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Standards and guidelines for forest plantation management: A global comparative study

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ABSTRACT

The increasing area covered by forest plantations creates a demand for trustworthy mechanisms to ensure they are responsibly established and managed. In the last twenty years efforts have increased to develop standards and guidelines as voluntary-based policy tools for guaranteeing sustainable forest management. However, most are focused exclusively or prevalently on natural or semi-natural forests, while only a few are specific to planted forests or plantations. Many differences can be identified among existing standards and guidelines that can be applied to planted forests and forest plantations. The paper, which main aim is to assess whether and to what extent planted forests are properly considered within the existing sets of standards/guidelines and to identify areas for improvements, is based on a series of comparative analysis. Both quantitative (number) and qualitative (quality in terms of coherency, consistency and completeness) aspects of indicators for addressing environmental, economic and social issues are considered. First, 42 standards/guidelines are classified and compared. Secondly, 3 standards for forest certification and 3 guidelines developed by international organisations are compared. Finally, a gap analysis is carried out with respect to an ad hoc "reference standard" with 386 indicators. Ball-charts, radar graphs and histograms are used to show results.

1. Introduction

Planted forests have represented a common land use and a very important resource for centuries. While plantation forestry has a long history in many countries, the development of a globally significant plantation estate and the establishment of large-scale planted areas is a relatively new phenomenon (Evans, 2009). Today, planted forests constitute about 6–7% of the global forest area, covering around 264 million (M) ha, with a steady increase in all regions since early 1990s. In the last ten years, the area covered by planted forests worldwide has increased by an average of almost 5 M ha/year: East-Asia, Europe and North America have the greatest coverage, together accounting for about 75% of global planted forest area. East-Asia alone makes up 35% of the total land, mainly due to China (FAO, 2010). Planted forests provide about 50% of global wood production (FAO, 2007) and 32% of industrial wood production (Buongiorno et al., 2012) with forecasts suggesting an increase of up to 80% by 2050 (Carle and Holmgren, 2008). Considering the projected increasing importance of this controversial land use, we think there is a need for scientists, practitioners and policy makers to better understand, more carefully plan and more responsibly manage forest plantations worldwide.

Planted forests vary widely, not only in terms of species, location and size, but also for their main purposes, from primarily protective functions to exclusively timber production. Forest plantations, defined as "forests of introduced and/or native species established through planting or seeding either for productive or protective purposes" (FAO, 2006), cover about half of the total planted area (140 M ha). Forest plantation issues and their relationships with natural forests are complex (White, 2003; Bull et al., 2006) and sometimes controversial, fuelling strong debates among forestry stakeholders about their potential multi-functionality as well as their positive and negative impacts.

On the one hand, although plantation forests are typically assumed to be poor substitutes for natural ones, according to many authors and several studies (e.g. Parrotta, 1995; Parrotta et al., 1997; Sedjo and Botkin, 1997; Bernhard-Reversat, 2001; Carnus et al., 2003; Montagnini et al., 2003; Toma, 2004; Kanowski et al., 2005; Montagnini et al., 2005), they can play an important role in the provision of a variety of ecosystem services, when compared with agriculture and other forms of land use or when natural forests have been degraded (Pawson et al., 2013). More in general, plantations help to relieve pressures on natural forests, contributing to reduce the harvest by about 20% in Africa, 23% in North-central America, 33% in Europe (on average, −26% at global level) and thus supporting the maintenance of ecosystem services from natural areas. According to this perspective, even if forest

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plantations are mostly (80%) intended for timber production (FAO, 2007), thus contributing towards meeting the growing global demand for timber and wood fibre, they often supply nontimber forest products (NTFPs) and contribute substantially to the provision of a wide range of other social, economic and environmental benefits. They assure forage, wildlife habitats, watershed and soil protection, recreational settings, aesthetic vistas, and ecological conditions for many other forest services, including carbon sequestration (Boyle, 1999; Evans and Turnbull, 2004; UNEP, 2009). Forest plantations, for example, represent the bulk of the 15 afforestation and reforestation projects implemented so far under the Clean Development Mechanism (CDM) of the Kyoto Protocol (UNFCCC, 2013). Plantations also play a central role in the voluntary carbon market: although the market share of afforestation/reforestation (A/R) projects has dropped significantly compared to 2011, together with reducing emissions from deforestation and forest degradation (REDD) projects they remain the most transacted forest offset type (Peters-Stanley et al., 2013). According to FAO (2010) figures about 25% of the world's forest plantations are established for protective purposes. These figures might be even higher because a large proportion of the increase in planted forests in the last years has taken place in China where many plantations are established for protective purposes, including desertification control and protection of soil and water resources. In terms of social benefits, plantations can directly or indirectly create employment, boosting the development of the wood–paper industry at local/national level; moreover, especially in Southern countries, plantation projects are often developing side healthcare programmes (e.g. HIV/AIDS programmes), providing resources and opportunities for children's education (schools, etc.), assuring job training for poor people, etc. (Bull et al., 2006).

On the other hand, according to other opinion makers, forest plantations are often described as "[…] *biological deserts, water guzzlers, livelihood saboteurs and carbuncles on the landscape*" (IUCN and WWF, 2006 — p. 1), replacing diversity with monocultures, local species with exotic ones, causing or hastening soil erosion and loss of fertility and excessive water consumption. In this perspective, while subsidising forest plantations has been a common practice (Szulecka et al., 2014), its effectiveness is debatable, since this may act as a disincentive to sustainable management of natural forests. Also, by flooding the market with cheap timber and fibres they can either make natural forest management uncompetitive or, on the contrary, help in raising consumer demand for wood products from both planted and natural forests (IIED, 2004; Buongiorno et al., 2012). In many cases, a lack of due diligence in financing forest plantation initiatives and connected investments (Spek, 2006) has been demonstrated, with public funds used to establish plantations in inappropriate sites, using poor genetic material, poorly managed or sited too far from markets. These mistakes can erode values of investment over time, which, when coupled with time-related uncertainty and risk, creates new challenges for raising capital for plantations (Cossalter and Pye-Smith, 2003; Brotto and Pettenella, 2012). More recently, afforestation/reforestation projects established for the purpose of carbon sequestration under either the CDM or REDD + mechanisms have in many countries been associated to land grabbing (e.g. Uganda and many other African countries) and/or unsustainable land uses/management (Görgen et al., 2009; Cotula, 2010; Oxfam, 2011; Deininger and Beyerlee, 2011; Anseeuw et al., 2012; FOEI, 2012).

Relevant potentials and challenges of plantations are connected with their growing role in providing timber and globally-sensitive environmental services, the conflicting positions of stakeholders about their effects on natural forests and people (namely, forest industries vs. environmental/social movements), the real impacts they might have on the environment and people, and the large and increasing amount of forest plantation investments worldwide. Despite all this, relatively few scientific papers have been published addressing these issues, in a systematic fashion. The scientific literature on plantations mostly references medium- to small-scale cases in different contexts, exploring, for example, the ecological effects of plant regeneration in restoring Mediterranean forests (Gomez-Aparicio et al., 2009), the potential positive impacts of multi-purpose plantations (Paquette and Messier, 2010), the potential socio-economic impacts of introducing forest plantations to rural households (Landry and Chirwa, 2011), the management practices that can contribute to improve water conservation in forest plantation landscapes (Ferraz et al., 2013) or providing an overview of policies for forest plantations in a large scale context like China and of main socio-ecological impacts (Turnbull, 2007). Most of these studies are focused on the identification of (often only potential) ecological and social impacts of plantations, either negative or positive, while very limited attention is given to the policy implications of their results and to the definition of common criteria and instruments to evaluate them. Moreover, a limited number of policy documents have so far been drawn up[1] specifically guiding the creation, management and evaluation of plantation investments.

The most common policy instruments currently available for addressing the establishment, management, monitoring and evaluation of forest plantations and improving their governance are sustainable forest management standards (STDs) and guidelines (GLs).[2] But, among the several STDs and GLs developed in the last 20 years (Holvoet and Muys, 2004; Marjokorpi and Salo, 2007; Clark and Kozar, 2011), which are fragmented, not sufficiently harmonised, overlapping each other or missing key issues, the majority are focused on natural or semi-natural forests while planted forests and forest plantations are considered marginally. Nowadays, more accurate, complete, specific and responsibility-oriented sets of criteria and indicators for sustainable management are required in order to successfully deal with the wide range of special environmental, social, economic and managerial challenges posed by forest plantations. STDs and GLs are considered the most useful policy instruments developed to operationalize SFM so far (Caswell, 2014). Standards or guidelines for natural forests — not having been designed for application to plantations — need proper interpretation. We assume that the more specific the policy instruments are, the more accurate and suitable the forest operations are expected to be, thus positively addressing the impacts of plantations in the long-term. Consequently, we argue that policy makers and scientists have not given enough attention so far in taking into consideration the specificities of forest plantations, both in developing or periodically updating standards and guidelines for assessing progress towards sustainability and management performances, in guiding management operations in the field, and evaluating impacts and effectiveness. Our paper, based on a comparative analysis of selected documents, has three main objectives: i) to investigate whether and to what extent existing standards and guidelines for sustainable development (SD) and sustainable forest management (SFM) specifically take forest plantations into consideration; ii) to highlight similarities and differences among existing standards/guidelines in order to assess their different (potential) effectiveness in ensuring sustainable management of forest plantations; and iii) to identify the main gaps existing between the analysed STDs/GLs and an "idealised (i.e. hypothetical, full comprehensive) list" of requirements for sustainable forest plantations that takes into consideration all environmental, social, economic and procedural issues of their management, with the aim of identifying possible areas for improvement. In the following sections, the Methodology, Results and discussion, as well as our Conclusions are presented.

2. Methodology

The methodology is based on 4 steps: (1) existing STD/GL identification and classification; (2) creation of a "reference standard"; (3) STD/

[1] As reported by Boscolo at the Scientific workshop "Governance, Economics and Trade, Markets, Profitability of Planted Forests" held in Porto (15–17th May 2013), a Sustainable Forest Management toolbox is currently under development at FAO.

[2] The definitions of "standard (STD)" and "guideline" (GLs) adopted for the purpose of this study are reported in paragraph 2.1.

GL selection; (4) STD/GL assessment and comparison. These research steps are described in the following sub-sections.

2.1. Standards and guidelines identification and classification

We have identified a total of 42 standards and guidelines for SFM and SD, following a previous study by Holvoet and Muys (2004). The list of standards provided by these authors was reviewed and updated, in order to include both new initiatives and any changes within those already considered. In the list, forest certification standards developed by the Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification schemes (PEFC), standards from intergovernmental processes for SFM (e.g. Pan-European process, Tarapoto proposal), guidelines developed by international organisations such as FAO and ITTO, and by research institutes such as CIFOR have been included. These 42 standards and guidelines have been classified in two main categories: "standards for certification" and "guidelines". For the purpose of this study a *standard* is defined as "[…] *a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*" (ISO/IEC, 2004). They are typically used to assess management practices and verify whether or not they can be certified as respecting the established rules. According to the Oxford Dictionary of English a *guideline* can be defined as a general rule, principle, or piece of advice providing guidance to appropriate behaviour. Various guidelines have been developed to assist managers in designing and undertaking operations to meet more specific requirements defined by standards (Marjokorpi and Salo, 2007). While some of the standards can — others cannot — be used as the basis for certification processes, by definition, guidelines cannot be used as the basis for certification; they can only be used as recommended actions to address management decisions. Both standards and guidelines can be expressed as a set of principles and indicators (ITTO, 1993). This first criterion of classification — i.e. the distinction between STDs and GLs — was functional to the selection of a limited number of STDs and GLs for the gap analysis (see Section 2.3).

