (YCELP and World Economic Forum 2016). However, even though the number of conflicts related to land use might not be significant, land tenure and property rights in the global south countries are diffused and likely to originate other environmental conflicts (Overbeek et al. 2012). Hence, this might induce a shift in how forest certification standards are developed in these regions.

Although few studies have explored how standards are shaped according to the social-economical context of the countries, there is evidence that forest certification has led the nations to make changes in governance, participation, rights, responsibilities, regulation, and monitoring policies (Meidinger et al. 2003). Similar studies have found that these differences can be shaped by factors such as biogeographical features, legal contexts, land ownership, enforcement capacity, and national conservation targets, among others (Englund and Berndes 2015b; Garzon et al. 2020). Hence, a bidirectional relationship between national standards and the context, policies, and regulations where these have been developed can be

suggested. Nonetheless, this is a topic worth exploring and analyzing in future studies.

The growing interest in biodiversity is not limited to forest managers, customers, and private companies. Indeed, public bodies' interest has been rapidly growing in the last decade, as confirmed by the development of a large body of policies, regulations, and initiatives such as for example (with reference to the EU context), the EU biodiversity strategy for 2030, the EU taxonomy for investments, the expected EU Deforestation Regulation, and the EU Close-to-Nature forest management standard). This interest has been shaping new outlines on how existing standards should address this topic. The outcomes from this thesis, similar studies, guidelines, and regulations provided by public bodies can guide the current standards toward understanding their weak points and improving their performance to remain competitive and appeal against more complete standards in the market.

Finally, the outcomes of this thesis aim to be merely constructive. It is well known that certificate holders and forest managers are making significant efforts to certify their forests and improve their practices. Forest certification standards mustn't become a certificate that only companies with high sustainability performance or with large financial, human, and technical capacity to make management decisions can achieve. The management decisions that can be enhanced from these results should not represent a burden and should avoid unnecessary requirements that might cause the opposite effect on biodiversity sustainable use by slowing the implementation or preventing forest managers from moving toward more sustainable paths in forestry. The reference standard produced in this thesis is not intended for being implemented as such in the field, rather it should provide a baseline on the relevant aspects that forest certification standards might lack attention or improvement. However, as explained before, biodiversity specificity and context-dependency require standards adapted to the features where these are expected to be implemented.

# 8. Conclusions

The recent global ecological crises (i.e., climate, biodiversity, plastic, resources, pollution, land use, etc.) have led the world towards a more and more urgent need for the sustainable use of natural resources. While ceasing the use of some resources seems unfeasible, the responsible use and management of social and natural assets portray an opportunity to contribute to building a more resilient, equitable, and endurable future to embrace the foreseen consequences of these global crises. As for biodiversity, the current crisis has gained much attention in the last decades. Several sectors, such as academia, non-profit organizations, the financial and private sector, public bodies, and organizations, have placed multiple efforts to assemble a solution that meets the critical demands at several scales of the biodiversity crisis. Nonetheless, biodiversity is context-dependent, multi-scale, complex, and underpins multiple dimensions.

Through experts' consultation, this study identified and built a meta-standard (or reference standard) containing key criteria and indicators focused on biodiversity maintenance, protection, enhancement, and conservation. A comparative

assessment of the extent to which selected forest certification standards address the multiple aspects of biodiversity included within the reference standard was then performed. As a final step, the study aimed to provide lessons learned and inputs on the least covered topics to contribute to future development and improvement of forest certification schemes.

Henceforth, according to the results presented and discussed, forest certification standards cover relevant biological aspects of biodiversity. Most of the standards strongly focused on protecting threatened and endangered species, high conservation value areas, and water bodies. Moreover, the prioritization of connectivity and complexity of the forest addressed landscape biodiversity issues stressed in previous studies to be lacking in forest certification standards, seems to be a widely covered topic in the assessed standards. In contrast, while many biological and ecosystemic problems are widely discussed, critical aspects intrinsically connected to biodiversity are still overlooked. Climate change mitigation, adaptation, and resilience building are poorly addressed in most standards. Similarly, most standards do not consider aspects related to research, education, and capacity-building programs oriented to strengthen the acknowledgment, governance, and sensitivity toward biodiversity.

Despite the limitations highlighted in section 5.3, the results of this study can not only guide future improvements of forest certification schemes but also can help customers and private companies choose the most suitable certification standard according to the particular interest they might have regarding specific aspects of biodiversity. This is of particular importance when considering that certification schemes ultimately are management and marketing tools, therefore companies investing in them or investors investing in certified companies are expected to be interested in finding the best, i.e., the most suitable, reliable, and consistent, solution among the multiple alternatives. In addition to this, better knowledge about the features, gaps, and limitations of standards provides transparent feedback and information to consumers (e.g., buyers of certified forest products) and public opinion in general, informing their consumer and procurement choices. Last but not least, given the existence of multiple certification initiatives, comparative and monitoring assessments could encourage their improvement over time, pushing towards more robust certification rules/mechanisms and ultimately ensuring better forest management conditions.

At the same time, forest certification can help mobilize resources to support the gaps that forest managers might be lacking in their SFM certifications. As a market-based instrument, voluntary forest certification provides the chance to help manage externalities that development activities might unintentionally cause. In this sense, forest certification can be presented as a nature-based solution to address the biodiversity crisis. This, through a credit and claims system, that if properly developed and implemented, can potentially become an offsetting mechanism to support various ecosystem services that can indirectly improve biodiversity.

Biophysical, social, cultural, and economic contexts have been found to be crucial elements in forest certification formulation and success. The selection of specific national standards endorsed internationally might have influenced more/less compliant results according to the country's specific characteristics. For this reason,

as explained in section 5.3, further studies are recommended to cluster the compared standards according to biodiversity, social, and economic indexes to have insights with commensurate contexts.

# 9. References


Addinsoft (2022) XLSTAT statistical and data analysis solution.

Angelstam P, Persson R, Schlaepfer R (2004) The Sustainable Forest Management Vision and Biodiversity: Barriers and Bridges for Implementation in Actual Landscapes. Ecol Bull 29–49

Arbainsyah, de Iongh HH, Kustiawan W, de Snoo GR (2014) Structure, composition and diversity of plant communities in FSC-certified, selectively logged forests of different ages compared to primary rain forest. Biodivers Conserv 23:2445–2472. https://doi.org/10.1007/s10531-014-0732-4

Bemelmans-Videc M-L, Rist RC, Vedung E (1998) Carrots, sticks & sermons. Policy instruments and their evaluation., Fifth edit. Transaction Publishers, New Brunswick, New Jersey, US

Blackman A, Raimondi A, Cubbage F (2017) Does Forest Certification in Developing Countries Have Environmental Benefits? Insights from Mexican Corrective Action Requests. Int For Rev 19:247–264. https://doi.org/10.1505/146554817821865072

Bougherara D, Grolleau G (2005) Designing Ecolabels In Order To Mitigate Market Failures. J Interdiscip Econ 16:411–430. https://doi.org/10.1177/02601079x05001600403

Brukas V, Sallnäs O (2012) Forest management plan as a policy instrument: Carrot, stick or sermon? Land use policy 29:605–613. https://doi.org/10.1016/j.landusepol.2011.10.003

Campos-Cerqueira M, Mena JL, Tejeda-Gómez V, et al (2020) How does FSC forest certification affect the acoustically active fauna in Madre de Dios, Peru? Remote Sens Ecol Conserv 6:274–285. https://doi.org/10.1002/rse2.120

Cardinale BJ, Duffy JE, Gonzalez A, et al (2012) Biodiversity loss and its impact on humanity. Nature 486:59–67. https://doi.org/10.1038/nature11148.Access

CBD (2013) Convention on Biological Diversity

CBD (2010) Strategic Plan for Biodiversity 2011-2020, including Aichi Biodiversity Targets

CBD (2016) National Indicators And Approaches To Monitor Progress Towards The Aichi Biodiversity Targets. Montreal, Canada

CBD (2019) Report of the Conference of the Parties to the Convention on Biological Diversity on its Fourteenth Meeting

CBD (2004) The Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity. Montreal, Canada

CBD (2001) Global Biodiversity Outlook. Annex 1. Biodiversity Information by Country. Montreal, Canada

Cerutti PO, Lescuyer G, Tacconi L, et al (2017) Social impacts of the forest stewardship council certification in the Congo Basin. Int For Rev 19:50–63. https://doi.org/10.17528/cifor/004487

Dare M, Schirmer J, Vanclay F (2011) Does forest certification enhance community engagement in Australian plantation management? For Policy Econ 13:328–337. https://doi.org/10.1016/j.forpol.2011.03.011

Di Girolami E, Arts B (2018) Environmental impacts of forest certifications. Wageningen, Netherlands

Dias FS, Bugalho MN, Orestes Cerdeira J, João Martins M (2013) Is forest certification targeting areas of high biodiversity in cork oak savannas? Biodivers Conserv 22:93–112. https://doi.org/10.1007/s10531-012-0401-4

