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Quantitative analysis of national biodiversity strategy and action plans about incorporating integrated approaches in production landscapes

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A global crisis for production landscapes has shed light on the importance of sustainable management of these landscapes in an integrated manner at local and national levels. However, there is a lack of quantitative research on the integration of relevant concepts into national-level policies and planning. Thus, we analyzed the National Biodiversity Strategy and Action Plans (NBSAPs) of 133 Convention on Biological Diversity parties using a text mining method to determine the current global situation regarding production landscape policies. The statistical results showed that (1) about half of parties mentioned integrated approaches in production landscapes (e.g., cultural landscapes, socio-ecological production landscapes and seascapes), (2) there were some regional differences in the number of references, (3) the introduction of these concepts has been increasing worldwide, and (4) these concepts have been accorded higher priority in national policy and planning.

Keywords: cultural landscapes; landscape approach; National Biodiversity Strategy and Action Plans; socio-ecological production landscapes and seascapes; text mining

1. Introduction

Humans have influenced most of the earth's ecosystems through production activities, such as agriculture, forestry, fisheries, herding, and livestock production (UNU-IAS, Biodiversity International, IGES and UNDP 2014). More than 75% of the world's ice-free land shows evidence of alteration as a result of human residence and land use (Ellis and Ramankutty 2008); that figure includes crop production, which accounts for 12% of land use (FAO 2015). Thus, protecting nature only in limited areas (e.g., protected areas) without considering human involvement is insufficient toward achieving global biodiversity goals. The global population will continue to grow over the next

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few decades and so will the demand for food and other materials. This will place even greater importance on areas devoted to agricultural production. Conserving biodiversity and maintaining healthy ecosystems in these production landscapes will be crucial for sustainable agriculture and future human well-being.

Globally, at least 53% of agricultural land consists of family farms, including small farms (Graeub *et al.* 2016). Family farmers are the predominant actors in the global agricultural system and make a significant contribution to agricultural production (Graeub *et al.* 2016). There are claims that industrial, large-scale agriculture is harmful to the environment, such as through biodiversity degradation, soil erosion, water pollution, and use of non-renewable resources (Horrigan, Lawrence, and Walker 2002); by contrast, traditional land-use systems of family or small farms are considered to maintain the resilience of local ecosystems (Plieninger, Höchtl, and Spek 2006; Koohafkan 2009; Takeuchi 2010; Mijatović *et al.* 2013). Many of these traditional systems are spread across landscapes that comprise a mosaic of different ecosystem types, which have been shaped by the production activities of local communities (Bergamini *et al.* 2013). Such traditional systems have been gaining attention since they tend to place less burden on the environment (Plieninger, Höchtl, and Spek 2006), play an important role in food security and poverty alleviation (Fan and Chan-Kang 2005; Koohafkan 2009), benefit biodiversity through the high habitat heterogeneity of their landscape mosaic (Benton, Vickery, and Wilson 2003; Plieninger, Höchtl, and Spek 2006; Koohafkan 2009; Takeuchi 2010; Kadoya and Washitani 2011; Mijatović *et al.* 2013), and are deeply linked to local traditional knowledge (Koohafkan 2009; Mijatović *et al.* 2013). These landscapes present different features depending on the natural environment and the way in which local communities utilize and manage them. Some of these landscapes have specific names; examples include *dehesa*, an agro-silvo-pastoral system in Spain (e.g., Vicente and Alés 2006), and the *satoyama* landscape in Japan (e.g., Kadoya and Washitani 2011; Takeuchi, Ichikawa, and Elmqvist 2016), a mosaic of coppiced woodland, paddy fields and farmland, irrigation canals and ponds, and human settlements. In many cases, practices in these systems (such as agroforestry, rotational farming, coppicing, and transhumance) safeguard the soil and vegetation for future production; the practices maintain agrobiodiversity, which supports ecosystems and the livelihood of local communities (Niamir-Fuller 1998; Finegan 2004; Jose 2009; Katoh, Sakai, and Takahashi 2009). Often, the use of natural resources is restricted in small parts of the landscape for cultural and religious purposes, resulting in greater biodiversity (e.g., sacred groves in India) (Ormsby and Bhagwat 2010). In addition, knowledge about the management of natural resources has accumulated over generations and helped sustain ecosystems and biodiversity. However, social and economic change accompanying modernization is threatening these landscapes around the world, and the importance of sustainable management has been increasingly discussed (Vos and Meekes 1999; Ichikawa 2013; Plieninger and Bieling 2013; Gu and Subramanian 2014; Takeuchi, Ichikawa, and Elmqvist 2016; Plieninger *et al.* 2017).