Standards and guidelines have also been classified according to their purpose, level of application, geographical location of origin, type of forest and approach, as suggested by Lammerts Van Bueren and Blom (1997) and Holvoet and Muys (2004). This second group of classification criteria was functional to the understanding of attention paid by policy makers and practitioners to forest plantations in the different regions of the world and for the different purposes, while also updating the interesting analysis carried out by Holvoet and Muys about 10 years ago. An important characteristic for understanding the type of STD/GL is the prevailing approach of their Indicators, which can be mainly a system-based approach (SA) or a performance-based approach (PA). In the first case, there is a substantial prevalence of "descriptive indicators", which are used to describe forest resources and assess their changes over time (e.g. area covered by forest, number of endangered species), thus evaluating system progress towards more sustainability or reversion towards degradation of forest resources. Often, in a STD with a system-based approach, typical of ISO standards (such as ISO 14001 on Environmental Management System), there are several indicators requiring the presence of management tools such as management plans, monitoring systems, and data file systems (without specifying the quality of such tools). In a performance-based approach, "prescriptive indicators" prevail, i.e. they refer to pre-defined thresholds to be reached/respected (e.g. limitations in the use of exotic species, ban on the use of GMOs) (Franc et al., 2001).

Each STD and GL has been analysed through its Indicators in order to identify four characteristics: 1) its *forest specificity* i.e. whether or not the STD or GL is specifically defined for the forest sector. This is calculated as the ratio between the number of forest related indicators and the total number of indicators; 2) its *plantation specificity,* i.e. relative importance of plantation-specific indicators in the STD/GL. This is calculated as the ratio between the number of plantation-specific indicators and the total number of indicators; 3) its *socio-economic relevance* and 4) its *environmental relevance,* i.e. the relevance and relative importance of socio-economic and environmental aspects in the STD/GL. These are calculated as the ratio between the number of socio-economic or environmental indicators and the total number of indicators.[3]

2.2. Creation of a "reference standard"

A reference standard can be defined as a "*standardized object or system which is used as a measurement base for similar objects or systems*" (ISO/IEC, 2005). For the purpose of our study, the reference standard has been developed as a tool for the gap analysis, i.e. the comparison of a selected number of standards and guidelines that apply to forest plantations with respect to a hypothetical, fully comprehensive list of existing SFM requirements. The reference standard is not intended for direct use in forest management assessment or field verification, not having "the ambition of being suitable for global use as an instrument for sustainability monitoring" and being de facto "impractical in use because it would contain irrelevant elements for each level of application or for every geographical region" (Holvoet and Muys, 2004 — p. 100). In other words, the reference standard should only be used to identify relative gaps, i.e. missing or under-considered themes on which policy makers can decide to focus when updating, harmonising or revising SFM standards and related requirements with respect to the full list of themes identified so far in literature. It has been compiled according to a structured hierarchical framework based on Principles, Criteria and Indicators (Lammerts van Bueren and Blom, 1997; CIFOR, 1999), which also include legal and institutional requirements at the level of principle (Ruitenbeek and Carter, 1998; Holvoet and Muys, 2004).[4] The reference standard was structured in 7 Principles, from A to G, 49 Criteria and a total of 384 Indicators, which include the 308 identified by Holvoet and Muys in their study in 2004 and 76 others deduced from the 42 STD/GL explored for our study. Table 1 reports a summary of the reference standard structure; Table 2 gives examples from the full list of indicators.

2.3. Standard and guideline selection

Among the 42 STDs and GLs identified, three STDs and three GLs have been selected for a detailed analysis according to the aim of our study. The selection criteria included plantation specificity, purpose, geographical scope and relevance, and endorsement. First of all, STDs/GLs with a high plantation specificity index (equal to 1) were identified. The list included 11 potential "candidates": CIFOR C&I for Sustainable Development of Industrial Tropical Tree Plantations, FAO Voluntary Guidelines for Responsible Management of Planted Forests, FSC standards for Brazil and Chile, ITTO Guidelines for the establishment and sustainable management of planted tropical forests, LEI SPFM standards, MTCC C&I for forest plantations and PEFC standards for Brazil, Chile, Italy and Spain. This list was divided into 2 groups, on the basis of STD/GL purposes: 1) standards intended for forest certification (such as FSC, PEFC, MTCC and LEI); and 2) guidelines not intended for certification (CIFOR, FAO and ITTO). All the GLs have been selected for our

[3] Some minor overlaps are possible when considering, for example, ecosystem services in those STDs or GLs where they are not clearly identifiable as mainly socio-economic (e.g. recreation) or environmental (e.g. biodiversity) services.

[4] Although Lammerts van Bueren and Blom (1997) strongly advise against this approach, the incorporation of legal and institutional requirements at the level of principle, as suggested by Ruitenbeek and Carter (1998) as well as by Holvoet and Muys (2004) is accepted in our framework for three main reasons: they are essential in achieving SFM; the majority of the considered standards or guidelines include elements related to legislation or institutional support at the highest level; and the topic of legality recently assumed a major role in forestry issues, in the wake of initiatives like the EU FLEGT Regulation and Timber Regulation, as well as the US Lacey Act.

Table 1
Summary of the reference standard developed for our study.

#	Principle	Number of criteria	Number of indicators
A	Policy and planning strive for sustainable and multifunctional forest management, and are supported by legislation and facilities.	9	65
B	The surface area, vitality and state of the forest resources will be maintained and protected, and where possible improved.	5	55
C	The productive forest function will be maintained, by sustainable forest exploitation and by reassuring forest regeneration	5	37
D	Biodiversity and ecological processes will be maintained and protected, and where possible strengthened.	17	94
E	Protective forest functions shall be maintained and protected, and where possible strengthened.	5	34
F	The sustainable forest management shall be economically viable and shall improve the conditions of local communities and local economies.	3	47
G	The social and cultural wellbeing of all stakeholders shall be maintained and protected, and improved when necessary	5	52
Total		49	384

Source: own elaboration.

study. Among certification STDs, LEI standard was selected because it is the only forest certification initiative outside the FSC and PEFC systems with specific STDs for forest plantations; while MTCC was excluded being PEFC endorsed. Among FSC and PEFC STDs, priority was given to fully endorsed STDs[5] for forest plantations and relevance of forest plantations at country level in terms of both planted area and certified planted area[6]: STDs developed for Chile were chosen because of the importance of certified planted area in that country.

2.4. Standards and guidelines assessment and comparison (gap analysis)

Each of the 3 selected STDs and 3 selected GLs has been assessed — Indicator by Indicator — and compared both with the "reference standard" and with the other STDs or GLs. For this purpose, two different aspects for each indicator were taken into consideration. First of all, the *approach of the indicator*, distinguishing between a prevailing performance-based approach (PA) or system-based approach (SA). A score (0, 0.5 or 1) was assigned to each indicator: when the considered approach is lacking, the score is "0"; when STD/GL partly covers the considered reference standard indicator by means of performance-based indicators together with system-based indicators (in a kind of mixed distribution), the score is "0.5"; when the considered approach is predominant, the score is "1". Secondly, the *quality of the indicator*, in terms of its coherency, consistency and completeness[7] with respect to the relevant criterion. A score ranging from 1 (i.e. low coherency, consistency and/or completeness) to 5 (i.e. high coherency, consistency and/or completeness)[8] was given to each indicator. In addition to the authors' evaluation, independent experts (n = 3) were asked to run the same evaluation procedure using the same scoring criteria. A mean value was calculated among the 4 evaluations for each indicator; all indicator values were finally summed up at the criterion level and plotted on bubble-charts. The relative position of a bubble on the chart indicates whether the correspondent criterion adopts a prevalently performance-based or system-based approach, while bubble size expresses the estimated quality for each analysed criterion. Assessment results were also summarised at principle level and plotted on radar graphs to observe differences and similarities among the surveyed STDs/GLs. Finally, a gap analysis (e.g. Ferrucci, 2004; Hickey and Innes, 2005) was conducted at the criterion level, in order to identify the present position of STDs or GLs with respect to an "ideal position" represented by a defined benchmark. The final aim of this exercise was the identification of gaps between actual and potential comprehensiveness of STDs/GLs, in order to suggest opportunities and future areas of improvement to enhance operational efficiencies within an existing situation (Franklin, 2006). Two different benchmark standards, one for certification STDs and one for GLs, were developed by extracting from the "reference standard" those indicators covered by at least one of the surveyed certification STD (or GL). Each indicator within the benchmark standard was given a default quality score equal to 5. Each surveyed certification STD (or GL) was matched with the relevant benchmark standard and the gap value for each indicator (i.e. the difference between the ideal maximum value of the indicator (5) and the value of the indicator as resulted from the assessment) was calculated. Calculated gaps were summed-up at the criterion level and normalised on a 1–100 scale; complementary values were then calculated for all of them. Results were plotted on bar charts and analysed in detail.

3. Results and discussion

Results are reported and discussed in the following sub-sections: STD/GL classification (Section 3.1); certification STD assessment and gap analysis (Section 3.2); and GL assessment and gap analysis (Section 3.3). Because of the need to keep the length of the paper within acceptable limits, only a part of the results is reported in detail as an example of the full analysis. In particular, Principle D (biodiversity) and Principle G (social and cultural well-being of stakeholders) are presented and discussed for the certification standards; while Principle F (economic viability and sustainable exploitation) and Principle A (legal framework) are discussed for the Guidelines. We based our decision to report the results of these four Principles and not others on three considerations. Firstly, three Principles (D, G and F) refer to the three pillars

Table 2
Examples of Indicators: excerpts from the reference standard.

#	Indicator	Principle	Criterion
1	H. Forest management plan publicly accessible	A	A
2	D. Monitoring of land use change	B	A
3	D. Harvested volume by species	C	A
4	D. Monitoring of the use of exotic tree species and their impacts on the environment	D	G
5	D. Percentage of margins of water resources protected by a buffer	E	D
6	S. Workers rights to organise and negotiate	F	C
7	A. Existence of clearly defined and legal property rights and rights of use	G	A

Source: own elaboration

[5] FSC ad interim standards, e.g. those under development for Brazil, were excluded.

[6] The collection of data on certified forest plantations was quite difficult because available information is sometimes inaccurate. Mistakes were found in figures reported by the FSC international database. The PEFC international database is widely inconsistent since no specification exists about tree species in certified areas and type of certified forest (i.e. plantation or natural forest). Whenever possible, data were collected from websites belonging to national standard setting bodies (especially in the case of PEFC) and accredited certification bodies (in the case of FSC, data from the database were matched with those reported in public summaries of certification reports available online). We selected the countries with the most relevant plantation area due to the assumption that, the larger the planted area, the higher likely the impacts of using more or less comprehensive sets of standards.