Doremus H (2003) TAKINGS AND TRANSITIONS. L Use Environ Law 19:1–46
Doswald N, Barcellos Hariss M, Jones M, et al (2012) Biodiversity offsets: voluntary and compliance regimes. A review of existing schemes, initiatives and guidance for financial institutions. Geneva, Switzerland
Elbakidze M, Dawson L, McDermott CL, et al (2022) Biodiversity conservation through forest certification: key factors shaping national Forest Stewardship Council (FSC) standard-development processes in Canada, Sweden, and Russia. Ecol Soc 27:. https://doi.org/10.5751/es-12778-270109
Elbakidze M, Ražauskaitė R, Manton M, et al (2016) The role of forest certification for biodiversity conservation: Lithuania as a case study. Eur J For Res 135:361–376. https://doi.org/10.1007/s10342-016-0940-4
Englund O, Berndes G (2015a) How do sustainability standards consider biodiversity? Wiley Interdiscip Rev Energy Environ 4:26–50. https://doi.org/10.1002/wene.118
Englund O, Berndes G (2015b) How do sustainability standards consider biodiversity? Wiley Interdiscip Rev Energy Environ 4:26–50. https://doi.org/10.1002/wene.118
FAO, UNEP (2020) The State of the World's Forests 2020. Rome
FC4S, UNDP (2022) Biodiversity finance. FC4S Work Programme outline.
Fransen L, Schalk J, Kok M, et al (2018) Biodiversity protection through networks of voluntary sustainability standard organizations? Sustain 10:1–20. https://doi.org/10.3390/su10124379
FSC (2015) FSC Principles and Criteria for Forest Stewardship
Galati A, Gianguzzi G, Tinervia S, et al (2017) Motivations, adoption and impact of voluntary environmental certification in the Italian Forest based industry: The case of the FSC standard. For Policy Econ 83:169–176. https://doi.org/10.1016/j.forpol.2017.08.002
Garzon ARG, Bettinger P, Siry J, et al (2020) A comparative analysis of five forest certification programs. Forests 11:. https://doi.org/10.3390/f11080863
Goulder L, Kennedy D (1997) Valuing ecosystem services: Philosophical bases and empirical methods. In: Daily GC (ed) Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, DC., pp 23–47
Gregory AJ, P.Atkins J, Burdon D, Elliott M (2013) A problem structuring method for ecosystem-based management: The DPSIR modelling process. Eur J Oper Res 227:558–569
Grime MM, Wright G (2016) Delphi Method. Wiley StatsRef Stat Ref Online 1–6. https://doi.org/10.1002/9781118445112.stat07879
Haines-Young R, Potschin M (2010) The links between biodiversity, ecosystem services and human well-being. In: Raffaelli DG, Frid CLJ (eds) Ecosystem Ecology. Cambridge University Press, Cambridge, UK, pp 111–139
Hennenberg KJ, Dragisic C, Haye S, et al (2010) The Power of Bioenergy-Related Standards to Protect Biodiversity. Conserv Biol 24:412–423. https://doi.org/10.1111/j.1523-1739.2009.01380.x
Holvoet B, Muys B (2004) Sustainable forest management worldwide: A comparative assessment of standards. Int For Rev 6:99–122. https://doi.org/10.1505/ifor.6.2.99.38388
IPBES (2019a) Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany
IPBES (2019b) Assessing a planet in transformation: Rationale and approach of the IPBES Global Assessment on Biodiversity and Ecosystem Services. In: IPBES

Global Assessment on Biodiversity and Ecosystem Services Chapter. IPBES secretariat, Bonn, Germany, pp 1–69
Kalonga SK, Midtgaard F, Klanderud K (2016) Forest certification as a policy option in conserving biodiversity: An empirical study of forest management in Tanzania. For Ecol Manage 361:1–12. https://doi.org/10.1016/j.foreco.2015.10.034
Korn H, Stadler J, Bonn A (2019) Global Developments: Policy Support for Linking Biodiversity, Health and Climate Change. In: Korn H, Stadler J, Bonn A (eds) Biodiversity and Health in the Face of Climate Change. Springer International Publishing, pp 315–328
Kuijk M Van, Putz FE, Zagt R (2009) Effects of Forest Certification on Biodiversity. Wageningen, the Netherlands
Kukkonen M, Hohnwald S (2009) Comparing floristic composition in treefall gaps of certified, conventionally managed and natural forests of northern Honduras. Ann For Sci 66:809–809. https://doi.org/10.1051/forest/2009070
Lammerts van Bueren EM, Blom EM (1997) Hierarchical Framework for the Formulation of Sustainable Forest Management Standards
Landeta J, Barrutia J (2011) People consultation to construct the future: A Delphi application. Int J Forecast 27:134–151. https://doi.org/10.1016/j.ijforecast.2010.04.001
Lapeyre R, Pirard R (2013) Payments for environmental services and market-based instruments: next of kin or false friends? Inst du développement durable des relations Int 14:1–16
Laurila-Pant M, Lehikoinen A, Uusitalo L, Venesjärvi R (2015) How to value biodiversity in environmental management? Ecol Indic 55:1–11. https://doi.org/10.1016/j.ecolind.2015.02.034
Lehtonen E, Gustafsson L, Lõhmus A, von Stedingk H (2021) What does FSC forest certification contribute to biodiversity conservation in relation to national legislation? J Environ Manage 299:. https://doi.org/10.1016/j.jenvman.2021.113606
Linser S, Wolfslehner B, Asmar F, et al (2018) 25 years of criteria and indicators for sustainable forest management: Why some intergovernmental C & I processes flourished while others faded. Forests 9:1–19. https://doi.org/10.3390/f9090515
Macharia JM, Thenya T, Ndiritu GG (2010) Management of highland wetlands in central Kenya: The importance of community education, awareness and eco-tourism in biodiversity conservation. Biodiversity 11:85–90. https://doi.org/10.1080/14888386.2010.9712652
Magurran AE (2004) Measuring Biological Diversity, First edit. Blackwell Publishing company, Padstow, Cornwall, UK
Makrickiene E, Brukas V, Brodrechtova Y, et al (2019) From command-and-control to good forest governance: A critical interpretive analysis of Lithuania and Slovakia. For Policy Econ 109:. https://doi.org/10.1016/j.forpol.2019.102024
Masiero M, Secco L, Pettenella D, Brotto L (2015) Standards and guidelines for forest plantation management: A global comparative study. For Policy Econ 53:29–44. https://doi.org/10.1016/j.forpol.2014.12.008
MEA (2005) Ecosystems & Human Well-being: Synthesis. Island Press, Washington, DC.
MEA (2003) Ecosystems and Their Services. Island Press
Meidinger E, Elliot C, Oesten G (2003) Social and political dimensions of forest certification. SUNY Buffalo Legal Studies

Mena S, Palazzo G (2012) Input and Output Legitimacy of Multi-Stakeholder Initiatives. Bus Ethics Q 22:527–556. https://doi.org/10.5840/beq201222333
Morar F, Peterlicean A (2012) The Role and Importance of Educating Youth Regarding Biodiversity Conservation in Protected Natural Areas. Procedia Econ Financ 3:1117–1121. https://doi.org/10.1016/s2212-5671(12)00283-3
Morgan EA, Osborne N, Mackey B (2022) Evaluating planning without plans: Principles, criteria and indicators for effective forest landscape approaches. Land use policy 115:106031. https://doi.org/10.1016/j.landusepol.2022.106031
Oettel J, Lapin K (2021) Linking forest management and biodiversity indicators to strengthen sustainable forest management in Europe. Ecol Indic 122:107275. https://doi.org/10.1016/j.ecolind.2020.107275
Overbeek W, Köger M, Gerber JF (2012) An Overview of Industrial Tree Plantations in the Global South: Conflicts, Trends and Resistance Struggles. EJOLT Rep 100
Owari T, Juslin H, Rummukainen A, Yoshimura T (2006) Strategies, functions and benefits of forest certification in wood products marketing: Perspectives of Finnish suppliers. For Policy Econ 9:380–391. https://doi.org/10.1016/j.forpol.2005.10.005
Paluš H, Krahulcová M, Parobek J (2021) Assessment of forest certification as a tool to support forest ecosystem services. Forests 12:. https://doi.org/10.3390/f12030300
Paluš H, Parobek J, Dzian M, et al (2019) How companies in the wood supply chain perceive the forest certification. Acta Fac Xylologiae Zvolen 61:155–165. https://doi.org/10.17423/afx.2019.61.1.15
Pearce D, Moran D (1994) The economic value of biodiversity. Cambridge University Press, London, United Kingdom
Pirard R (2012) Market-based instruments for biodiversity and ecosystem services: A lexicon. Environ Sci Policy 19–20:59–68. https://doi.org/10.1016/j.envsci.2012.02.001
Poland TM, Patel-Weynand T, Finch DM, et al (2022) Invasive Species in Forests and Rangelands of the United States: A Comprehensive Science Synthesis for the United States Forest Sector
Pörtner H-O, Scholes RJ, Agard J, et al (2021) Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change
Putz F, Redford K, Robinson JG, et al (2000) Biodiversity Conservation in the Context of Tropical Forest Management. Washington, DC.
Randall A (1983) The Problem of Market Failure Published by : Regents of the University of New Mexico on behalf of its School of Law Stable URL : https://www.jstor.org/stable/24882453 The Problem of Market Failure *. 23:131–148
Rayamajhi S, Smith-Hall C, Helles F (2012) Empirical evidence of the economic importance of Central Himalayan forests to rural households. For Policy Econ 20:25–35. https://doi.org/10.1016/j.forpol.2012.02.007
Rissman AR, Kohl PA, Wardropper CB (2017) Public support for carrot, stick, and no-government water quality policies. Environ Sci Policy 76:82–89. https://doi.org/10.1016/j.envsci.2017.04.012
Savasta-Kennedy M (2014) The dangers of carbon reduction tunnel vision
Schmitz OJ, Lawler JJ, Beier P, et al (2015) Conserving biodiversity: Practical guidance about climate change adaptation approaches in support of land-use planning. Nat Areas J 35:190–203. https://doi.org/10.3375/043.035.0120