The roles of humans in biodiversity conservation through production activities and natural resource management have been clearly recognized in the Convention on Biological Diversity (CBD) since its adoption in 1992. For example, the convention recognizes the importance of traditional knowledge held by indigenous and local communities for conservation and the sustainable use of biodiversity. The livelihoods and culture of those communities have directly depended on nature. One of the objectives of the convention is the sustainable use of biodiversity, focusing on both human and natural elements. Recently, the 13th Conference of Parties of CBD (CBD COP) discussed how conservation and sustainable use of biodiversity could be integrated into sectoral and cross-sectoral plans, especially in the agriculture, forestry, fisheries, and tourism sectors (CBD 2016b).

There are more focused international efforts concerning production landscapes with the aim of achieving multiple objectives, such as development and conservation. One example is the Satoyama Initiative. This was established through collaboration between the Ministry of the Environment of Japan and the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS). It has the vision of "realizing societies in harmony with nature" (IPSI Secretariat 2015, 4). A global network called the International Partnership for the Satoyama Initiative (IPSI) was established at the time of the 10th CBD COP. The aim was to implement the IPSI through promoting efforts to conserve biodiversity while securing local socio-cultural and economic benefits in areas the initiative calls "socio-ecological production landscapes and seascapes" (SEPLS) (IPSI Secretariat 2015, 9). In terms of agriculture, one program of the Food and Agriculture Organization (FAO) of the United Nations called Globally Important Agricultural Heritage Systems (GIAHS) was launched in 2002. GIAHS underscores that various agricultural systems that have been shaped by generations of farmers and herders have contributed to the food and livelihood security of small farmers, agricultural biodiversity, culture, and knowledge in addition to landscape beauty (FAO 2013). In Europe, it is recognized that most rural areas have been under human influence and can be regarded as cultural landscapes; many of them provide multiple benefits for humans, including culture and biodiversity (Tieskens *et al.* 2017). Many landscape-level initiatives are being implemented to address various issues caused by globalization and associated changes (García-Martín *et al.* 2016). These movements are in alignment with the rise of a more integrated approach in various conservation efforts or development interventions. For example, activities for sustainable management of SEPLS by IPSI members have been implemented while recognizing the importance of the landscape approach (Lopez-Casero *et al.* 2016; UNDP 2016). Recognizing the multi-functionality of landscapes and various interrelated issues, approaches using multiple objectives and dealing with a broader understanding of landscapes have become promoted around the world (Sayer *et al.* 2013).

In addition to these global trends, it is vital that such concepts and approaches are incorporated into policies so as to bring about changes to real landscapes (Vos and Meekes 1999; Pfund 2010; Gu and Subramanian 2014; Takeuchi, Ichikawa, and Elmqvist 2016; Plieninger *et al.* 2017); national-level policy is key to incorporating global-level recognition and affecting landscapes directly or indirectly through local-level policies. However, it is largely unknown to what extent such new concepts and approaches are being applied in national policies. Such knowledge could inform current global-level policy processes and national-level policy discussions.

In the present study, we attempted to determine the trend of national-level policies on biodiversity from the perspective of sustainable production landscapes, including traditional land-use systems that are shaped by human–nature co-evolution. Such landscapes provide multiple benefits to humans, and they require integrated approaches for their sustainable management. We analyzed National Biodiversity Strategy and Action Plans (NBSAPs), which are the highest national policy documents on biodiversity developed by a country for implementing the CBD at the national level.

Hitherto, no scientific, quantitative analysis of NBSAPs has focused on concepts and approaches, such as SEPLS, cultural landscapes GIAHS, landscape approaches, and other integrated managements. Therefore, to analyze the application status of these concepts, we adopted a quantitative approach, with text mining and statistical and co-word analysis of NBSAPs. In the next section, we present a review and examination of various related concepts; we then review recent studies on NBSAPs and text mining. In the Methods section, after reviewing studies on text mining, we introduce the text data and set the codes based on the concept review; that is followed by the text mining analysis. Through the statistical and co-word analysis, we determined to what extent the concepts are being globally applied in NBSAPs – partially or comprehensively.