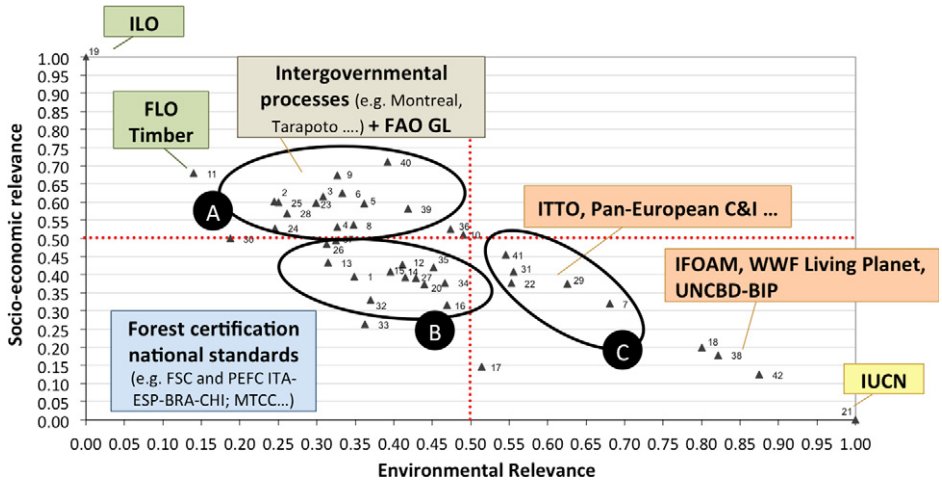
[7] "Coherency" means whether the surveyed indicator is in line with issues covered by the relevant criterion; "consistency" means whether it is in line with the purpose of the relevant criterion; and "completeness" means whether it is able to cover all aspects raised by the relevant criterion.

[8] The terminology used to describe forest related subjects can differ strongly between standards and regions of the world (Dobbertin and Prüller, 2002). In our study, attention was mainly given to the presence/absence of elements, and not to their exact wording, except for the use of forms like "*shall*/*shall not*" or "*should*/*should not*", where the former was considered stricter and thus associated to a higher score.

Table 3
Main characteristics of the 42 identified standards and guidelines.
Source: own elaboration.

#	STD or GL	Purpose	Level of application	Geographical location	Type of forest	Approach	Total indicators (T)	Indicators (number)				F / T	E / T	S / T	P / T*
								Forest-related (F)	Environ-mental (E)	Socio-economic (S)	Plantation-related (P)				
1	CCBA	C	FMU	N	NF + P	PA	86	65	30	34	Potentially 1 to 13	0.756	0.349	0.395	0.012
2	CIFOR C&I generic template	I	RN	S	NF + P	SA	98	98	24	59	0	1.000	0.245	0.602	0.000
3	CIFOR C&I plantations	I	RN	S	P	SA	52	52	16	32	52	1.000	0.308	0.615	1.000
4	Dry forests in Asia	I	RN	S	NF + P	SA	49	49	16	26	2	1.000	0.327	0.531	0.041
5	Dry Zone Africa (CILSS)	I	RN	S	NF + P	SA	47	47	17	28	3	1.000	0.362	0.596	0.064
6	Dry Zone Africa (SADC)	I	RN	S	NF + P	SA	48	48	16	30	2	1.000	0.333	0.625	0.042
7	EEA	I	RN	N	NF + P	SA	169	4	115	54	0	0.024	0.680	0.320	0.000
8	FAO Guidelines for Plan. For.	I	RN	N + S	P	SA	95	95	33	51	95	1.000	0.347	0.537	1.000
9	FLO generic HL	C	FMU	N + S	NF + P	PA	156	5	51	105	0	0.032	0.327	0.673	0.000
10	FLO generic SPO	C	FMU	N + S	NF + P	PA	104	5	51	53	0	0.048	0.490	0.510	0.000
11	FLO timber	C	FMU	N + S	NF + P	PA	100	90	14	68	5	0.900	0.140	0.680	0.050
12	FSC P&C	C	FMU	N + S	NF + P	PA	56	56	23	24	56, 9 specific	1.000	0.411	0.429	0.161
13	*FSC Brazil*	C	FMU	S	P	PA	143	143	45	62	143	1.000	0.315	0.434	1.000
14	*FSC-Chile*	C	FMU	S	P	PA	224	224	93	88	224	1.000	0.415	0.393	1.000
15	*FSC Italy*	C	FMU	N	NF + P	PA	162	162	64	66	162, 28 specific	1.000	0.395	0.407	0.173
16	*FSC Spain*	C	FMU	N	NF + P	PA	164	164	77	52	164, 38 specific	1.000	0.470	0.317	0.232
17	IFOAM basic standards	C	FMU	N + S	NF + P	PA	103	5	53	15	2	0.049	0.515	0.146	0.019
18	IFOAM Draft BoD-Landscap.	C	FMU	N + S	NF + P	PA	30	9	24	6	Potentially 10 to 12	0.300	0.800	0.200	0.667
19	ILO	I	FMU	N	NF + P	PA	732	732	0	732	3	1.000	0.000	1.000	0.004
20	ITTO Guidelines Planted For.	I	RN	S	P	SA	75	75	33	28	75	1.000	0.440	0.373	1.000
21	IUCN	I	RN	N	NF + P	SA	21	4	21	0	0	0.190	1.000	0.000	0.000
22	IUCN/ITTO Guidelines BoD	I	RN	S	NF + P	SA	85	85	47	32	7	1.000	0.553	0.376	0.082
23	LEI-SPFM	C	FMU	S	P	PA	67	67	20	40	67	1.000	0.299	0.597	1.000
24	Lepaterique (C. America) NL	I	RN	S	NF + P	SA	53	53	13	28	3	1.000	0.245	0.528	0.057
25	Lepaterique (C. America) RL	I	RN	S	NF + P	SA	40	40	10	24	2	1.000	0.250	0.600	0.050
26	Montreal Process	I	RN	N	NF	SA	64	64	20	31	0	1.000	0.313	0.484	0.000
27	MTCC	C	FMU	S	P	PA	105	105	45	41	105	1.000	0.429	0.390	1.000
28	Near-East Process	I	RN	N	NF + P	SA	65	65	17	37	8	1.000	0.262	0.569	0.123
29	OECD	I	RN	N	NF + P	SA	64	7	40	24	0	0.109	0.625	0.375	0.000
30	ATO/ITTO PCI	C	RN	S	NF	SA	80	80	15	40	0	1.000	0.188	0.500	0.000
31	PEFC C&I (PAN-EU)	C	RN	N	NF	SA	27	27	15	11	0	1.000	0.556	0.407	0.000
32	*PEFC Brazil*	C	FMU	S	P	PA	100	100	37	33	100	1.000	0.370	0.330	1.000
33	*PEFC-Chile*	C	FMU	S	P	PA	193	193	70	51	193	1.000	0.363	0.264	1.000
34	*PEFC Italy*	C	FMU	N	P	PA	45	45	21	17	45	1.000	0.467	0.378	1.000
35	*PEFC Spain*	C	FMU	N	NF + P	PA	31	31	14	13	Potentially 31	1.000	0.452	0.419	1.000
36	Rainforest Alliance SAN	C	FMU	N	P	PA	500	22	237	263	8	0.044	0.474	0.526	0.016
37	Tarapoto Process	I	RN	S	NF	SA	77	77	25	38	0	1.000	0.325	0.494	0.000
38	UNCBD-BIP	I	RN	N	NF + P	SA	28	6	23	5	0	0.214	0.821	0.179	0.000
39	UNCTAD — BioTrade	I	RN	N	NF + P	PA	55	6	23	32	Potentially 1 to 8	0.109	0.418	0.582	0.018
40	UNDSD	I	RN	N	NF + P	SA	97	3	38	69	0	0.031	0.392	0.711	0.000
41	WB (WDI)	I	RN	N	NFP	SA	99	7	54	45	0	0.071	0.545	0.455	0.000
42	WWF Living Planet	I	RN	N	NFP	SA	8	3	7	1	0	0.375	0.875	0.125	0.000

Legend: C = certification; I = intergovernmental processes or other purposes; RN = regional/national level; FMU = forest management unit level; N = North; S = South; N + S = both North and South; NF = natural forests; P = only forest plantations; NF + P = both natural forests and forest plantations; PA = performance based approach; SA = system based approach.* P/T: the ratio has been calculated considering the lowest possible P values (e.g. in the case of CCBA, a P = 1 value has been considered). Acronyms of STD/GL names: (1) Climate, Community and Biodiversity Alliance, CCBA; (2) Center for International Forestry Research Criteria and Indicators; (3) Center for International Forestry Research Criteria and Indicators; (4); (31) Program for the Endorsement Forest Certification, Pan-European Criteria and Indicators, PEFC C&I (PAN-EU); (36) Rainforest Alliance Sustainable Agriculture Network, Rainforest Alliance SAN; (37) Tarapoto Process; (38) United Nations Convention on Biological Diversity and Biodiversity Indicators Partnership, UNCBD-BIP; (39) United Nations Conference on Trade and Development BioTrade Initiative, UNCTAD — BioTrade; (40) United Nations Commission for Sustainable Development, UNDSD; (41) World Bank World Development Indicators, WB (WDI); and (42) World Wildlife Conservation Living Planet, WWF Living Planet.



Source: own elaboration

Fig. 1. Distribution of the 42 standards/guidelines according to their socio-economic (SER) and environmental relevance (ER). Source: own elaboration.

of sustainability (respectively the environmental, economic and social dimensions of forest management). The fourth Principle (A) refers to legality-related issues, which are becoming more and more important in the international policy agenda. Secondly, Principles D and A are the two largest Principles in terms of the number of criteria, and all together, the four selected Principles D, G, F and A, cover about 69% of the criteria and 67% of the indicators included in the reference standard. Finally, these four Principles are those characterised by the highest number of gaps with respect to the reference standard, therefore representing the main areas of interest for policy makers' periodical revision of STDs or GLs. Their analysis is sufficiently complete to understand the general situation.

3.1. Standard and guideline classification

The main characteristics of the 42 identified STDs and GLs are provided in Table 3. Only 11 STDs are specifically intended for forest plantations (26% of the total); even fewer are specifically for natural forests (4, i.e. about 10% of the total), while the larger set of STDs (27, i.e. 64% of the total) are designed for natural forests but also include indicators for plantations. The number of STDs/GLs with a prevailing system-based approach (22) is slightly higher than those with a dominant performance-based approach (20). Regarding their geographical location, 43% of STDs/GLs are from the North, 40% from the South, and 17% are for both areas. In terms of purpose, 48% are designed to be used as management requirements by forest certification schemes (e.g. assessing management practices in the field); 52% are intended for other uses (e.g. assessing changes in forest resources at country level). The purpose being directly connected with the level of application, 47% of STDs/GLs are designed to be applied at forest management unit level (FMU), while 53% are to be applied at the regional or national level (RN).

The STDs/GLs can also be analysed in terms of their environmental (ER) and socio-economic relevance (SR) (Fig. 1). Three clusters (A, B and C) can be identified. Cluster A includes standards or guidelines with a prevalent focus on socio-economic issues (SER value from 0.5 to 0.711), such as FLO generic standards, some standards developed by intergovernmental processes (e.g. Lepaterique, Near East) and the FAO Guidelines for planted forests. A couple of outliers can be identified as well, i.e. ILO and FLO standards for timber, both characterised by a strong SER dimension coherent with these two organisations' missions (i.e. respectively, protection of workers' rights and better social and economic conditions for small producers in developing countries), which are positioned in the top-left corner of the graph. Other documents having a more central position within Cluster A, such as FAO Guidelines for Planted Forests, can be understood in the light of the people-centred approach promoted by many international development agencies (Cleary, 2003). Cluster B mainly includes STDs designed for forest certification, where the attention towards socio-economic and environmental aspects is more balanced (ER from 0.313 to 0.47; SER from 0.317 to 0.494); this cluster includes FSC international and national standards (with the exception of Smartwood ad interim FSC standards for Brazilian plantations and PEFC Chile), PEFC national standards for Brazil, Italy and Spain and the MTCC standards for plantations. These

Table 4
Indicators in the 3 assessed certification standards with respect to the "reference standard" indicators, per principle.
Source: own elaboration.