Schneiders A, Van Daele T, Van Landuyt W, Van Reeth W (2012) Biodiversity and ecosystem services: Complementary approaches for ecosystem management? Ecol Indic 21:123–133. https://doi.org/10.1016/j.ecolind.2011.06.021
Sheil D, Putz FE, Zagt R (2010) Biodiversity conservation in certified forests: an overview. Tropenbos International, Wageningen, Netherlands
Skulmoski GJ, Hartman FT, Krahn J (2007) The Delphi Method for Graduate Research. J Inf Technol Educ 6:. https://doi.org/10.1007/3-540-47847-7_10
Sterner T, Coria J (2013) Policy instruments for environmental and natural resource management. Policy Instruments Environ Nat Resour Manag 1–638. https://doi.org/10.4324/9781315780894
Sun Z, Behrens P, Tukker A, et al (2022) Shared and environmentally just responsibility for global biodiversity loss. Ecol Econ 194:107339. https://doi.org/10.1016/j.ecolecon.2022.107339
Tayleur C, Balmford A, Buchanan GM, et al (2017) Global Coverage of Agricultural Sustainability Standards, and Their Role in Conserving Biodiversity. Conserv Lett 10:610–618. https://doi.org/10.1111/conl.12314
Temper L, del Bene D, Martinez-Alier J (2015) Mapping the frontiers and front lines of global environmental justice: the EJAtlas.
Thorsen BJ, Mavsar R, Tryväinen L, et al (2014) The Provision of Forest Ecosystem Services
TNC (2022) Biodiversity: Nature by Another Name. In: Nat. Conserv.
Trombulak SC, Omland KS, Robinson JA, et al (2004) Principles of conservation biology: Recommended guidelines for conservation literacy from the education committee of the society for conservation biology. Conserv Biol 18:1180–1190. https://doi.org/10.1111/j.1523-1739.2004.01851.x
Tröster R, Hiete M (2018) Success of voluntary sustainability certification schemes – A comprehensive review. J Clean Prod 196:1034–1043. https://doi.org/10.1016/j.jclepro.2018.05.240
Tsanga R, Lescuyer G, Cerutti PO (2014) What is the role for forest certification in improving relationships between logging companies and communities Lessons from FSC in Cameroon. Int For Rev 16:14–22. https://doi.org/10.1505/146554814811031305
Turner K (2010) A pluralistic approach to ecosystem services evaluation
UN (2015) Sustainable Development Goals. https://www.un.org/sustainabledevelopment/sustainable-development-goals/. Accessed 19 Jul 2021
UNEP-WCMC (2011) Review of the Biodiversity Requirements of Standards and Certification Schemes: A snapshot of current practices.
UNEP, CBD (1994) Convention on Biological Diversity
UNESCO, CBD (2010) Natural habitats Linking Biological and Cultural Diversity. Programme tangible heritage man affected habitats intangible heritage
Villalobos L, Coria J, Nordén A (2018) Has forest certification reduced forest degradation in Sweden? Land Econ 94:220–238. https://doi.org/10.3368/le.94.2.220
Wilson CD, Roberts D, Reid N (2011) Applying species distribution modelling to identify areas of high conservation value for endangered species: A case study using Margaritifera margaritifera (L.). Biol Conserv 144:821–829. https://doi.org/10.1016/j.biocon.2010.11.014
World Economic Forum (2021) The Global Risks Report 2021
WWF (2018) Living Planet Report 2018: Aiming higher. Gland, Switzerland

YCELP, World Economic Forum (2016) Global Metrics for the Environment. The Environmental Performance Index ranks countries‘ performance on high-priority environmental issues. Yale Cent Environ Law Policy 123

Zhang C, Li J, Zhou Z (2022) Ecosystem service cascade: Concept, review, application and prospect. Ecol Indic 137:108766. https://doi.org/10.1016/j.ecolind.2022.108766

# Annexes

# Annex 1. Survey Delphi questionnaire

Thank you for taking the time to contribute to our research project. We are developing this project to understand better how biodiversity is addressed in international and national forest certification standards. The reference standard that we invited you to critique has been constructed using the biodiversity loss drivers ((IPBES 2019)In addition, the reference standard was completed by using similar studies for other land use certifications (Holvoet and Muys 2004; Hennenberg et al. 2010; Doswald et al. 2012; Englund and Berndes 2015; Masiero et al. 2015; Tayleur et al. 2017; Fransen et al. 2018; Tröster and Hiete 2018; Garzon et al. 2020; Elbakidze et al. 2022). The questionnaire comprises nine principles, which underpin a series of criteria and indicators.

Principles describe specific elements the goal aspires to achieve. Criteria aim to outline the state or aspects of a dynamic forest ecosystem process without explaining how to accomplish the state or implying its achievement. Indicators are a practical resource used to monitor and report the fulfilment of the principles and criteria.

In order to make sure this reference standard is peer-reviewed and assessed by experts, your input will be used to revise it and improve it. The instructions on how to respond to the questionnaire are as follows:
-Respondents are expected to select the option for each principle, criteria, and indicator: Yes, without comments/Yes, but reformulated/No and exclude/No answer.
-According to the Delphi procedure, **we must emphasise that respondents are asked to answer only on those topics they feel expert** (No answer in this case).
-If the respondents think that the principles, criteria, and indicators are not comprehensive enough, space for new criteria and/or indicators is provided at the end of each section.
-There is also the option to keep your answers anonymous; please mark the right cell if that is the case.

**The deadline to fill out the questionnaire and send it back is the 6th of June.**

| Do you wish to remain anonymous? | Choose an option |
|---|---|

| | | Choose an option | Space for reformulation or why exclusion |
|---|---|---|---|
| | **Principle** | | |
| A | Endangered species are assessed, protected and enhanced, if possible. | Choose an option | |
| | **Criteria** | | |
| 1 | Endangered species within the production area protected | Choose an option | |
| 2 | Endangered species around the production area considered | Choose an option | |
| 3 | Endemic species within the production area protected | Choose an option | |
| | **SPACE FOR ADDING NEW CRITERIA** | | |
| | **Indicators** | | |
| i. | changes | Choose an option | |
| ii. | Percentage of land surface with protective status | Choose an option | |
| iii. | Total number of red list species per surface | Choose an option | |
| iv. | Number of threatened species per surface | Choose an option | |
| v. | Number of endemic species per surface | Choose an option | |
| vi. | Number of species per surface | Choose an option | |
| vii. | Existence of procedures for monitoring of damage to forest resources caused by bad harvesting practices and illegal extraction of individuals | Choose an option | |
| viii. | Protective measures for the controlling and/or prevention of forest damage caused by bad harvesting practices and illegal extraction of individuals | Choose an option | |
| ix. | Existence and implementation of measures for the protection of key species | Choose an option | |
| x. | Monitoring the protected areas and its changes | Choose an option | |
| | **SPACE FOR ADDING NEW INDICATORS** | | |
| | **Principle** | | |
| B | Habitat destruction and fragmentation are assessed, avoided, mitigated and compensated | Choose an option | |
| | **Criteria** | | |
| 1 | Habitat destruction avoided | Choose an option | |
| 2 | Habitat fragmentation avoided | Choose an option | |
| 3 | High Conservation Value areas identified and protected | Choose an option | |
| 4 | Rehabilitation and restoration | Choose an option | |
| | **SPACE FOR ADDING NEW CRITERIA** | | |
| | **Indicators** | | |
| i. | Existence and implementation of measures for the protection of specific biotopes with large biodiversity value | Choose an option | |
| ii. | Existence of procedures for monitoring of damage to forest resources caused by encroachment (illegal sttlements, illegal agricultural expansion) | Choose an option | |
| iii. | Protective measures for the controlling and/or prevention of forest damage caused by encroachment (illegal sttlements, illegal agricultural expansion) | Choose an option | |
| iv. | Existence and implementation of measures for the conservation or improvement of habitat diversity | Choose an option | |
| v. | Existence and implementation of measures for the conservation or restoration of natural ecosystem complexity | Choose an option | |
| vi. | Existence of data about occurring ecosystem types | Choose an option | |
| vii. | Harvesting limited to periods with little impact on fauna and flora | Choose an option | |
| viii. | Degree of fragmentation or connectivity (corridor function) | Choose an option | |
| ix. | Existence and implementing programs for maintenance of keystone species and functional groups | Choose an option | |
| | **SPACE FOR ADDING NEW INDICATORS** | | |
| | **Principle** | | |
| C | Habitat degradation, modification and pollution are assessed, avoided, mitigated and compensated | Choose an option | |
| | **Criteria** | | |
| 1 | Pesticide use restricted | Choose an option | |
| 2 | Guidance for pesticide application provided | Choose an option | |
| 3 | Guidance for fertilisation provided to avoid nutrient leaching | Choose an option | |
| 4 | Buffer zones required | Choose an option | |
| 5 | Water resources protected | Choose an option | |
| 6 | Soil erosion prevented | Choose an option | |
| 7 | Soil quality maintained | Choose an option | |
| 8 | Waste management required | Choose an option | |
| 9 | Recycling required | Choose an option | |
| 10 | Imitation of effects of natural disturbances | Choose an option | |
| 11 | Maintenance of decomposition and nutrient cycling | Choose an option | |
| | **SPACE FOR ADDING NEW CRITERIA** | | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Existence and implementation of measures for the conservation of existing genetic diversity | **Choose an option** |
| ii. | Existence and implementation of measures for the minimisation of negative impacts of forest management on biological diversity | **Choose an option** |
| iii. | Existence of procedures for monitoring of damage to forest resources caused by infrigements (illegal waste disposal) | **Choose an option** |
| iv. | Protective measures for the controlling and/or prevention of forest damage caused by infrigements (illegal waste disposal) | **Choose an option** |
| v. | Existence and implementation of measures for the conservation of the litter layer | **Choose an option** |
| vi. | Existence and implementation of measures that guarantee the presence of sufficient amounts of dead wood, standing as well as lying on the forest floor | **Choose an option** |
| vii. | Preference for mechanical techniques for the removal of non-indigenous harmful species | **Choose an option** |
| viii. | Existence and implementation of regulations for the use of biocides and pesticides | **Choose an option** |
| ix. | Amounts and/or types of used biocides and pesticides | **Choose an option** |
| x. | Existence and implementation of regulations for the use of fertilisers | **Choose an option** |
| xi. | Amounts and/or types of used fertilisers | **Choose an option** |
| xii. | Degree of use of environmentally friendly control agents | **Choose an option** |
| xiii. | Existence of measures to maintain soil fertility and site productivity | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

| | | |
|---|---|---|
| | **Principle** | |
| D | Overexploitation of organisms is avoided and mitigated | **Choose an option** |
| | **Criteria** | |
| 1 | Long-term sustainability considered | **Choose an option** |
| 2 | Sustainable harvest rates identified and applied | **Choose an option** |
| 3 | Crop-rotation applied | **Choose an option** |
| | **SPACE FOR ADDING NEW CRITERIA** | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Existence of procedures for monitoring of damage to forest resources caused by bad harvesting practices and illegal extraction of individuals | **Choose an option** |
| ii. | Protective measures for the controlling and/or prevention of forest damage caused by bad harvesting practices and illegal extraction of individuals | **Choose an option** |
| iii. | Monitoring the changes in wood stocks | **Choose an option** |
| iv. | Harvested volume by species | **Choose an option** |
| v. | Existence of sustainable harvest levels per product | **Choose an option** |
| vi. | Incentives for the use of lesser known woody forest species | **Choose an option** |
| vii. | Measures for rehabilitation or reintroduction are present | **Choose an option** |
| viii. | Provision for actions to ensure natural regeneration | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