2. Concept review

Various terms embrace the perspective of the human–nature interrelationship in multifunctional production landscapes and integrated approaches to conservation and people's well-being. This section reviews such terms to derive a set of terms for use in the subsequent text mining analysis.

2.1. Production landscapes

SEPLS are dynamic mosaics of habitats and land and sea uses where the harmonious interaction between people and nature maintains biodiversity while providing humans with the goods and services needed for their livelihoods, survival, and well-being in a sustainable manner (IPSI Secretariat 2015). The term originated in the work of the Japan Satoyama Satoumi Assessment (Duraiappah *et al.* 2012), which was implemented from 2006 to 2010 by over 200 experts, applying the framework used in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005). The assessment identified the nature of *satoyama* and *satoumi* (coastal landscapes) as producing multiple benefits to humans: the interaction between humans and their environment is mutually beneficial if properly managed.

Around the world, there are many SEPLS that derived from traditional production activities and land uses (Ichikawa 2012; UNU-IAS and IGES 2015; UNU-IAS and UTIAS/UTIAS 2016). In some cases, they have specific local names, e.g., *muyong* in the Philippines, *kebun* in Indonesia and Malaysia, and *dehesa* in Spain (IGES 2013); in others, they lack specific names. Some traditional production activities and land uses are supported by development and conservation projects by international organizations (UNDP 2016; GEF CI UNU-IAS IGES and Satoyama Initiatives 2017).

Similar to SEPLS, the term "cultural landscape" is used to refer to landscapes that have been shaped through long-term interaction between nature and humans, such as Scandinavian semi-natural grasslands, *coltura promiscua* in Italy, and *dehesa* in Spain (Plieninger, Höchtl, and Spek 2006). In the Operational Guidelines for the Implementation of the World Heritage Convention of UNESCO, cultural landscape is described as "combined works of nature and of man" (UNESCO 2017, 4). Farina (2000, 313) stated, "Cultural landscapes are geographical areas in which the relationships between human activity and the environment have created ecological, socioeconomic, and cultural patterns and feedback mechanisms that govern the presence, distribution, and abundance of species assemblages." The concept of cultural landscapes is complex and ambiguous owing to their long history (e.g., Vos and Meekes 1999; Jones 2003; Plieninger and Bieling 2012); however, SEPLS and cultural landscapes have many points in common, such as dynamic mosaics, harmony between human society and nature, and a focus on local knowledge and culture (Plieninger and

Bieling 2013; Plieninger *et al.* 2017; Tieskens *et al.* 2017). SEPLS and cultural landscapes share some examples, such as *dehesa* in Spain. Like SEPLS, many cultural landscapes contribute to farmland biodiversity (Farina 2000; Plieninger and Bieling 2013).

Another similar concept that represents multi-functional production landscapes in the context of conservation and development is GIAHS. GIAHS was defined by the FAO in 2002 as "remarkable land use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development" (FAO 2013, 3). As pointed out by Takeuchi (2010) and Plieninger *et al.* (2017), SEPLS and GIAHS share a similar spirit. However, with GIAHS, it is necessary that the landscape have a "global" significance. As of 5 February 2018, 47 sites from 19 countries had been designated as GIAHS, such as the *ghout* system in Algeria, the Fuzhou jasmine and tea culture system in China, and Andean agriculture in Peru.

2.2. Integrated management approaches

Although there is no universal definition of "landscape approach," it has been widely applied to various types of research and practices (Sayer *et al.* 2013, 2017; Reed *et al.* 2017) and Sayer *et al.* (2017, 466) defined the landscape approach as "a long-term collaborative process bringing together diverse stakeholders aiming to achieve a balance between multiple and sometimes conflicting objectives in a landscape or seascape." Many collaborative initiatives called "integrated landscape initiatives" have been identified around the world: there are 71 such initiatives in Europe; 166 in South and Southeast Asia; 382 in Latin America and the Caribbean; and 105 in Africa (Estrada-Carmona *et al.* 2014; Milder *et al.* 2014; García-Martín *et al.* 2016; Zanzanaini *et al.* 2017). The approach derived from landscape-scale thinking in the context of biodiversity conservation. It further developed by recognizing the need to address the priorities of people in relation to landscapes (Sayer *et al.* 2013). In practice, the approach provides a framework for many interventions to deal with multiple objectives for both development and conservation. The term "integrated landscape management" has been used to signify almost the same as "integrated landscape approach" (Estrada-Carmona *et al.* 2014). "Landscape management" was defined as "action, from a perspective of sustainable development, to ensure the regular upkeep of a landscape, so as to guide and harmonize changes that are brought about by social, economic and environmental processes" in Article 1e of the European Landscape Convention (https://rm.coe.int/1680080621). Integrated landscape management focuses on merging the nature and cultural aspects of landscape management (Stenseke 2016).