		FSC-Chile				LEI				PEFC-Chile			
		In absolute values		In %		In absolute values		In %		In absolute values		In %	
Principle	Reference standard indicators (RI) (number)	Total (T)	RI − T	T / RI	(RI − T) / RI	Total (T)	RI − T	T / RI	(RI − T) / RI	Total (T)	RI − T	T / RI	(RI − T) / RI
A	65	40	25	*61.5*	*38.5*	7	58	*10.8*	*89.2*	33	32	*50.8*	*49.2*
B	55	31	24	*56.4*	*43.6*	5	50	*9.1*	*90.9*	27	28	*49.1*	*50.9*
C	37	25	12	*67.6*	*32.4*	8	29	*21.6*	*78.4*	22	15	*59.5*	*40.5*
D	94	44	50	*46.8*	*53.2*	12	82	*12.8*	*87.2*	34	60	*36.2*	*63.8*
E	34	10	24	*29.4*	*70.6*	14	20	*41.2*	*58.8*	16	18	*47.1*	*52.9*
F	47	20	27	*42.6*	*57.4*	15	32	*31.9*	*68.1*	19	28	*40.4*	*59.6*
G	52	23	29	*44.2*	*55.8*	13	39	*25.0*	*75.0*	25	27	*48.1*	*51.9*
Total	384	193	191	*50.3*	*49.7*	74	310	*19.3*	*80.7*	*176*	208	*45.8*	*54.2*

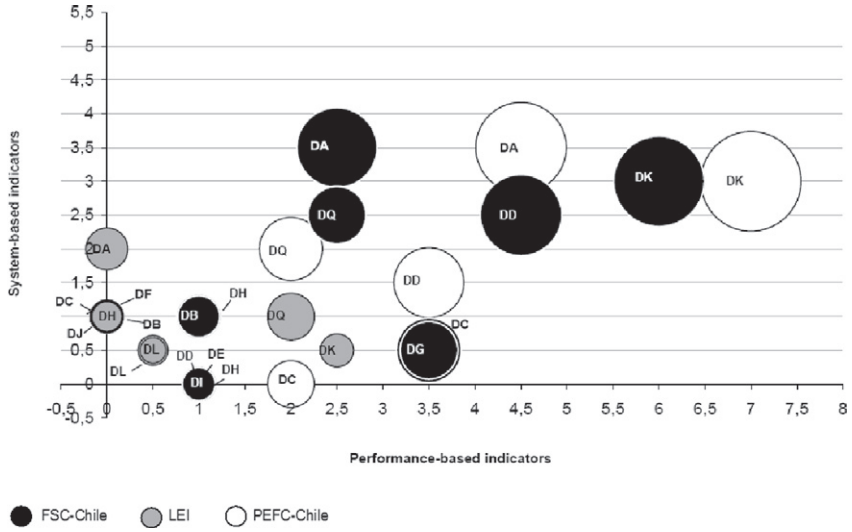
Table 5
Assessment of the 3 surveyed certification standards against the reference standard per criterion — Principles D and G.

Reference criterion	FSC-Chile			LEI			PEFC-Chile		
	P	S	Q	P	S	Q	P	S	Q
Principle 4 — D. Biodiversity and ecological processes shall be maintained and protected, and where necessary restored									
DA	2.5	3.5	29	0	2	8	4.5	3.5	37
DB	1	1	9	0	0	0	0	1	5
DC	3.5	0.5	19	0	1	5	2	0	10
DD	4.5	2.5	30	1	0	4	3.5	1.5	22
DE	1	0	5	0	0	0	1	0	3
DF	0	1	5	0	0	0	0	0	0
DG	3.5	0.5	15	0	0	0	0	0	0
DH	1	1	8	0	1	4	1	0	5
DJ	0	1	5	0	0	0	0	1	4
DK	6	3	37	2.5	0.5	5	7	3	45
DI	1	0	5	0	0	0	0	0	0
DL	0.5	0.5	4	0.5	0.5	3	0.5	0.5	4
DM	0	0	0	0	0	0	0	0	0
DN	0	0	0	0	0	0	0	0	0
DO	0	0	0	0	0	0	0	0	0
DP	0	0	0	0	0	0	0	0	0
DQ	2.5	2.5	15	2	1	10	2	2	18
Sub-total	27.0	17.0	186	6.0	6.00		21.5	12.5	153
Principle 7 — G. Social and cultural well-being of stakeholders									
GA	6.5	2.5	38	4	1	17	2.5	2.5	19
GB	1.5	1.5	13	0	2	6	2	2.0	17
GC	1.5	1.5	10	2	0	6	3.5	1.5	21
GD	1.5	0.5	10	0	0	0	2.5	1.5	12
GE	3.5	2.5	25	2	2	10	5	2.0	31
Sub-Total	14.5	8.5	96	8	5	39	15.5	9.5	100

Legend: P = performance-b. approach; S = system-b. approach; and Q = general quality in terms of coherence, consistency and completeness with respect to the reference standard.

more balanced positions are in line with the basic approach in forest certification schemes of taking into consideration, and balancing evenly, the three pillars of sustainability in their STDs. The relative positions of each certification STD within Cluster B reflect the specific differences in the priorities assigned to socio-economic or environmental requirements in the standard setting process. To some extent this also mirrors different stakeholder groups involved in such processes. Cluster C, where the focus of the STDs/GLs is on environmental (ER: 0.545–0.68) rather than socio-economic issues (SER: 0.32–0.455), includes the ATO/ITTO Guidelines for the establishment and sustainable management of planted tropical forests and the Pan-European C&I. Both their positions, more focused on environmental aspects, might be due to the conservation-oriented policy discourses which have affected the development of these two sets of policy documents respectively in the tropics (as a reaction to deforestation) and in the European context (as a reaction to the loss of biodiversity due to improper management practices in the past) (Henle et al., 2008). Other STDs/GLs, in line with the missions of the promoter organisations, are even more focused on environmental issues, such as the IFOAM basic standards, WWF Living Planet, IUCN-ITTO standards: they can be seen as outliers and found on the bottom-right-hand corner in Fig. 1.

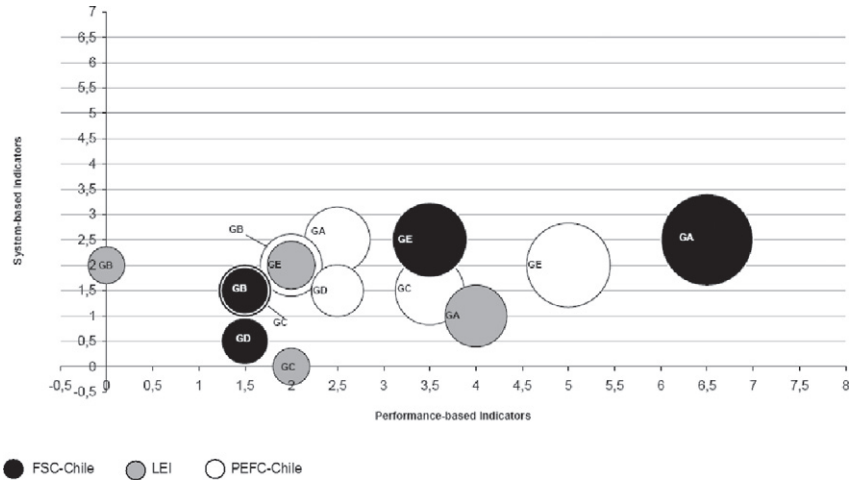
ILO Code of Practice on Safety and Health in Forestry Work is wholly included within FSC Principles and Criteria and is part of national standard setting process and certification assessment (FSC, 2002a and 2002b). It is also "[…] *recognised as a helpful document, which should be considered when developing national and regional certification criteria*" by the PEFC Technical Document (PEFC Council, 2007). FLO standards for timber can be used only together with FSC standards for smallholders (i.e. the so called Small and Low Intensity Managed Forests (SLIMF) standards) (FLO, 2011). As for CCBA, it is the only carbon standard included in the list. It is quite well balanced in terms of both environmental and socio-economic relevance, but both ER and SER show values between 0.35 and 0.4 because a relevant number of indicators within the standard are dedicated to the definition of requirements that are specific to carbon projects (e.g. methodologies for calculating carbon stocks). This is probably linked to the fact that the public views those plantations intended for multiple purposes as having a positive role in sequestering an important part of the atmospheric carbon released by humans (Paquette and Messier, 2010), and specific policy instruments for analysing the related effects are needed. Similar needs can be foreseen for all technical issues connected with plantation



Notes-Overlapping of the following bubbles: (0,1) FSC: DF and DI; LEI: DC and DH; PEFC: DB and DJ; (1,0) FSC: DE and DI; LEI: DD; PEFC: DE and DH;(1,1) FSC: DB and DH; (3.5, 0.5) FSC: DC and DG.

Source: own elaboration

Fig. 2. Assessment and comparison of the 3 surveyed certification standards against the reference standard, per criterion — Principle D. Notes — overlapping of the following bubbles: (0,1) FSC: DF and DI; LEI: DC and DH; PEFC: DB and DJ; (1,0) FSC: DE and DI; LEI: DD; PEFC: DE and DH; (1,1) FSC: DB and DH; and (3.5, 0.5) FSC: DC and DG.
Source: own elaboration.



Notes-Overlapping of the following bubbles: (1.5,1.5) FSC: GB and GC; (2,2) LEI: GE; PEFC: GB.

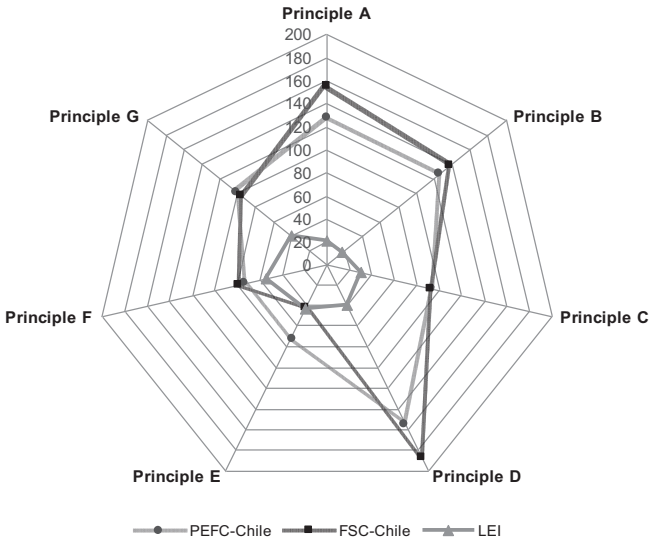
Source: own elaboration

Fig. 3. Assessment and comparison of the 3 surveyed certification standards against the reference standard per criterion — Principle G. Notes — overlapping of the following bubbles: (1.5,1.5) FSC: GB and GC; (2,2) LEI: GE; and PEFC: GB.
Source: own elaboration.

management practices, including use of fertilisers and pesticides, and methods of regeneration, especially those more critical with respect to the demands of society (biodiversity conservation, water protection, recreation, etc.).