| | | |
|---|---|---|
| | **Principle** | |
| E | Invasive species and GMOs are restricted, regulated, managed and avoided, if necessary. | **Choose an option** |
| | **Criteria** | |
| 1 | Native species preferred over exotic | **Choose an option** |
| 2 | Measures taken to prevent introduction of invasive species | **Choose an option** |
| | **SPACE FOR ADDING NEW CRITERIA** | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Existence of procedures for monitoring of damage to forest resources caused by invasive alien species | **Choose an option** |
| ii. | Protective measures for the controlling and/or prevention of forest damage caused by invasive alien species | **Choose an option** |
| iii. | Existence and implementation of measures which protect, support or strengthen indigenous biodiversity | **Choose an option** |
| iv. | Existence of regulations and limitations for the use of exotic tree species in regeneration activities | **Choose an option** |
| v. | Monitoring of the use of exotic tree species and their impacts on the environment | **Choose an option** |
| vi. | Genetically modified organisms are not allowed | **Choose an option** |
| vii. | The use of biological control agents is strictly regulated | **Choose an option** |
| viii. | Existence of regulations which prevent introduction and spreading of non-indigenous species | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

| | | |
|---|---|---|
| | **Principle** | |
| F | Climate change adaptation, resistance, resilience and mitigation measures are taken around biodiversity threats | **Choose an option** |
| | **Criteria** | |
| 1 | Energy use minimized | **Choose an option** |
| 2 | Fossil energy avoided | **Choose an option** |
| 3 | Carbon stock maintained or enhanced | **Choose an option** |
| 4 | Resilience, response and, mitigation measures are addressed | **Choose an option** |
| | **SPACE FOR ADDING NEW CRITERIA** | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Existence of procedures for monitoring of damage to forest resources caused by climate extreme events | **Choose an option** |
| ii. | Protective measures for the controlling and/or prevention of forest damage caused by climate extreme events | **Choose an option** |

| | | |
|---|---|---|
| iii. | Preference for long rotations | **Choose an option** |
| iv. | Preference for natural stem reduction | **Choose an option** |
| v. | Protected and/or old trees are identified and are not felled during harvesting | **Choose an option** |
| vi. | Existence of procedures for reducing greenhouse gas emissions from operational activities in forest management | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

| | | |
|---|---|---|
| | **Principle** | |
| G | Research, awareness and education around biodiversity aspects is promoted | **Choose an option** |
| | **Criteria** | |
| 1 | Research supported | **Choose an option** |
| 2 | Awareness spread | **Choose an option** |
| 3 | Education to workers provided | **Choose an option** |
| | **SPACE FOR ADDING NEW CRITERIA** | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Existing education, training, and capacity-building programs on biodiversity management | **Choose an option** |
| ii. | Incentives for the use of non-wood forest species | **Choose an option** |
| iii. | Research activity related to potential human impacts on biodiversity | **Choose an option** |
| iv. | Research for possible harmful consequences of unwanted introduction or spreading of non-indigenous species | **Choose an option** |
| v. | Availability of maps of the protected forest area | **Choose an option** |
| vi. | Amounts of investments in research, development and education | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

| | | |
|---|---|---|
| | **Principle** | |
| H | Social and cultural biodiversity aspects are respected, protected, maintained and enhanced | **Choose an option** |
| | **Criteria** | |
| 1 | Provision for duly established Aboriginal and local communities rights | **Choose an option** |
| 2 | Aboriginal traditional land use and forest-based ecological knowledge is considered | **Choose an option** |
| 3 | Forest community well-being and resilience | **Choose an option** |
| 4 | Forest management pays sufficient attention to cultural, recreational, spiritual and archeological values | **Choose an option** |
| 5 | Clear land titles and usage rights | **Choose an option** |
| 6 | Disturbances are limited to a minimum and are restricted by regulations | **Choose an option** |
| | **SPACE FOR ADDING NEW CRITERIA** | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Recognize and implement Aboriginal rights | **Choose an option** |
| ii. | Identify and map areas of importance to Aboriginal People (such as hunting and trap- ping, sacred areas, medicinal plant areas, and others). | **Choose an option** |
| iii. | Protect areas of importance to Aboriginal people | **Choose an option** |
| iv. | Ensure that Aboriginal people have access to areas of importance to them | **Choose an option** |
| v. | Manage forests to ensure that forest products are available for Aboriginal people | **Choose an option** |
| vi. | Recognise species with some degree of importance for Aboriginal people | **Choose an option** |
| vii. | Existence and implementation of measures for the conservation of relevant man made ecosystems | **Choose an option** |
| viii. | Existence and implementation of noise reducing measures | **Choose an option** |
| ix. | Existence of silent zones inside the forests | **Choose an option** |
| x. | Area or percentage of the forest estate reserved for recreation and tourism | **Choose an option** |
| xi. | Number and/or area of sites managed for the protection of cultural, archeological, social and spiritual values | **Choose an option** |
| xii. | Measures to avoid damage by recreation and tourism | **Choose an option** |
| xiii. | Monitoring signs of cultural disintegration | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

| | | |
|---|---|---|
| | **Principle** | |
| I | Biodiversity aspects shall be economically viable and improve conditions of local communities and economies | **Choose an option** |
| | **Criteria** | |
| 1 | Economic benefits | **Choose an option** |
| 2 | Distribution of benefits | **Choose an option** |
| 3 | Sustainability of benefits | **Choose an option** |
| | **SPACE FOR ADDING NEW CRITERIA** | |

| | | |
|---|---|---|
| | **Indicators** | |
| i. | Existence of the right to employment for local and/or indigenous population | **Choose an option** |
| ii. | Percentage of GDP generated in the forestry sector | **Choose an option** |
| iii. | Identification of non-wood forest products and their potential uses | **Choose an option** |
| iv. | Percentage of total population employed | **Choose an option** |
| v. | Percentage of females in total number of employment | **Choose an option** |
| | **SPACE FOR ADDING NEW INDICATORS** | |

## Annex 2. List of experts

Leland Werden. Crowther Lab. ETH Zurich.
Nicolas Urbina. Pontificia Universidad Javeriana. Bogota, Colombia.
Pablo Alejandro Lopez. Universidad de Caldas. Manizales, Colombia.
Wesley Martin Snell. Etifor. Padua, Italy.

*Three of the respondents asked to remain anonymous.

## Annex 3. List of standards

| Name of the standard | Scope |
|---|---|
| African Timber Organization (ATO) | African countries |
| Argentine Forest Certification System | Argentina |
| Brazilian Forest Certification Programme | Brazil |
| Cameroon, GTZ | Cameroon |
| Canadian Standards Association (CSA) | Canada |
| CERFLOR | Brazil |
| Certforchile | Chile |
| Costa Rica - CNFC | Costa Rica |
| ForestCare | Canada |
| FSC | Global |
| FSC Australia | Australia |
| FSC Belgium | Belgium |
| FSC Belize | Belize |
| FSC Bolivia | Bolivia |
| FSC Bosnia and Herzegovina | Bosnia and Herzegovina |
| FSC Brazil | Brazil |
| FSC Bulgaria | Bulgaria |
| FSC Cambodia | Cambodia |
| FSC Cameroon | Cameroon |
| FSC Canada | Canada |
| FSC Chile | Chile |
| FSC China | China |
| FSC Colombia | Colombia |
| FSC Congo | Congo |
| FSC Congo Basin Region | Congo Basin |
| FSC Croatia | Croatia |
| FSC Cuba | Cuba |
| FSC Czech Republic | Czech Republic |
| FSC Dambach | Dambach |
| FSC Denmark | Denmark |
| FSC Ecuador | Ecuador |
| FSC Estonia | Estonia |
| FSC eSwatini | eSwatini |

| Name of the standard | Scope |
|---|---|
| FSC Finland | Finland |
| FSC France | France |
| FSC Gabon | Gabon |
| FSC Germany | Germany |
| FSC Ghana | Ghana |
| FSC Guyana | Guyana |
| FSC Honduras | Honduras |
| FSC Indonesia | Indonesia |
| FSC Ireland | Ireland |
| FSC Italy | Italy |
| FSC Japan | Japan |
| FSC Kenya | Kenya |
| FSC Kosovo | Kosovo |
| FSC Kyrgyz | Kyrgyz Republic |
| FSC Laos | Laos republic |
| FSC Lithuania | Lithuania |
| FSC Luxembourg | Luxembourg |
| FSC Madagascar | Madagascar |
| FSC Malasya | Malasya |
| FSC Mexico | Mexico |
| FSC Namibia | Namibia |
| FSC Nepal | Nepal |
| FSC Netherlands | Netherlands |
| FSC New Caledonia | New Caledonia |
| FSC New Zealand | New Zealand |
| FSC Nicaragua | Nicaragua |
| FSC Papua New Guinea | Papua New Guinea |
| FSC Peru | Peru |
| FSC Philippines | Philippines |
| FSC Poland | Poland |
| FSC Portugal | Portugal |
| FSC Romania | Romania |
| FSC Russia | Russia |
| FSC Rwanda | Rwanda |
| FSC South Africa | South Africa |
| FSC Spain | Spain |
| FSC Sri Lanka | Sri Lanka |
| FSC Suriname | Suriname |
| FSC Sweden | Sweden |
| FSC Switzerland | Switzerland |
| FSC Tanzania | Tanzania |
| FSC Uganda | Uganda |