3.2. Certification standards assessment and gap analysis

Table 4 summarises the indicators' distribution of the three surveyed certification STDs (FSC-Chile, LEI and PEFC-Chile[9] i.e. Certfor) in absolute values and percentage. Their distance from the "reference standard" list in terms of number of indicators is reported per Principle. While FSC-Chile STD indicators cover 50.3% of all the indicators listed in the "reference standard", PEFC-Chile STD covers 45.8% and LEI STD covers only 19.3%. However, figures vary significantly depending on the Principle. For example, in Principle E (protective functions of forests) the 10 FSC indicators cover only 29.4% of the reference standard indicators, with a gap of 70.6% with respect to an ideal set of standards for forest plantations; in Principle C (productive function of forests and sustainable exploitation), the 25 FSC indicators cover 67.6% of the 37 reference standard indicators (with a gap of 32.4%). In the same way, in Principle G (social and cultural well-being of stakeholders), the 25 PEFC-Chile indicators cover 48.1% of the 52 total indicators in the reference standard, while the 23 FSC-Chile indicators cover 44.2% of them. In general terms, FSC-Chile has fewer gaps with respect to the reference standard in 5 out of 7 Principles, while PEFC-Chile in 2 of them (Principles E and G). LEI STD shows the biggest gaps with respect to both FSC and PEFC standards in all Principles except Principle E, which contents are underestimated by FSC-Chile STD. These differences are likely to be due to different environmental conditions in the two countries (Indonesia and Chile). Protective functions of forest are probably of particular relevance in Indonesia, due to the well-known deforestation and forest degradation processes that occurred in the past combined with the country's soil fragility (Gillis, 1988). Thus, the protective functions of plantations gained a paramount importance in the case of Indonesia when SFM standards were developed at the national level. This is in line with the idea that standards should be adapted "to the specific circumstances in biophysical and socio-economic terms" (Prabhu et al., 2001, as cited in Holvoet and Muys, 2004 — p. 100). However, even if differences among standards might also be based on different application contexts and these preliminary observations are merely quantitative (e.g. based on analysis of differences in terms of number of Indicators per Principle in the various standards), they can already provide an idea of the general orientation of each certification standard with respect to the main environmental, social and economic issues connected with sustainable management of forest plantations as identified in existing policy documents. Therefore, for example, they can help national policy makers adapt or integrate their standards based on the issues listed in order to cover sustainability in a more comprehensive way, and also find inspiration in other countries' standards requirements.



Source: own elaboration.

Fig. 4. Quality of indicators for the 3 surveyed forest certification standards with respect to the "reference standard", per principle.
Source: own elaboration.

[9] Unless stated otherwise, when speaking about PEFC reference is made to Certfor (i.e. PEFC-Chile) and corresponding standards, while when speaking about FSC reference is made to FSC-Chile and corresponding standards.

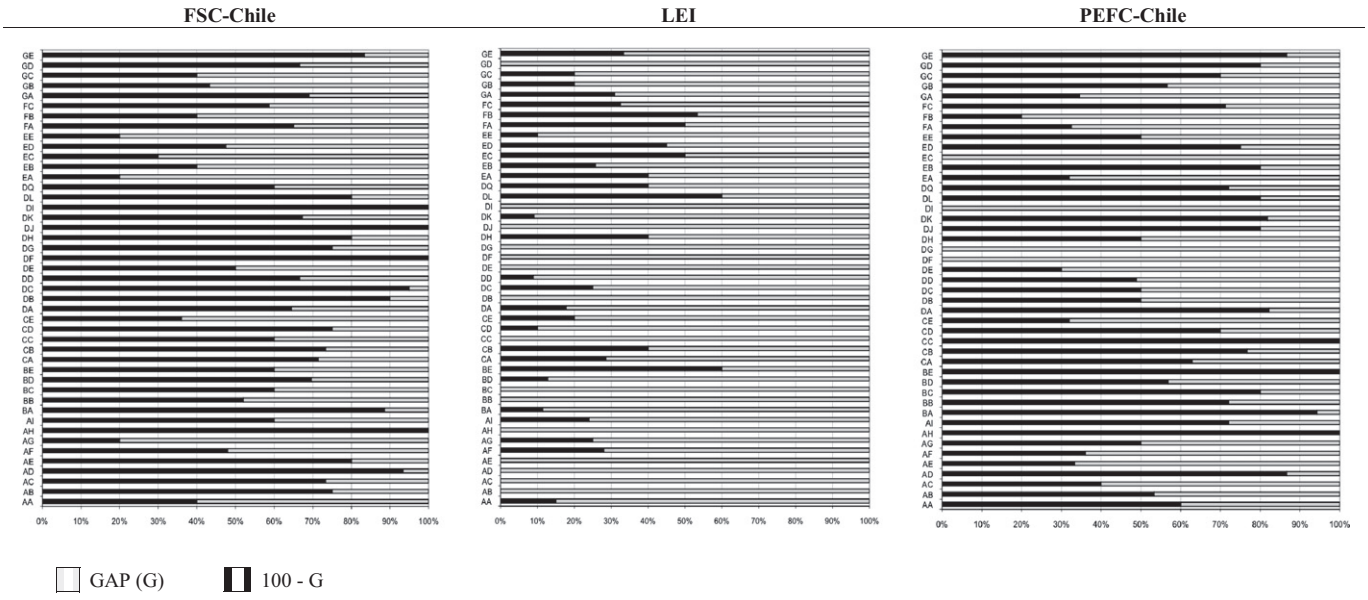
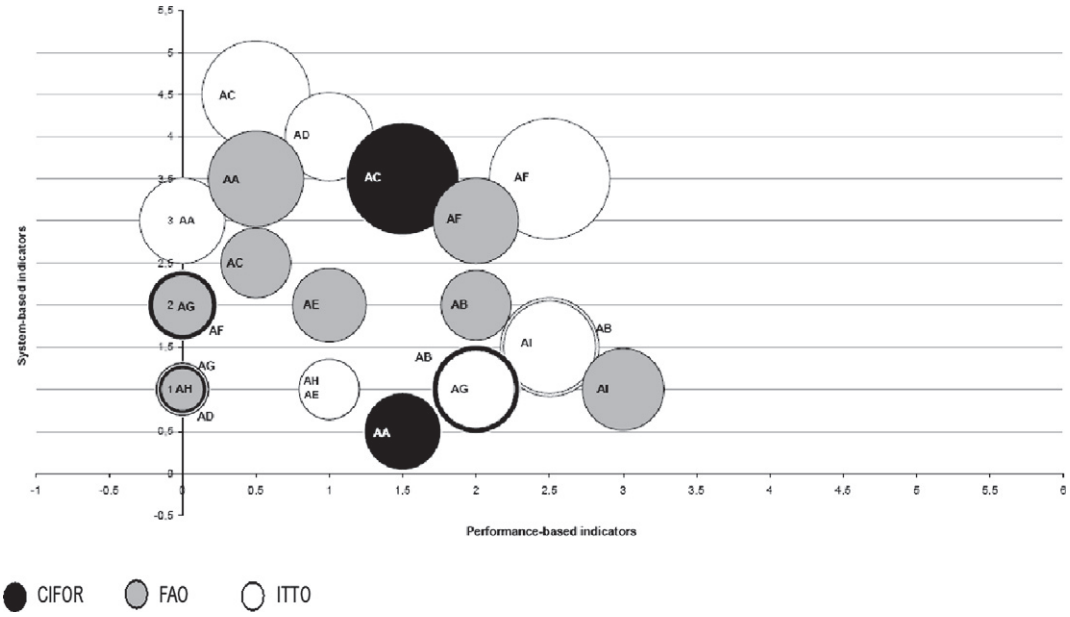


Fig. 5. Gap analysis of the 3 surveyed forest certification standards with respect to the "reference standard" for forest plantation management.
Source: own elaboration.

Detailed assessment results are reported only for Principle D on biodiversity and the role of forests and forest management in ecological processes and Principle G on social and cultural well-being of stakeholders (Table 5 and Fig. 2). In the case of Principle D, due to the high number of criteria, overlapping is frequent (see for example criteria DE, DJ and DL). As for the latter (waste removal from the ecosystem), the three standards have similar results, with LEI showing a (slightly) lower quality output. In the case of accidental introduction or spreading of non-indigenous species (criterion DJ) and management of game and fish populations (DE), LEI does not have Indicators, while FSC-Chile and PEFC-Chile are almost coincident, with the former showing larger bubbles (representing, as explained in Section 2.4, a higher quality of indicators in terms of coherency, consistency and completeness with respect to the criterion) because it includes indicators like the existence of clear and strict procedures and protocols to prevent introduction and spreading of non-indigenous species (indicator DJA); and the implementation of control on illegal hunting and fishing. Criterion DE is in connection with criterion DG, where FSC-Chile is the only standard providing specific indicators for regulations concerning the species mixture and the use of exotic species in regeneration activities. The inclusion of indicators on the species mixture and the use of non-indigenous species by both FSC-Chile and PEFC-Chile are likely to be connected to the need to remedy a critique made in relation to the traditional industrial plantation models in the country, which are often based on large scale monocultures that negatively affected biodiversity protection (Estades and Temple, 1999; Paritsitis and Aizen, 2008). Criteria DA and DK show similar scenarios, with PEFC being more complete with respect to the reference standard when compared with the others, mainly due to the presence of specific requirements for staff training on biodiversity issues and the presence of a person in charge for both biodiversity aspects and the control of pests and diseases. In the case of DK, however, FSC is the only standard asking for priority given to the use of organic and biological fertilisation methods. As for criteria DC and DA, they represent two relevant gaps for LEI that does not explicitly ask for avoiding the establishment of forest plantations in primary/native forest areas nor for the conservation and preservation of primary/native forest remnants. In a country, such as Indonesia, with high deforestation rates and a growing pressure from forest plantations this seems to be a strong deficiency. This seems to be confirmed by the fact that both FSC and PEFC Chilean standards stress the point of designing plantations in order to reduce pressure on natural forests, by carefully selecting and managing the site, the layout and species composition, while LEI just has a general system-based requirement for careful selection of sites, species and genotype adapted to local conditions. Finally a remarkable aspect is that none of the standards shows indicators for criteria from DM to DP. This is probably due to the fact that this set of criteria refers to very

Table 6
Indicators in the 3 assessed guidelines, per principle.
Source: own elaboration.

		CIFOR				FAO				ITTO			
		In absolute values		In %		In absolute values		In %		In absolute values		In %	
Principle	Reference standard indicators (RI) (number)	Total (T)	RI − T	T / RI		Total (T)	RI − T	T/RI	(RI − T) / RI	Total (T)	RI − T	T / RI	(RI − T) / RI
A	65	14	51	*21.5*	*78.5*	30	35	*46.2*	*53.8*	34	31	*52.3*	*47.7*
B	55	6	49	*10.9*	*89.1*	13	42	*23.6*	*76.4*	20	35	*36.4*	*63.6*
C	37	12	25	*32.4*	*67.6*	14	23	*37.8*	*62.2*	13	24	*35.1*	*64.9*
D	94	12	82	*12.8*	*87.2*	30	64	*31.9*	*68.1*	28	66	*29.8*	*70.2*
E	34	4	30	*11.8*	*88.2*	12	22	*35.3*	*64.7*	8	26	*23.5*	*76.5*
F	47	13	34	*27.7*	*72.3*	17	30	*36.2*	*63.8*	9	38	*19.1*	*80.9*
G	52	16	36	*30.8*	*69.2*	18	34	*34.6*	*65.4*	14	38	*26.9*	*73.1*
Total	384	77	307	*19.8*	*79.9*	134	250	*34.9*	*65.1*	126	258	*32.8*	*67.2*



Notes-overlapping of the following bubbles: (0,1) CIFOR: AD and AG; FAO: AH; (1,1) ITTO: AE and AH; (0,2) CIFOR: AF; FAO: AG; (2,1)CIFOR: AB; ITTO:AG.

Source: own elaboration.

Fig. 6. Assessment of the 3 surveyed guidelines against the reference standard, Principle A. Notes — overlapping of the following bubbles: (0,1) CIFOR: AD and AG; FAO: AH; (1,1) ITTO: AE and AH; (0,2) CIFOR: AF; FAO: AG; (2,1) CIFOR: AB; and ITTO: AG.
Source: own elaboration.

technical aspects dealing with microclimate parameters, silvicultural practices (e.g. crown cover density or natural stem reduction) and ecological issues (monitoring of climatic parameters), which are in many cases covered by best practices, technical codes/manuals or even normative requirements.

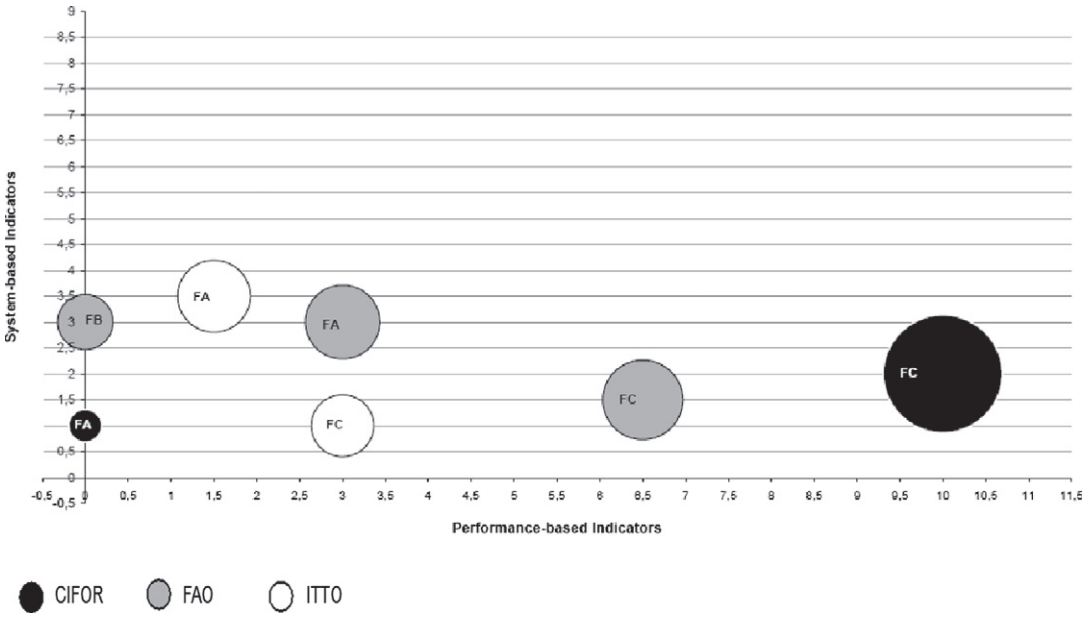
For Principle G (social and cultural well-being of stakeholders), relevant differences can be identified among the three standards (Table 5 and Fig. 3). In land use and property rights issues (criterion GA), for example, FSC-Chile shows higher values in terms of both performance-based indicators and indicators quality, as illustrated, respectively, by the relative position (on the right) and size (the largest) of the black bubble representing FSC-Chile. This is mainly due to the strong relevance given to land property and use rights, with reference to both legal and traditional rights, including those of access to the forest and gathering products. FSC-Chile STD states that, on the basis of agreed mechanisms, forest managers shall allow neighbouring communities to gather harvest residues and other forest associated products if they do not interfere with the forest management activities. This seems to be a relevant point, especially in those areas hosting indigenous communities (e.g. Mapuche people) with traditional rights over local resources that have already experienced severe social conflicts over this issue. As for efficient communication between stakeholders (criterion GC), while all standards have requirements for distributing information on forest management activities, as well as for the definition and implementation of procedures for conflicts resolution between stakeholders, LEI and PEFC-Chile ask forest managers to produce periodic reports on forest management practices. On the issue of absence of negative consequences for the health and well-being of people (criterion GE), FSC-Chile and PEFC-Chile show better results in comparison to LEI, which is basically focused on the existence of procedures for guaranteeing health and safety and statistics on accidents in the forest area. FSC and PEFC are almost super-imposable, but PEFC includes an extra indicator asking forest managers to develop and implement a strategy to protect the lives and properties of local inhabitants from fire in plantations. As a final comment, LEI has no indicators for Criterion GD that reads: Forest management pays sufficient attention to cultural, recreational, spiritual and archaeological values.

The comparison of the three selected STDs, summarised at the Principle level, in terms of the overall quality of indicators is reported in Fig. 4. The quality of FSC-Chile STD is the highest with respect to the other STDs in Principles A (compliance with law and policy), B (forest health, vitality and extent), and D (biodiversity). The quality of PEFC-Chile STD is higher in Principle G. While these two STDs show very similar profiles for Principle C (productive forest function and sustainable

Table 7
Assessment of the 3 surveyed guidelines against the reference standard, Principles A and F.
Source: own elaboration.

Reference criterion	CIFOR			FAO			ITTO		
	P	S	Q	P	S	Q	P	S	Q
Principle 1 — A. Legal, policy and institutional framework, forest planning									
AA	1.5	0.5	10	0.5	3.5	15	0	3	12
AB	2	1	13	2	2	8	2.5	1.5	16
AC	1.5	3.5	21	0.5	2.5	8	0.5	4.5	19
AD	0	1	5	0.5	3.5	12	1	4	13
AE	0	0	0	1	2	9	1	1	6
AF	0	2	8	2	3	12	2.5	3.5	24
AG	0	1	4	0	2	6	2	1	10
AH	0	0	0	0	1	3	1	1	6
AI	0	0	0	3	1	11	2.5	1.5	14
Sub-total	5	9	61	9.5	20.5	84	13	21	120
Principle 6 — F. Forest management shall be economically viable and shall improve the conditions of local communities and local economies									
FA	0	1	4	3	3	20	1.5	3.5	19
FB	0	0	0	0	3	11	0	0	0
FC	10	2	51	6.5	1.5	23	3	1	14
Sub-total	10	3	55	9.5	7.5	54	4.5	4.5	33

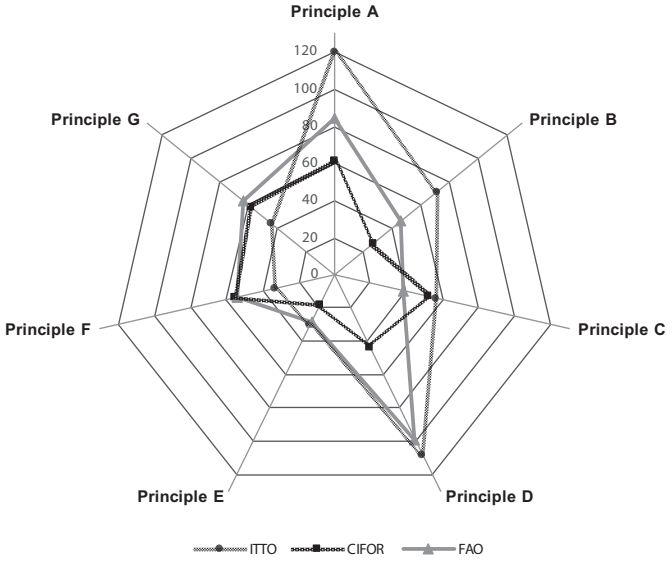
Legend: P = performance-b. approach; S = system-b. approach; and Q = general quality in terms of coherence, consistency and completeness with respect to the reference standard.



Source: own elaboration

Fig. 7. Assessment of the 3 surveyed guidelines against the reference standard, Principle F.
Source: own elaboration.

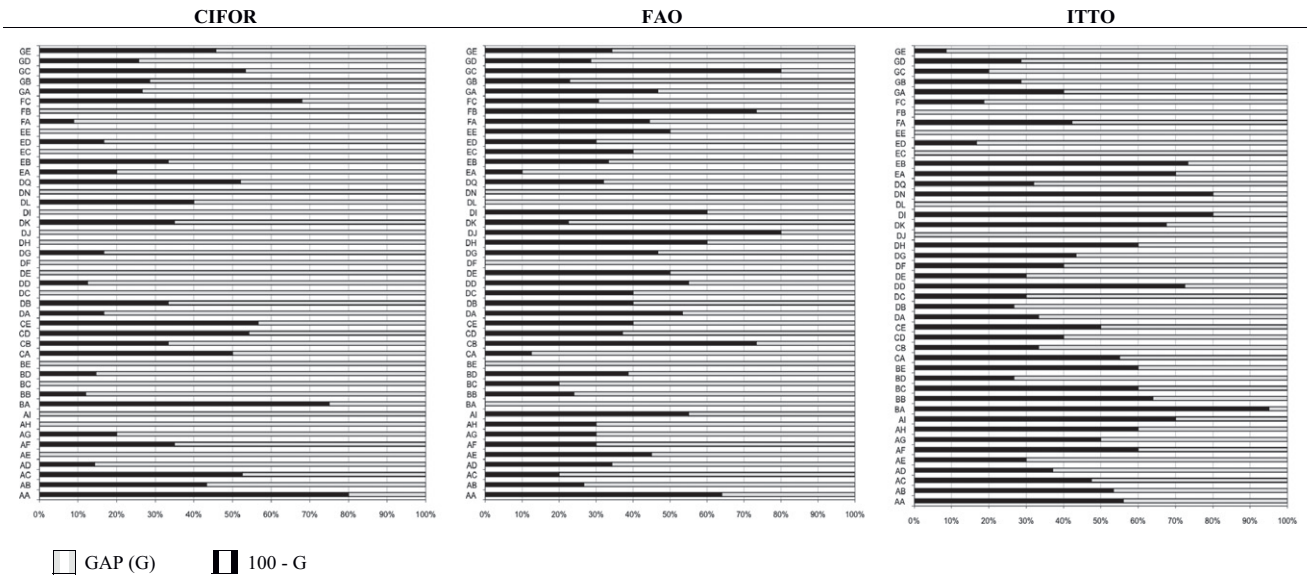
exploitation), and limited difference can also be noticed for the other Principles, LEI shows the lowest results, with the only exception of Principle F (economic viability and improvement of local communities and economies). The analysis shows that the key-issues where all three selected STDs for plantations should be improved, both in terms of number of indicators and their quality, are those covered by Principles C, E (protective forest functions), F and G (social and cultural wellbeing of stakeholders). As already mentioned, this does not mean STDs should be modified in order to look more like the reference standard, which is not intended for direct use in forest management assessment and field verification. Rather, the exercise performed in this study wishes to identify areas for future improvements.



Source: own elaboration.