| Name of the standard | Scope |
|---|---|
| FSC UK | UK |
| FSC Ukraine | Ukraine |
| FSC Uruguay | Uruguay |
| FSC USA | USA |
| FSC Vietnam | Vietnam |
| GreenTag Forestry | USA |
| Guyana Forestry Commission | Guyana |
| International Organization for Standardization (ISO) | Global |
| Lembaga Ekolabel Indonesia (LEI) | Indonesia |
| Malasyan C&I | Malasya |
| Naturland | Germany |
| New Zealand Forest Certification Association | New Zealand |
| PEFC Austria | Austria |
| Republican Association of Forest Certification System | Belarus |
| PEFC Belgium | Belgium |
| Association of Private Forest Owners "Nasa Suma" | Bosnia and Herzegovina |
| Council for Sustainable Forest Management and Certification in Bulgaria | Bulgaria |
| PAFC Cameroon | Cameroon |
| PEFC Canada | Canada |
| PEFC Chile | Chile |
| China Forest Certification Council | China |
| PAFC Congo | Congo |
| PEFC Czech Republic | Czech Republic |
| PEFC Denmark | Denmark |
| Estonian Forest Certification Council | Estonia |
| PEFC Finland | Finland |
| Finnish Forest Certification System | Finland |
| PEFC France | France |
| PEFC France | France |
| PAFC Gabon | Gabon |
| PEFC Germany | Germany |
| Working Group on Forest Certification | Ghana |
| Hungarian Forest Certification Non-profit | Hungary |
| Network for Certification and Conservation of Forests | India |
| Indonesian Forestry Certification Cooperation | Indonesia |
| PEFC International Standard | Global |
| PEFC Ireland | Ireland |
| PEFC Italy | Italy |
| SGEC/PEFC Japan | Japan |
| Korean Forest Certification Council | Korea |
| PEFC Latvia | Latvia |
| PEFC Latvia | Latvia |

| Name of the standard | Scope |
|---|---|
| PEFC Lithuania | Lithuania |
| PEFC Luxembourg | Luxembourg |
| Malasyan Timber Certification Council | Malasya |
| Myanmar Forest Certification Committee | Myanmar |
| PEFC Netherlands | Netherlands |
| The Council for Sustainable Forest Management int he Republic of Macedonia | North Macedonia |
| PEFC Norway | Norway |
| PEFC Poland | Poland |
| PEFC Portugal | Portugal |
| PEFC Romania | Romania |
| PEFC Russia | Russia |
| PEFC Slovakia | Slovakia |
| Institute for Forest Certification | Slovenia |
| South African Forestry Assurance Scheme | South Africa |
| PEFC Spain | Spain |
| PEFC Sweden | Sweden |
| PEFC Switzerland | Switzerland |
| The Federation of Thai Industries | Thailand |
| Association for Sustainable Forest Management, Forest Products and Services Certification | Turkey |
| PEFC UK | UK |
| Association National Voluntary Forest Certification System | Ukraine |
| PEFC Uruguay | Uruguay |
| Vietnamese Academy of Forest Science | Vietnam |
| Responsible Wood | Australia |
| Scientific Certification System - FSC Standard | Global |
| SCS - Natural Forest Management | Global |
| SCS Generic Standard | Global |
| Silva Forest Foundation | Canada |
| Solomon Islands - pacific ecotimber | Solomon Islands |
| Sustainable Forestry Initiative (SFI) | Global |
| Tree Farm System | USA |
| Naturland Standards for Organic Forest Management | Global |
| International Tropical Timber Organization | Global |
| SCS Generic Interim Standard for Forest Management Certification under the FSC | Global |
| SCS Interim Standard for Argentina | Argentina |
| SCS Interim Standard for Costa Rica | Costa Rica |
| SCS Interim Standard for Estonia | Estonia |
| SCS Interim Standard for Fiji | Fiji |
| SCS Interim Standard for Hawaii | Hawaii |
| SCS Interim Standard for India | India |

| Name of the standard | Scope |
|---|---|
| SCS Interim Standard for Latvia | Latvia |
| SCS Interim Standard for Panama | Panama |
| SCS Interim Standard for Paraguay | Paraguay |

## Annex 4. Reference standard resulting from the Delphi survey

| | Principle |
|---|---|
| **1** | Endangered species are identified, monitored, and protected. |
| | **Criteria** |
| **1,1** | Endangered species within the production area protected |
| **1,2** | Endangered species around the production area considered |
| **1,3** | Endemic and rare species at risk within the production area are protected |
| **1,4** | Endangered, threatened, or vulnerable species within relevant proximal zone are identified and monitored |
| | **Indicators** |
| **1a** | Existence of procedures for the determination of terrestrial biological diversity in several aspects (taxonomic, functional, and genetic) and its changes inside the production area |
| **1b** | Percentage of land surface with protected status |
| **1c** | Total number of red list species per surface area |
| **1d** | Number of threatened species per surface area |
| **1e** | Number of functional role of species per surface area, it should emphasize in specialist species and low population rate species |
| **1f** | Number and list of species per surface area |
| **1g** | Existence of procedures for monitoring damage to species caused by unsustainable harvesting practices and illegal extraction of individuals (e.g. harvest rates, heavy machinery, skid trails, forest roads, light and noise pollution, soil compaction and erosion, over selection of particular species or structures) |
| **1h** | Protective measures in place for the controlling and/or prevention of forest damage caused by unsustainable harvesting practices and illegal extraction of individuals (e.g. harvest rates, heavy machinery, skid trails, forest roads, light and noise pollution, soil compaction and erosion, over selection of particular species or structures) |
| **1i** | Existence and implementation of measures for the protection of endangered, sensitive species (core forest species, habitat specialist species), endemic species |
| **1j** | Preservation measures of remnant natural forest core habitat and ecological restoration of edges to buffer edge effects |
| | **Principle** |
| **2** | Ecosystems and habitat destruction, fragmentation and other forms degradation are avoided, mitigated, and compensated |
| | **Criteria** |
| **2,1** | Ecosystems and habitat loss and fragmentation is avoided, minimized, or mitigated |
| **2,2** | High Conservation Value areas identified and protected |
| **2,3** | Rehabilitation and restoration actions are implemented where destruction or fragmentation have occurred |
| **2,4** | Potential leakage effects of restoration assessed |

| | Indicators |
|---|---|
| **2a** | Existence and implementation of measures for the protection of specific ecosystems and habitat with high biodiversity value |
| **2b** | Existence of procedures for monitoring of damage to forest resources caused by encroachment (illegal settlements, illegal agricultural expansion), resource extraction and use |
| **2c** | Protective measures in place for the controlling and/or prevention of forest damage caused by encroachment (illegal settlements, illegal agricultural expansion), resource extraction and use |
| **2d** | Existence and implementation of measures for the conservation or improvement of ecosystems and habitat diversity |
| **2e** | Existence and implementation of measures for the conservation or restoration of natural ecosystem complexity |
| **2f** | Existence of data about occurring ecosystem types within the production area |
| **2g** | Harvesting limited to periods and areas with little impact on fauna, flora, and soil |
| **2h** | Degree of structural fragmentation or connectivity (corridor function) measured between habitat fragments |
| **2i** | Existence and implementing programs for maintenance, conservation or preservation of keystone species and functional groups |
| **2j** | Existence and implementation of programs for maintaing key structural diversity at both landscape and stand levels |
| | **Principle** |
| **3** | Habitat degradation, modification and pollution are assessed, avoided, mitigated, and compensated |
| | **Criteria** |
| **3,1** | Pesticide use restricted to irreplaceable management activities that require it |
| **3,2** | Guidance for pesticide application provided |
| **3,3** | Guidance for fertilisation provided to avoid nutrient leaching |
| **3,4** | Buffer zones required if adjacent to sensitive areas like core forest areas, water bodies, etc. |
| **3,5** | Water resources like springs, water bodies or wetland, are protected |
| **3,6** | Soil erosion prevented and mitigated |
| **3,7** | Soil quality maintained through actions like avoiding soil compactation, maintaining canopy cover, ground vegetation, the layer of soil organic matter, etc. |
| **3,8** | Waste management required |
| **3,9** | Management activities are designed in alignment with natural disturbance regimes with justification |
| **3,10** | Maintenance of decomposition and nutrient cycling |
| | **Indicators** |
| **3a** | Existence and implementation of measures for the conservation of existing genetic diversity |
| **3b** | Existence and implementation of measures for the minimisation of negative impacts of forest management on biological diversity in several aspects (taxonomic, functional, and genetic) |
| **3c** | Existence of procedures for monitoring of damage to forest resources caused by infringements (illegal waste disposal) |
| **3d** | Protective measures for the controlling and/or prevention of forest damage caused by infringements (illegal waste disposal) |
| **3e** | Existence and implementation of measures for the conservation of the litter layer |

| | |
|---|---|
| **3f** | Existence and implementation of measures that guarantee the presence of sufficient amounts of dead wood, standing as well as lying on the forest floor according to the structural and functional characteristics of the forest |
| **3g** | Preference for mechanical techniques for the removal of non-indigenous harmful species |
| **3h** | Existence and implementation of regulations for the use of biocides and pesticides |
| **3i** | Amounts and/or types of used biocides and pesticides |
| **3j** | Existence and implementation of regulations for the use of fertilisers |
| **3k** | Amounts and/or types of used fertilisers |
| **3l** | Degree of use of environmentally friendly control agents |
| **3m** | Existence of measures to maintain soil fertility and site productivity |
| | **Principle** |
| **4** | Overexploitation of forest resources is avoided and mitigated |
| | **Criteria** |
| **4,1** | Approach for long-term sustainability in functional and structural ecosystem processes and socio-economic aspects. |
| **4,2** | Sustainable harvest rates and measures identified and applied according to the status of the extracted species |
| | **Indicators** |
| **4a** | Existence of procedures for monitoring of damage to forest resources caused by harvesting practices and illegal extraction of individuals |
| **4b** | Protective measures for the controlling and/or prevention of forest damage caused by harvesting practices and illegal extraction of individuals |
| **4c** | Monitoring mechanisms for changes in growing stock by species and age class |
| **4d** | Harvested volume by species |
| **4e** | Existence and adoption of product-specific sustainable harvest levels |
| **4f** | Incentives for the use of lesser-known woody forest species |
| **4g** | Measures for rehabilitation or restoration and for targeted and controlled reintroductions of extracted individuals are present |
| **4h** | Forest is managed using close-to-nature principles that prioritizes maintaining site conditions to allow natural regeneration over artificial planting |
| | **Principle** |
| **5** | Invasive species and GMOs are restricted, regulated, managed and if necessary, avoided |
| | **Criteria** |
| **5,1** | Native species preferred over exotic |
| **5,2** | Measures taken to prevent introduction of invasive species |
| **5,3** | Generation of early warnings (spatially explicit) to identify sites vulnerable to invasion and constant monitoring for the presence of invasive species at that site. |
| | **Indicators** |
| **5a** | Existence of procedures for monitoring of damage to forest resources caused by invasive alien species |
| **5b** | Protective measures for the controlling and prevention of forest damage caused by invasive alien species |
| **5c** | Existence and implementation of measures which protect, support or strengthen indigenous biodiversity |
| **5d** | Existence of regulations and limitations for the use of exotic tree species in regeneration activities |

| | |
|---|---|
| **5e** | Monitoring of the use of exotic tree species and their impacts on the environment such as use, geographic distribution, competition with native species, functional degradation and ecosystem services |
| **5f** | The use of biological control agents is strictly regulated |
| **5g** | Existence of regulations which prevent introduction and spreading of non-indigenous species |
| **5h** | Existence of procedures for monitoring the presence of invasive alien species |
| **5i** | Total number of invasive species per area in the production area |
| | **Principle** |
| **6** | Climate change adaptation, resistance, resilience, and mitigation measures are taken around biodiversity potential threats and synergies with other change drivers |
| | **Criteria** |
| **6,1** | Measures to reduce the release of GHG |
| **6,2** | Fossil energy and GHG avoided to the extent that there are suitable available alternatives |
| **6,3** | Carbon stock maintained or enhanced |
| **6,4** | Resilience, response of forest resources assessed and, mitigation measures are addressed |
| | **Indicators** |
| **6a** | Existence of procedures for monitoring of damage to forest resources caused by climate extreme events |
| **6b** | Protective measures for the controlling and/or prevention of forest damage caused by climate extreme events |
| **6c** | Climate-smart forest management practices are adopted, e.g.: preference for long rotations |
| **6d** | Protected and/or trees above a certain diameter for each species are identified and are not felled during harvesting |
| **6e** | Existence of procedures for reducing greenhouse gas emissions from operational activities in forest management |
| **6f** | Selection of durable and adapted native species resistant to drought, flooding, heat, etc according to various climate change scenarios (e.g. high water use efficiency, toleration of anaerobic conditions, etc) |
| | **Principle** |
| **7** | Research, awareness, education and capacity building around biodiversity aspects is promoted and budgeted |
| | **Criteria** |
| **7,1** | Research supported to all stakeholders |
| **7,2** | Awareness spread and social appropriation of biodiversity to all stakeholder |
| **7,3** | Education and capacity building to all stakeholders provided |
| **7,4** | Stakeholders involvement in planning process is adopted |
| **7,5** | Strategies to help improving local livelihoods are adopted |
| **7,6** | Long-term monitoring strategy with SMART indicators is planned, properly budgeted, and implemented at appropriate time scales for meaningful results |
| | **Indicators** |
| **7a** | Existing education, training, and capacity-building programs on biodiversity management |
| **7b** | Encourage the use, if sustainable, of non-wood forest species. |
| **7c** | Research activities supported related to pressures caused by humans actions (land use change, overexploitation, etc) on biodiversity |
| **7d** | Research for possible consequences of unwanted introduction or spreading of |

| | |
|---|---|
| | invasive alien species |
| **7e** | Availability and update of maps of the protected forest area |
| **7f** | Amounts of investments in research, development and education in the topics prioritised before. |
| | **Principle** |
| **8** | Social and cultural dimensions of biodiversity are valued, respected, protected, maintained and enhanced |
| | **Criteria** |
| **8,1** | Clear established indigenous and local communities rights in the production area where relevant |
| **8,2** | Forest management plan engage indigenous communities traditional land use and forest-based ecological knowledge, where relevant |
| **8,3** | Forest community level of well-being and resilience derived from forest resources are valued, maintained and enhanced |
| **8,4** | Forest management consider, values and protect cultural, recreational, spiritual and archaeological values |
| **8,5** | Clear and unambiguous land tenure, access, and use rights including customary rights |
| **8,6** | Disturbances are limited to a minimum and are restricted by regulations |
| | **Indicators** |
| **8a** | Recognize and implement indigenous and local communities rights where relevant |
| **8b** | Areas of importance to indigenous and local communities are mapped (such as hunting and trap- ping, sacred areas, medicinal plant areas, and others). |
| **8c** | Areas of importance to indigenous and local communities are safeguarded |
| **8d** | Indigenous and local communities have secure access rights to areas for which they hold customary access rights |
| **8e** | Forest management engages indigenous and local communities in decisions about use of forest resources from the areas but ensuring sustainability of natural capital stocks |
| **8f** | Recognition and valuation of species with some degree of importance for indigenous and local communities |
| **8g** | Existence and implementation of measures for the conservation of relevant human made ecosystems |
| **8h** | Percentage of the whole forest reserved for recreation and tourism in consultation with indigenous communities |
| **8i** | Number and/or area from the whole forests managed for the protection of cultural, archaeological, social and spiritual values in consultation with indigenous communities |
| **8j** | Measures to avoid damage by recreation and tourism are in place |
| **8k** | Monitoring system in place to check for signs of cultural degradation |
| | **Principle** |
| **9** | Use of biodiversity shall be economically sustainable, improve conditions of local communities and economies and equitably distributed among local stakeholders |
| | **Criteria** |
| **9,1** | Economic benefits derived from the use of biodiversity are produced locally and the reporting should be timely, transparent, and easily accessible |
| **9,2** | Distribution of benefits derived from the use of biodiversity are equitably distributed across gender, and social groups within local communities |

| | |
|---|---|
| **9,3** | Benefits derived from use of the biodiversity shall not produce any long-term impact on the resource base to guarantee sustainability |
| | **Indicators** |
| **9a** | The forest management must recruit a minimum percentage from local and/or indigenous population |
| **9b** | Identification of non-wood forest products and their potential uses |
| **9c** | Gender and other demographics balance in employment rate, in forest-related activities and in management/decision-making positions. |
| **9d** | The wages are fair in comparison to local context average |
| **9e** | Benefits in place for female employees |

**Annex 5. Summary of the frequency statistics of the compliance of the principles from all the forest standards against the principles of the reference standard.**

| Principle / Statistics | Mode | Mode frequency | Categories | Frequency per category | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| Endangered species are identified, monitored, and protected. | Yes | 10 | Partially | 3 | 23 |
| | | | Yes | 10 | 77 |
| Ecosystems and habitat destruction, fragmentation and other forms degradation are avoided, mitigated and compensated | Yes | 10 | Partially | 3 | 23 |
| | | | Yes | 10 | 77 |
| Habitat degradation, modification and pollution are assessed, avoided, mitigated and compensated | Yes | 8 | Partially | 5 | 38 |
| | | | Yes | 8 | 62 |
| Overexploitation of forest resources is avoided and mitigated | Yes | 10 | Partially | 3 | 23 |
| | | | Yes | 10 | 77 |
| Invasive species and GMOs are restricted, regulated, managed and if necessary, avoided | Yes | 9 | No | 2 | 15 |
| | | | Partially | 2 | 15 |
| | | | Yes | 9 | 69 |
| Climate change adaptation, resistance, resilience and mitigation measures are taken around biodiversity potential threats and synergies with other change drivers | Yes | 7 | No | 4 | 31 |
| | | | Partially | 2 | 15 |
| | | | Yes | 7 | 54 |
| Research, awareness, education and capacity building around biodiversity aspects is promoted and budgeted | Partially | 7 | No | 3 | 23 |
| | | | Partially | 7 | 54 |
| | | | Yes | 3 | 23 |
| Social and cultural dimensions of biodiversity are valued, respected, protected, maintained and enhanced | Yes | 12 | Partially | 1 | 8 |
| | | | Yes | 12 | 92 |
| Use of biodiversity shall be economically sustainable, improve conditions of local communities and economies and equitably distributed among local stakeholders | Yes | 11 | No | 1 | 8 |
| | | | Partially | 1 | 8 |
| | | | Yes | 11 | 85 |

**Annex 6. Summary of the frequency statistics for principle one and its criteria and indicators.**

| | Principle/Statistics | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 1 | Endangered species are identified, monitored, and protected. | Yes | 10 | Partially<br>Yes | 23<br>77 |
| | Criteria | | | | |
| 1,1 | Endangered species within the production area protected | Yes | 13 | Yes | 100 |
| 1,2 | Endangered species around the production area considered | No | 9 | No<br>Yes | 69<br>31 |
| 1,3 | Endemic and rare species at risk within the production area are protected | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 1,4 | Endangered, threatened, or vulnerable species within relevant proximal zone are identified and monitored | No | 9 | No<br>Partially<br>Yes | 69<br>15<br>15 |
| | Indicators | | | | |
| 1a | Existence of procedures for the determination of terrestrial biological diversity in several aspects (taxonomic, functional and genetic) and its changes inside the production area | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 1b | Percentage of land surface with protected status | Yes | 9 | No<br>Partially<br>Yes | 8<br>23<br>69 |
| 1c | Total number of red list species per surface area | Yes | 7 | No<br>Partially<br>Yes | 38<br>8<br>54 |
| 1d | Number of threatened species per surface area | Yes | 7 | No<br>Partially<br>Yes | 38<br>8<br>54 |
| 1e | Number of functional role of species per surface area, it should emphasize in specialist species and low population rate species | No | 9 | No<br>Partially<br>Yes | 69<br>23<br>8 |
| 1f | Number and list of species per surface area | No | 11 | No<br>Partially | 85<br>15 |
| 1g | Existence of procedures for monitoring of damage to species caused by unsustainable harvesting practices and illegal extraction of individuals (e.g. harvest rates, heavy machinery, skid trails, forest roads, light and noise pollution, soil compaction and erosion, over selection of particular species or | Yes | 9 | No<br>Partially<br>Yes | 8<br>23<br>69 |

| | | | | | |
|---|---|---|---|---|---|
| | structures) | | | | |
| 1h | Protective measures in place for the controlling and/or prevention of forest damage caused by unsustainable harvesting practices and illegal extraction of individuals (e.g. harvest rates, heavy machinery, skid trails, forest roads, light and noise pollution, soil compaction and erosion, over selection of particular species or structures) | Yes | 10 | No<br>Partially<br>Yes | 8<br>15<br>77 |
| 1i | Existence and implementation of measures for the protection of endangered, sensitive species (core forest species, habitat specialist species), endemic species | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 1j | Preservation measures of remnant natural forest core habitat and ecological restoration of edges to buffer edge effects | Yes | 8 | No<br>Partially<br>Yes | 23<br>15<br>62 |