Fig. 8. Quality of the Indicators for the 3 surveyed guidelines, per principle.
Source: own elaboration.

Finally, the *gap analysis* results for certification STDs is summarised in Fig. 5. LEI *standards for plantations* show the biggest gaps. On a total of 45 criteria included in the benchmark standard, LEI covers 30, while no indicators are developed for 15 criteria, mainly referring to Principles A (4 full gaps) and D (5 full gaps), i.e. indicators are lacking with reference to the legal, policy and institutional framework and to biodiversity and forest ecological services. In particular, with reference to Principle A, LEI appears to be devoid of clear requirements about forest planning (e.g. with reference to minimum contents of forest management plans, as well as to revision of the plan itself), monitoring (e.g. frequency and accuracy of monitoring activities, as well as inclusion of forest results in planning activities), clear definition of forest management objectives and mechanisms to manage possible conflicts between certification requirements and the law. As for Principle D, LEI is missing effective mechanisms for the identification of ecosystems and landscapes with high biodiversity value and measures for managing fauna resources (game and fish). Procedures to help natural regeneration are also lacking: this may seem quite obvious when speaking about forest plantations, where regeneration is, by definition, artificial, but it may suggest a different concept of forest plantations if compared with the one adopted by other forest certification STDs, where forest plantations are only allowed when they lower the pressure on existing natural forests and when they do not replace them, and/or when they create socio-economic benefits without significant negative impacts. This is confirmed also by the fact that LEI standards lack requirements to prefer the use of local species instead of exotic ones and measures to control and minimise the (accidental) introduction of non-indigenous plants, animals, pests or diseases. No indicators at all are available for prevention and monitoring with reference to potential forest damages (criteria BB and BC); monitoring of forest regeneration (criterion CC) and attention to cultural, recreational, spiritual and archaeological values (criterion GD). Even where indicators are available, there are evident gaps as in



Source: own elaboration.

Fig. 9. Gap analysis of the 3 surveyed guidelines with respect to the benchmark standard calculated for forest plantation management.
Source: own elaboration.

the case of several criteria within Principle D, such as biodiversity conservation through proper plantation planning, sound use of chemicals and protection/restoration of natural ecosystems. For example no requirement exists about the presence of an area within the forests estate to be released for natural evolution. Serious gaps can also be noted in the adoption of sound harvesting and planting techniques (Principle C) and in the stakeholders' involvement and participation, transparency and efficiency in communication (criteria GB and GC). However, it is worthwhile to mention that LEI standards for forest plantations were developed in 2005. From April 2010 till August 2014, they have been under a revision process, which included stakeholders' consultation and started in connection with the agreement signed between FSC and LEI for an 18-month collaboration to advance forest certification in Indonesia. In the list of the themes identified by LEI as key-issues to be discussed in its plantations standards revision, most of the above mentioned gaps were included. A new version of LEI STDs is not yet available.

In the case of *PEFC standards for Chile*, full gaps regard 4 criteria, 3 of which belong to Principle D (biodiversity) and one to Principle E (protective forest functions). With regard to the first, PEFC-Chile is completely missing indicators regarding support to natural regeneration, the use of native species and strict control over the use of biological agents. This might be partially due to the technical definition for "forest plantation/timber plantation/productive plantation" provided by the international PEFC standards,[10] where planting or seeding is just expected to be based on "introduced species, and in some cases native species". Another full gap is related to maintenance of water quality through forest management (criterion ED), although other criteria cover descriptive requirements for this issue (e.g. percentage of forest area managed for restoration or protection of water quality). Minor gaps can be identified with reference to economic and financial planning related to forest management, basically in terms of active and direct promotion of forest products on the market, including market analysis and marketing practices (criteria FA and FB), protection and maintenance of soil quality (EA), management of fauna (DE), adoption of sound operations for forest plantation establishment and management (CE) with special reference to planning of site preparation to minimise negative impacts and the use of vegetation strips to contain the spread of diseases. Minor gaps can also be identified with reference to a couple of criteria included in Principle A and dealing with modalities for conducting monitoring activities (i.e. accuracy, frequency and reporting) and mechanisms for resolving potential conflicts between certification requirements and the law. Finally, 3 criteria reached the benchmark level: AH (area use and use intensity of existing infrastructure), CA (sustainable production of wood forest products) and CC (forest regeneration).

With reference to *FSC standards for Chile*, no full gaps can be identified, while 4 criteria fulfil the benchmark requirements: 3 of them regard Principle D, i.e. biodiversity issues, an area where — contrary to what has been observed for LEI and PEFC — no significant gaps seem to exist. The last fulfilled criterion is about the adequacy of infrastructure, as in the case of PEFC. Minor gaps are mainly concentrated in Principle E, with special reference to criteria EA, EC and EE. In the case of EA (soil quality is maintained and protected), gaps regard availability of clear data about areas within the forest estate characterised by soil loss and erosion, and a similar situation can be observed in the case of EC (lack of percentage figures about water bodies with significant change in water quality). Criterion EE, dealing with the role of forests in the carbon cycle, represents a potential area for future improvement, this being a recognized role of multi-purposes-oriented plantations (Paquette and Messier, 2010). Another minor gap regards the increased use of research outputs and new technologies in forest management (criterion AG), which however seems more an institutional gap (or a matter of forest management ideology) rather than a technical one. Finally it can be observed that some room for improvement exists in the case of Principle G, where for example FSC could adopt one of the tools already implemented by PEFC in Chile, i.e. a periodic public reports on forest management activities with results provided by the forest managers.

3.3. Guidelines assessment and gap analysis

The three selected Guidelines for forest plantation management are those developed by CIFOR, FAO and ITTO. According to the first part of

[10] In the glossary "Forest plantation/timber plantation/productive plantation" are reported as "Forest or other wooded land *of introduced species, and in some cases native species*, established through planting or seeding mainly for production of wood or non-wood goods". However, in the requirement 5.4 it is mentioned that a precautionary approach in using exotic species should be adopted (PEFC ST 1003:2010 — Sustainable Forest Management — Requirements).

the analysis (Table 6), none of these have a number of indicators that reach 35% of the total number of reference standard indicators, with CIFOR covering less than 20% (with 77 indicators out of 384), FAO covering 34.9% (134 indicators out of 384) and ITTO covering 32.8% (126 indicators).

Principle A (compliance with law and policy) covers a relevant role in all three selected GLs. Bubbles (Fig. 6) are concentrated in the lower-left corner of the chart, i.e. on average they lie on medium-low system-based values and low performance-based ones. Three groups of criteria[11] (Table 7) can be identified. In the first, including criteria AA and AC, CIFOR shows higher performance-based values than FAO and ITTO (low or null values), but for criterion AA the overall quality of its indicators is lower and for criterion AC it is higher. This is due mainly to the fact that, while asking for policy and planning to include all necessary elements for monitoring and evaluation of current forest management, it requires the availability of historical data on forest management in the area, the incorporation of results from studies and analyses related to all forest functions into planning and the definition of a plan for resources requirements and allocation. The second group includes criteria AF and AB, with different situations. In the case of criterion AF, ITTO's comprehensiveness is higher for all three dimensions, with FAO and CIFOR having similar sizes but different positions: the former shows higher values in terms of performance-based indicators, while the latter is characterised by pure system-based approach indicators. The prevalence of ITTO is mainly connected to the requirement for the presence of an administration responsible for management of all forest resources, with adequate capabilities in terms of financial resources, staff, expertise and equipment. As for criterion AB (presence and implementation of a forest management plan), the three guidelines are quite similar, but ITTO is more complete because it asks also for a periodic revision of the plan on the basis of monitoring results. The third group includes criteria AE, AH and AI, for which indicators are available only in FAO and ITTO GLs, not in CIFOR. For criterion AE both GLs show the same performance level, but FAO has a greater system-based coverage and size, as its GLs ask for the definition of mechanisms for conflict solving between legislation and standard demands, as well as for regular revision of policy and legislation. This might be due to the fact that while CIFOR and ITTO GLs date back to the 1990s, FAO GLs were published in 2006 and thus take advantage of knowledge about forest policy and practices effectiveness gained in the meanwhile.

When considering Principle F (Table 7 and Fig. 7), no overlapping can be observed and three groups[12] can be clearly identified. As shown by the relative position of the bubbles, criterion FA has a prevalent system-based approach, including requirements for economic viability of forest management and improvement of conditions for local communities and local economies. FAO and ITTO show similar results, while CIFOR only covers requirements for the maximisation of the efficiency of management operations. Criterion FB is only covered by FAO, which asks for economic incentives to promote sustainable forest management at the local/national level, including investments in research, development and education on forestry issues. The indicators' approach is, in this case, clearly system-based, as illustrated by the position of the bubble. With reference to criterion FC, CIFOR has the higher number of performance-based indicators (as shown by the position of its black bubble at the extreme right of *x* axis) and a higher relative quality of indicators (as demonstrated by the bubble size). While ITTO guidelines limit themselves to ask for compliance with existing labour laws and regulations (without directly mentioning ILO conventions[13]) and to assure the right to employment and training for local and/or indigenous communities, FAO also includes requirements for safety and health and for guaranteeing negotiation and association rights. CIFOR extends these requirements by including indicators dealing with a clear definition and communication of rights and responsibilities of both forest managers and local communities, as well as the development and real improvement of operational guidelines and training for health and safety procedures. These include cooperation with public health authorities regarding illnesses related to forest management, the use of equipment and the establishment of camps for forestry workers, with special reference to hygiene issues. CIFOR also includes a requirement for equitable distribution and presence of economic rent. All these requirements are perfectly aligned with CIFOR's mission, as stated in its Strategy 2008–2018.

GLs' assessment results have been summarised at the principle level and plotted on a radar chart (Fig. 8). ITTO guidelines play a leading role with reference to Principles A to D, although in the case of Principle C CIFOR guidelines are very close to them, and in the case of Principles D and E FAO GLs show similar results. In other words, ITTO GLs seem to more comprehensive when speaking about compliance with the law and general descriptive requirements to define a picture of forest resources, including figures on extent, general conditions, and health status. The relatively low results of FAO GLs with reference to these same principles can be justified by the different reference-scale — broader in the case of FAO — and by the fact that FAO GLs include direct and continuous links to regional, national or local legislation and regulations. In the case of Principles F and G, ITTO GLs are quite different from FAO and CIFOR ones, with CIFOR showing a prevalent development of its indicators in the field of social and socio-economic issues.

Finally, the *gap analysis results for guidelines* (Fig. 9) show that all three surveyed GLs have full gaps, with none of them totally fulfilling the requirements of the benchmark standards for at least one criterion. *CIFOR guidelines* show the higher gap figures with 15 criteria (out of 45) characterised by a full gap. Most of them (7) are concentrated in Principle D (biodiversity), with special reference to aspects like the use of GMOs, introduction of exotic species, natural regeneration and management of fauna. CIFOR has full gaps with reference to the existence of mechanisms for managing conflicts between guidelines requirements and the law, the implementation of environmental, social and economic assessments when conducting plantation projects and the presence of procedures for assessing whether forest infrastructure is adequate and efficiently used (Principle A). A third big area of full gaps for CIFOR is Principle B, with special reference to the inclusion of a scientific monitoring system for the evaluation of forest damages. Finally, full gaps can be observed in the case of criteria EC (water quality maintenance and protection) and FB (with reference to the presence of indicators to assess whether investments in forest management are adequate and can ensure full sustainability over time). Another area of strong gaps for CIFOR guidelines is related to Principle F, where an improvement would be extremely useful at least regarding water management issues and soil protection. The only Principles where CIFOR guidelines seem to cover the requirements of the benchmark standard quite well are C and G, where only minor improvements can be suggested. In the case of Principle C they regard management and production of non-timber forest products, an issue that is almost entirely ignored by the

[11] See Annex 1 for a full list of criteria codes. Hereafter, only those mentioned in the text are reported: AA — strategic planning of forest resources and environment, in long-term, as part of the overall landscape; AB — a transparent, flexible and efficient management plan exists and is updated on a regular base; AC — policy and planning include all necessary elements for monitoring and evaluation of current management; AF — institutions and adequate means for the support of sustainable forest management exist; AE — sustainable forest management is complementary to prevailing legislation at all levels; AH — adequate and efficient infrastructure is present and maintained with minimal negative impact on the environment; AI — environmental, social and economic impacts assessment are carried out and results included in management plan.

[12] See Annex 1 for a full list of criteria codes. Hereafter are reported the three criteria mentioned in the text. They are all those included under Principle F (Principle F: forest management shall be economically viable and shall improve the conditions of local communities and local economies): FA — the sustainable forest management is economically viable; FB — financial sources and investments in the forest sector guarantee the sustainability of management in the long term; FC — forest management improves local economies by creating employment, training opportunities and education chances for the local and/or indigenous population.

[13] Contrary to ITTO, both FAO and CIFOR directly mention ILO conventions and regulations.

guidelines, while in the case of Principle G they include increased attention to minorities and gender issues within stakeholders' consultation processes and public availability of information on the managed forest area.

In *FAO guidelines* for planted forests, 5 full gaps can be observed with respect to the benchmark: 3 regarding Principle D and Principle B (area, vitality and state of the forest resources maintained). Again biodiversity appears to be an area with limited number of indicators, although in this case their lack regard very specific issues — such as the requirement for silvicultural treatments aiming at stability, uneven-aged and complex forest structures — that can be partly delegated to lower level regulations completing guidelines at local level. Regarding Principle B, full gaps mainly refer to descriptive indicators asking for availability of figures on extension of planted areas, as well as monitoring of land use change, including afforestation and reforestation activities. Minor gaps within guidelines regard the presence of clear indications for the development, updating and improvement of forest management plans (criterion AB) and definition of specific procedures for monitoring (AC). Moreover, considering criterion CA, clear requirements for collection and availability of data on harvesting and timber production (e.g. harvested volumes by species, balance between harvested volumes and increment, appropriateness of harvesting cycles) should be included in the guidelines. Minor gaps can also be identified in Principles E and G. In the first case improvements are possible with regard to maintenance of soil fertility, for instance by asking for the development and implementation of regulations related to soil management and tillage. In the second case, improvements would be recommendable with regard to specific attention and measures to improve stakeholders inclusion and participation in the forest planning and management process, even by encouraging the use (or recuperation) of indigenous knowledge and/or techniques and defining fair compensation mechanisms for their use by forest managers (criterion GB). By the way, these gaps were not expected, being these issues stressed in many FAO policy documents. Improvements are also possible in supporting the recreational function of plantations (mainly in terms of data availability, for instance on access numbers, infrastructure types) as well as the definition and implementation of measures to avoid damage to third party properties and infrastructure.

In *ITTO guidelines*, 4 full gaps can be observed: 2 on Principle D and one each for Principles E and F. For Principle D, specific requirements for controlling and minimising the accidental introduction and/or spreading of non-indigenous plants or animals, pests or diseases (criterion DJ) are missing. Clear requirements for assuring the systematic and timely removal of waste from forest ecosystems are also missing. The indicators asking for the availability of data that can help in assuring maintenance and protection of water quality (criterion EC) and for a clear planning of economic and financial resources in the long term (criterion FB) are also lacking. In addition three areas of relevant gaps can be identified within Principles F and G. In the former, the most critical point is criterion FC, which can become more complete by including specific indicators regarding at least: the degree of equity in the distribution of economic benefits proceeding from forest management; full recognition of workers rights to organise and negotiate; clear definition of rights and responsibilities of both forest managers and local communities; development and implementation of operational guidelines and training for health and safety procedures and equipment for forestry workers, including aspects related to forest camps for workers. Regarding Principle G, additional efforts are needed to improve efficiency and effectiveness of communication between stakeholders, including the definition and implementation of mechanisms for the resolution of conflicts and complaints, and an increased attention on potential negative consequences of forest management activities for the health and well-being of people, even by introducing clear requirements for monitoring and minimising accidents and injures within forest plantations. ITTO guidelines meet the requirements of the benchmark standard quite well with reference to Principles A, B and — partly — C, where just minor gaps can be observed. Among these, the widening of monitoring activities to cover additional aspects (such as illegal activities), damage from bad harvesting practices, pests/diseases and the presence of invasive species. Additional gaps also involve Principle D, when considering for instance the advisability of reinforcing protection and conservation measures for natural ecosystems, landscapes and habitats within the plantation, starting from the introduction of a clear requirement to avoid the establishment of forest plantations at the cost of primary or natural forests. Indicators can also be added with reference to protection of key-species, with a growing use of native trees, to encourage diversity in composition whenever appropriate (in terms of size, spatial distribution, number of species and genes, ages, structures) of forest plantations and favour monitoring of the use of exotic tree species and their impacts on the environment.

4. Conclusions

Different opinions on the relevance, effects and effectiveness of forest plantation and related investments persist, with continuing conflict between supporters and detractors. Despite this strongly debated background, there are no doubts that forest plantations — especially in certain countries, for example China — have expanded rapidly during the last decades, also because of financial resources allocated by national forest policy and international investments. Recent data and analyses show they are likely to continue to grow in the next years.

When analysing initiatives aiming at supporting sustainable development and responsible forest management the thing that strikes most is the contrast between the relevance of forest plantation issues within the international debate and the marginal role the same issues are often given by these initiatives. Few specific initiatives exist. Although the setting of forest management standards increased a lot in the last 20 years, it mostly concentrated on natural forests. Just 11 out of 42 cases assessed in this study are plantation-specific while 15 standards and guidelines do not include any indicators for plantations and 9 of them dedicate less than 5% to forest plantations. Not only are initiatives rarely plantation-specific but they also normally include few and quite generic indicators related to this topic, indirectly suggesting an underestimation of the increasing role of forest plantations in forestry, environment and social sustainability. The analysed standards and guidelines are in many cases focused on environmental or socio-economic topics, but forest plantation issues are seldom addressed or even mentioned.

Clear differences exist among the surveyed set of standards and guidelines in terms of quality of their contents. In all of them, the biggest gap has been identified in the area of maintenance, protection and restoration of biodiversity and ecological processes. In particular, gaps have been identified with reference to monitoring of natural ecosystem components, the maintenance of intact ecosystems and landscapes — including the avoidance of primary/natural forest conversion into forest plantations — the use of exotic species and GMOs. There seems to be some overlapping between the main gaps of standards/guidelines and the areas of biggest concern about forest plantations, so that — although generalisations are not possible — these concerns appear to be well-grounded (see e.g. Estades and Temple, 1999; Paritsitis and Aizen, 2008; Meynard et al., 2014). Other common (though minor) gap-areas are those of protective functions, with special reference to soil protection against erosion and losses in general and water quality maintenance and improvement. Moreover gap-areas also involve the socio-economic and cultural well-being of stakeholders, with special reference to workers conditions and the role of local communities — including indigenous peoples — in forest management planning and, in broader terms, in benefiting from the presence of plantations. Some specific areas of improvement also emerged, for instance the idea of including landscape issues in planning activities. Another “new” area could be that of carbon issues: until now, with few exceptions, they played a complementary role within some standards and guidelines,

being in many other cases just a general topic in the background. The growing attention paid to climate change and the increasing number of carbon projects in the forest sector, acting as one of the most relevant driving forces for the expansion of forest plantations, should lead to the inclusion of specific requirements to link carbon standards with forest management standards as a form of warranty (Caswell, 2014). The partnership agreement signed by FSC and the Gold Standard Foundation in 2012 goes in this direction, trying to combine the FSC approach to social and environmental safeguards and the Gold Standard approach to carbon certification, respectively. Finally, some room for improvement seems to exist with reference to the exploitation and value of NTFPs: they are only marginally considered by standards and guidelines and could provide useful and interesting opportunities for companies and local communities (Ogunsanwo and Adetogun, 2001). The overall impression is that in many cases the productive function still deserves greater attention and catalyses most indicators and measures. Although arguments supporting forest plantations strongly stress aspects dealing with multi-functionality (Stephens and Wagner, 2007; Tomasevic and Estades, 2008; Pawson et al., 2013; Meynard et al., 2014; Wilson et al., 2014), they seem to have remained discourses rather than being explicitly reported in the standards or guidelines text (Bauhus et al., 2010).

Different initiatives show different quality outputs level: for instance, FSC standards for Chile are the only forest certification-based instrument without any full gap in comparison to the benchmark standard, and at the same time they show the higher number of fulfilled criteria, while LEI standards have the lower quality level. Differences in the standards are likely to be connected to the national policy approach towards forest certification initiatives and the international market for certified products. Chile and Indonesia, for example, are both leading countries in the field of forest plantations and related industries, but their national standards have totally different consistency. In the future, research should focus on exploring the situation in other countries and possibly in identifying the internal and external factors influencing the forest plantation standards contents and their different performances. We expect that standards' incompleteness and gaps are more related to the basic structure of the standards formulation rather than to the specific national context.

Among the guidelines, the FAO ones seem to be the most well-balanced, and able to take into account also the more recent trends concerning the need for innovative governance mechanisms based on strengthening stakeholders involvement and introducing conflicts resolution procedures, as well as legal and institutional framework adaptation processes. As mentioned, one of the possible reasons for the leading position of FAO guidelines with respect to CIFOR and ITTO guidelines is the period of their development: about 20 years divide FAO GLs from the other two, which in the meanwhile have not been updated. While the standards for certification are typically revised and updated every few years to take into consideration innovations in technology, knowledge and stakeholders demands, guidelines are not periodically revised/updated even if they might play a relevant role in orienting policy makers and practitioners. With the current trend towards a global forest governance, forest plantation guidelines — with their potential relevant role as policy instruments — should be innovated and globally harmonised.

We are aware — as recently recommended by Clark and Kozar (2011) in the case of forest certification systems — that credible and useful comparisons among effects and effectiveness of sustainable forest management standards should be based on empirically collected data rather than on the wording of principles, criteria and indicators. However, we believe that by highlighting elements of incomprehensiveness of existing standards and guidelines, our gap analysis contributes towards improving the understanding and governance of the forest plantation sector in the future. On the one hand, we are aware that our analysis method could be improved. For example, by introducing a systematic peer-review procedure to be run by a panel of experts by means of a Delphi method approach to reduce subjectivity and divergences of judgement when assessing indicator quality (the weakest point of our study). On the other, we believe that our analysis allows harmonisation and simplification in standards comparison, providing a quick analysis and easy visualisation of results. Our results offer a proxy of the extent to which the standards and guidelines for forest plantation management can indicate sustainability, highlighting gaps and areas for future improvements (e.g. biodiversity and carbon issues), common themes (e.g. forest management plans and fire management), innovative (e.g. visual impacts of forestry activity) and neglected aspects (e.g. the role and importance of NTFPs).

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