## Annex 7. Summary of the frequency statistics for principle two and its criteria and indicators.

| Principle | | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 2 | Ecosystems and habitat destruction, fragmentation and other forms degradation are avoided, mitigated and compensated | Yes | 10 | Partially<br>Yes | 23<br>77 |
| **Criteria** | | | | | |
| 2,1 | Ecosystems and habitat loss and fragmentation is avoided, minimized, or mitigated | Yes | 9 | No<br>Partially<br>Yes | 15<br>16<br>69 |
| 2,2 | High Conservation Value areas identified and protected | Yes | 12 | No<br>Yes | 8<br>92 |
| 2,3 | Rehabilitation and restoration actions are implemented where destruction or fragmentation have ocurred | Yes | 10 | Partially<br>Yes | 23<br>77 |
| 2,4 | Potential leakage effects of restoration assessed | No | 13 | No | 100 |
| **Indicators** | | | | | |
| 2a | Existence and implementation of measures | Yes | 12 | Partially | 8 |

| | | | | | |
|---|---|---|---|---|---|
| | for the protection of specific ecosystems and habitat with high biodiversity value | | | Yes | 92 |
| 2b | Existence of procedures for monitoring of damage to forest resources caused by encroachment (illegal sttlements, illegal agricultural expansion), resource extraction and use | Yes | 7 | No<br>Partially<br>Yes | 31<br>15<br>54 |
| 2c | Protective measures in place for the controlling and/or prevention of forest damage caused by encroachment (illegal sttlements, illegal agricultural expansion), resource extraction and use | Yes | 7 | No<br>Partially<br>Yes | 31<br>15<br>54 |
| 2d | Existence and implementation of measures for the conservation or improvement of ecosystems and habitat diversity | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 2e | Existence and implementation of measures for the conservation or restoration of natural ecosystem complexity | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 2f | Existence of data about occurring ecosystem types within the production area | Yes | 7 | No<br>Partially<br>Yes | 23<br>23<br>54 |
| 2g | Harvesting limited to periods and areas with little impact on fauna, flora and soil | Yes | 9 | No<br>Partially<br>Yes | 8<br>23<br>69 |
| 2h | Degree of structural fragmentation or connectivity (corridor function) measured between habitat fragments | Yes | 8 | No<br>Partially<br>Yes | 23<br>15<br>62 |
| 2i | Existence and implementing programs for maintenance, conservation or preservation of keystone species and functional groups | Yes | 7 | No<br>Partially<br>Yes | 31<br>15<br>54 |
| 2j | Existence and implementation of programs for maintaing key structural diversity at both landscape and stand levels | Yes | 10 | No<br>Partially<br>Yes | 15<br>8<br>77 |

## Annex 8. Summary of the frequency statistics for principle three and its criteria and indicators.

| Principles | | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 3 | Habitat degradation, modification and | Yes | 8 | Partially | 38 |

| | | | | | |
|---|---|---|---|---|---|
| | pollution are assessed, avoided, mitigated and compensated | | | Yes | 62 |
| **Criteria** | | | | | |
| 3,1 | Pesticide use restricted to irrepleaceable management activities that require it | Yes | 11 | No<br>Yes | 15<br>85 |
| 3,2 | Guidance for pesticide application provided | No | 7 | No<br>Yes | 54<br>46 |
| 3,3 | Guidance for fertilisation provided to avoid nutrient leaching | Yes | 6 | No<br>Partially<br>Yes | 46<br>8<br>46 |
| 3,4 | Buffer zones required if adjacent to sensitive areas like core forest areas, water bodies, etc. | Yes | 7 | No<br>Partially<br>Yes | 23<br>23<br>54 |
| 3,5 | Water resources like springs, water bodies or wetland, are protected | Yes | 10 | Partially<br>Yes | 23<br>77 |
| 3,6 | Soil erosion prevented and mitigated | Yes | 13 | Yes | 100 |
| 3,7 | Soil quality maintained through actions like avoiding soil compactation, maintaining canopy cover, ground vegetation, the layer of soil organic matter, etc. | Yes | 7 | Partially<br>Yes | 46<br>54 |
| 3,8 | Waste management required | Yes | 8 | No<br>Partially<br>Yes | 23<br>15<br>62 |
| 3,9 | Management activities are designed in alignment with natural disturbance regimes with justification | Yes | 7 | No<br>Yes | 46<br>54 |
| 3,1 | Maintenance of decomposition and nutrient cycling | Partially | 5 | No<br>Partially<br>Yes | 38<br>46<br>15 |
| **Indicators** | | | | | |
| 3a | Existence and implementation of measures for the conservation of existing genetic diversity | Yes | 10 | No<br>Partially<br>Yes | 15<br>8<br>77 |
| 3b | Existence and implementation of measures for the minimisation of negative impacts of forest management on biological diversity in several aspects (taxonomic, functional and genetic) | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 3c | Existence of procedures for monitoring of damage to forest resources caused by infrigements (illegal waste disposal) | No | 7 | No<br>Partially<br>Yes | 54<br>15<br>31 |
| 3d | Protective measures for the controlling and/or prevention of forest damage caused by infrigements (illegal waste disposal) | Yes | 6 | No<br>Partially<br>Yes | 31<br>23<br>46 |

| | | | | | |
|---|---|---|---|---|---|
| 3e | Existence and implementation of measures for the conservation of the litter layer | Yes | 5 | No<br>Partially<br>Yes | 31<br>31<br>38 |
| 3f | Existence and implementation of measures that guarantee the presence of sufficient amounts of dead wood, standing as well as lying on the forest floor according to the structural and functional characteristics of the forest | Yes | 10 | No<br>Yes | 23<br>77 |
| 3g | Preference for mechanical techniques for the removal of non-indigenous harmful species | No | 13 | No | 100 |
| 3h | Existence and implementation of regulations for the use of biocides and pesticides | Yes | 12 | No<br>Yes | 8<br>92 |
| 3i | Amounts and/or types of used biocides and pesticides | Yes | 7 | No<br>Partially<br>Yes | 38<br>8<br>54 |
| 3j | Existence and implementation of regulations for the use of fertilisers | Yes | 6 | No<br>Partially<br>Yes | 38<br>15<br>46 |
| 3k | Amounts and/or types of used fertilisers | No | 7 | No<br>Partially<br>Yes | 54<br>8<br>38 |
| 3l | Degree of use of environmentally friendly control agents | No | 7 | No<br>Yes | 54<br>46 |
| 3m | Existence of measures to maintain soil fertility and site productivity | Yes | 12 | Partially<br>Yes | 8<br>92 |

## Annex 9. Summary of the frequency statistics for principle four and its criteria and indicators.

| Principles | | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 4 | Overexploitation of forest resources is avoided and mitigated | Yes | 10 | Partially<br>Yes | 23<br>77 |
| **Criteria** | | | | | |
| 4,1 | Approach for long-term sustainability in functional and structural ecosystem processess and socio-economic aspects. | Yes | 13 | Yes | 100 |
| 4,2 | Sustainable harvest rates and measures identified and applied according to the status of the extracted species | Yes | 11 | No<br>Yes | 15<br>85 |
| **Indicators** | | | | | |
| 4a | Existence of procedures for monitoring of | Yes | 11 | No | 15 |

| | | | | | |
|---|---|---|---|---|---|
| | damage to forest resources caused by harvesting practices and illegal extraction of individuals | | | Yes | 85 |
| 4b | Protective measures for the controlling and/or prevention of forest damage caused by harvesting practices and illegal extraction of individuals | Yes | 12 | No<br>Yes | 8<br>92 |
| 4c | Monitoring mechanisms for changes in growing stock by species and age class | Yes | 10 | No<br>Yes | 23<br>77 |
| 4d | Harvested volume by species | Yes | 12 | No<br>Yes | 8<br>92 |
| 4e | Existence and adoption of product-specific sustainable harvest levels | Yes | 10 | No<br>Partially<br>Yes | 15<br>8<br>77 |
| 4f | Incentives for the use of lesser known woody forest species | No | 10 | No<br>Yes | 77<br>23 |
| 4g | Measures for rehabilitation or restoration and for targeted and controlled reintroductions of extracted individuals are present | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 4h | Forest is managed using close-to-nature principles that prioritizes maintaining site conditions to allow natural regeneration over artificial planting | Yes | 10 | No<br>Partially<br>Yes | 8<br>15<br>77 |

## Annex 10. Summary of the frequency statistics for principle five and its criteria and indicators.

| Principles | | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 5 | Invasive species and GMOs are restricted, regulated, managed and if necessary, avoided | Yes | 9 | No<br>Partially<br>Yes | 15<br>15<br>69 |
| **Criteria** | | | | | |
| 5,1 | Native species preferred over exotic | Yes | 9 | No<br>Partially<br>Yes | 8<br>23<br>69 |
| 5,2 | Measures taken to prevent introduction of invasive species | Yes | 6 | No<br>Partially<br>Yes | 38<br>15<br>46 |
| 5,3 | Generation of early warnings (spatially explicit) to identify sites vulnerable to | No | 11 | No<br>Partially | 85<br>8 |

| | | | | | |
|---|---|---|---|---|---|
| | invasion and constant monitoring for the presence of invasive species at that site. | | | Yes | 8 |
| **Indicators** | | | | | |
| 5a | Existence of procedures for monitoring of damage to forest resources caused by invasive alien species | Yes | 8 | No<br>Yes | 38<br>62 |
| 5b | Protective measures for the controlling and prevention of forest damage caused by invasive alien species | Yes | 9 | No<br>Yes | 31<br>69 |
| 5c | Existence and implementation of measures which protect, support or strengthen indigenous biodiversity | Yes | 11 | No<br>Yes | 15<br>85 |
| 5d | Existence of regulations and limitations for the use of exotic tree species in regeneration activities | Yes | 10 | No<br>Partially<br>Yes | 8<br>16<br>77 |
| 5e | Monitoring of the use of exotic tree species and their impacts on the environment such as use, geographic distribution, competition with native species, functional degradation and ecosystem services | Yes | 7 | No<br>Yes | 46<br>54 |
| 5f | The use of biological control agents is strictly regulated | Yes | 9 | No<br>Yes | 31<br>69 |
| 5g | Existence of regulations which prevent introduction and spreading of non-indigenous species | Yes | 8 | No<br>Yes | 38<br>62 |
| 5h | Existence of procedures for monitoring the presence of invasive alien species | No | 9 | No<br>Yes | 69<br>31 |
| 5i | Total number of invasive species per area in the production area | No | 13 | No | 100 |

## Annex 11. Summary of the frequency statistics for principle six and its criteria and indicators.

| | Principle | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 6 | Climate change adaptation, resistance, resilience and mitigation measures are taken around biodiversity potential threats and synergies with other change drivers | Yes | 7 | No<br>Partially<br>Yes | 31<br>15<br>54 |
| **Criteria** | | | | | |
| 6,1 | Measures to reduce the release of GHG | No | 10 | No<br>Yes | 77<br>23 |
| 6,2 | Fossil energy and GHG avoided to the extent that there are suitable available alternatives | No | 10 | No<br>Yes | 77<br>23 |
| 6,3 | Carbon stock maintained or enhanced | Yes | 9 | No<br>Partially | 15<br>15 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Yes | 69 |
| 6,4 | Resilience, response of forest resources assessed and, mitigation measures are addressed | Yes | 7 | No<br>Partially<br>Yes | 23<br>23<br>54 |
| **Indicators** | | | | | |
| 6a | Existence of procedures for monitoring of damage to forest resources caused by climate extreme events | No | 5 | No<br>Partially<br>Yes | 38<br>23<br>38 |
| 6b | Protective measures for the controlling and/or prevention of forest damage caused by climate extreme events | Yes | 6 | No<br>Partially<br>Yes | 15<br>39<br>46 |
| 6c | Climate-smart forest management practices are adopted, e.g.: preference for long rotations | Yes | 7 | No<br>Partially<br>Yes | 23<br>23<br>54 |
| 6d | Protected and/or trees above a certain diameter for each species are identified and are not felled during harvesting | Yes | 9 | No<br>Partially<br>Yes | 23<br>8<br>69 |
| 6e | Existence of procedures for reducing greenhouse gas emissions from operational activities in forest management | No | 10 | No<br>Yes | 77<br>23 |
| 6f | Selection of durable and adapted native species resistant to drought, flooding, heat, etc according to various climate change scenarios (e.g. high water use efficiency, toleration of anerobic conditions, etc) | Yes | 8 | No<br>Partially<br>Yes | 23<br>15<br>62 |

## Annex 12. Summary of the frequency statistics for principle seven and its criteria and indicators.

| | Principle | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 7 | Research, awareness, education and capacity building around biodiversity aspects is promoted and budgeted | Partially | 7 | No<br>Partially<br>Yes | 23<br>54<br>23 |
| **Criteria** | | | | | |
| 7,1 | Research supported to all stakeholders | No | 9 | No<br>Partially<br>Yes | 69<br>23<br>8 |
| 7,2 | Awareness spread and social appropriation of biodiversity to all stakeholder | No | 10 | No<br>Partially<br>Yes | 77<br>16<br>8 |
| 7,3 | Education and capacity building to | Yes | 6 | No | 15 |

| | | | | | |
|---|---|---|---|---|---|
| | all stakeholders provided | | | Partially | 39 |
| | | | | Yes | 46 |
| 7,4 | Stakeholders involvement in planning process is adopted | Yes | 13 | Yes | 100 |
| 7,5 | Strategies to help improving local livelihoods are adopted | Yes | 12 | Partially | 8 |
| | | | | Yes | 92 |
| **Indicators** | | | | | |
| 7a | Existing education, training, and capacity-building programs on biodiversity management | Yes | 5 | No | 31 |
| | | | | Partially | 31 |
| | | | | Yes | 38 |
| 7b | Encourage the use, if sustainable, of non-wood forest species. | Yes | 6 | No | 15 |
| | | | | Partially | 39 |
| | | | | Yes | 46 |
| 7c | Research activities supported related to pressures caused by humans actions (land use change, overexploitation, etc) on biodiversity | No | 10 | No | 77 |
| | | | | Partially | 8 |
| | | | | Yes | 15 |
| 7d | Research for possible consequences of unwanted introduction or spreading of invasive alien species | No | 10 | No | 77 |
| | | | | Yes | 23 |
| 7e | Availability and update of maps of the protected forest area | Yes | 11 | Partially | 15 |
| | | | | Yes | 85 |
| 7f | Amounts of investments in research, development and education in the topics prioritised before. | No | 11 | No | 85 |
| | | | | Partially | 8 |
| | | | | Yes | 8 |

## Annex 13. Summary of the frequency statistics for principle eight and its criteria and indicators.

| Principles | | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 8 | Social and cultural dimensions of biodiversity are valued, respected, protected, maintained and enhanced | Yes | 12 | Partially | 8 |
| | | | | Yes | 92 |
| **Criteria** | | | | | |
| 8,1 | Clear established indigenous and local communities rights in the production area where relevant | Yes | 13 | Yes | 100 |
| 8,2 | Forest management plan engage indigenous communities traditional land use and forest-based ecological knowledge, where relevant | Yes | 13 | Yes | 100 |

| | | | | | |
|---|---|---|---|---|---|
| 8,3 | Forest community level of well-being and resilience derived from forest resources are valued, maintained and enhanced | Yes | 13 | Yes | 100 |
| 8,4 | Forest management consider, values and protect cultural, recreational, spiritual and archeological values | Yes | 13 | Yes | 100 |
| 8,5 | Clear and unambiguous land tenure, access, and use rights including customary rights | Yes | 13 | Yes | 100 |
| 8,6 | Disturbances are limited to a minimum and are restricted by regulations | No | 9 | No<br>Partially<br>Yes | 69<br>15<br>15 |
| **Indicators** | | | | | |
| 8a | Recognize and implement indigenous and local communities rights where relevant | Yes | 13 | Yes | 100 |
| 8b | Areas of importance to indigenous and local communities are mapped (such as hunting and trap- ping, sacred areas, medicinal plant areas, and others). | Yes | 13 | Yes | 100 |
| 8c | Areas of importance to indigenous and local communities are safeguarded | Yes | 13 | Yes | 100 |
| 8d | Indigenous and local communities have secure access rights to areas for which they hold customary access rights | Yes | 13 | Yes | 100 |
| 8e | Forest management engages indigenous and local communities in decisions about use of forest resources from the areas but ensuring sustainability of natural capital stocks | Yes | 11 | Partially<br>Yes | 16<br>85 |
| 8f | Recognition and valuation of species with some degree of importance for indigenous and local communities | Yes | 6 | No<br>Partially<br>Yes | 31<br>23<br>46 |
| 8g | Existence and implementation of measures for the conservation of relevant human made ecosystems | No | 9 | No<br>Partially<br>Yes | 69<br>8<br>23 |
| 8h | Percentage of the whole forest reserved for recreation and tourism in consultation with indigenous communities | No | 8 | No<br>Partially<br>Yes | 62<br>15<br>23 |
| 8i | Number and/or area from the whole forests managed for the protection of cultural, archeological, social and spiritual values in consultation with indigenous communities | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 8j | Measures to avoid damage by recreation and tourism are in place | No | 12 | No<br>Yes | 92<br>8 |
| 8k | Monitoring system in place to check for signs of cultural degradation | No | 12 | No<br>Yes | 92<br>8 |

## Annex 14. Summary of the frequency statistics for principle nine and its criteria and indicators.

| Principles | | Mode | Mode frequency | Categories | Rel. frequency per category (%) |
|---|---|---|---|---|---|
| 9 | Use of biodiversity shall be economically sustainable, improve conditions of local communities and economies and equitably distributed among local stakeholders | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| **Criteria** | | | | | |
| 9,1 | Economic benefits derived from the use of biodiversity are produced locally and the reporting should be timely, transparent, and easily accessible | Yes | 12 | No<br>Yes | 8<br>92 |
| 9,2 | Distribution of benefits derived from the use of biodiversity are equitably distributed across gender, and social groups within local communities | No | 6 | No<br>Partially<br>Yes | 46<br>31<br>23 |
| 9,3 | Benefits derived from use of the biodiversity shall not produce any long-term impact on the resource base to guarantee sustainability | Yes | 13 | Yes | 100 |
| **Indicators** | | | | | |
| 9a | The forest management must recruit a minimum percentage from local and/or indigenous population | Yes | 11 | No<br>Yes | 15<br>85 |
| 9b | Identification of non-wood forest products and their potential uses | Yes | 5 | No<br>Partially<br>Yes | 23<br>38<br>39 |
| 9c | Gender and other demographics balance in employment rate, in forest-related activities and in management/decision-making positions. | Yes | 8 | No<br>Partially<br>Yes | 31<br>8<br>62 |
| 9d | The wages are fair in comparison to local context average | Yes | 11 | No<br>Partially<br>Yes | 8<br>8<br>85 |
| 9e | Benefits in place for female employees | No | 8 | No<br>Yes | 62<br>38 |