It is notable that these approaches were embraced in the ecosystem approach, which was adopted in the second CBD COP in 1995 as the primary framework for action under the convention (Sayer *et al.* 2013). As further elaborated in the fifth COP (https://www.cbd.int/decision/cop/default.shtml?id=7148), "ecosystem approach" was defined as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (CBD 2000). In dealing with more complex situations, the ecosystem approach integrates previous approaches (such as biosphere reserves, protected areas, and single-species conservation programs) that had hitherto been mainstream. The CBD requires that parties take into account the ecosystem approach and highlight the ecosystem services in their NBSAPs (CBD 2008).

2.3. Conceptual focus of the analysis

For practical purposes in the present study, we tentatively refer to all the above concepts as "integrated approaches in production landscapes." Our intention is not to propose a new concept to integrate all related concepts: we aim to determine how such a group of concepts – expressed using different terms – is reflected in national policies around the world.

3. Materials

We analyzed NBSAPs, which are the highest national policy documents on biodiversity developed by a country for implementing the CBD at the national level. The CBD requires that parties prepare an NBSAP and ensure that this strategy is mainstreamed into the planning and activities of all sectors that can affect biodiversity (CBD Article 6). As of 31 July 2016, 185 of 196 parties formulated and submitted their NBSAPs to the CBD Secretariat. Thus, it may be supposed that global trends in national policies on biodiversity can be assessed by analyzing NBSAPs. We have observed that, even if an NBSAP referred to new concepts and approaches, this did not always mean that the concepts would transform into concrete measures. It is necessary to conduct an in-depth study to examine the details of the situation in each country. To research laws, budgets, projects, and subsidies in each country would help in determining the actual situation about concepts becoming incorporated into policies. However, we may say that references to concepts in NBSAPs signify that a country is, to some extent, focused on such concepts.

The CBD Secretariat reviews the situation regarding formulation and revision of NBSAPs on a regular basis (see CBD 2014, 2016b). The FAO and CBD conducted quantitative analyes of NBSAPs using a key word search; they identified the overall trend using frequency of key words, such as "ecosystem" (FAO and CBD 2016; FAO, CBD, SPREP, and SPC 2016). However, not many scientific studies have been conducted about NBSAPs (e.g., Prip *et al.* 2010; Adenle, Stevens, and Bridgewater 2015; Pisupati and Prip 2015; Sarkki *et al.* 2015). Prip *et al.* (2010) conducted a comprehensive assessment of the preparation, content, adequacy, and effectiveness of NBSAPs; it included desktop overall reviews of a large number of NBSAPs and in-depth studies for nine countries. Adenle, Stevens, and Bridgewater (2015) adopted qualitative research, including interviews, which focused on the development process of NBSAPs. The authors argued that limiting the power of NBSAPs should be avoided by improving awareness of biodiversity values in public or other ministries in developing countries. Pisupati and Prip (2015) conducted an assessment of NBSAPs after 2010. They undertook a preliminary desktop review of 25 NBSAPs after the 10th COP and focused on the incorporation of the Aichi Biodiversity Targets. Sarkki *et al.* (2015) focused on the Finnish NBSAP. They reviewed the development process of the NBSAP in terms of mainstreaming biodiversity in other sectors. However, no scientific, quantitative analysis of NBSAPs has focused on the related concepts of integrated approaches in production landscapes.

4. Text mining and statistical analysis

4.1. Text mining

This study employed text mining to analyze the penetration of concepts related to integrated approaches in production landscapes in NBSAPs. Text mining is a knowledgeintensive process that seeks to extract useful information from unstructured textual data from document collections by identifying and exploring interesting patterns (Feldman and James 2007; Horbach and Halffman 2016). Many researchers have successfully used text mining to analyze large amounts of textual data (e.g., He, Zha, and Li 2013), including the analysis of policy documents (e.g., Cojanu, Gavris, and Popescu 2015; Murao and Sakaba 2016; Ishihara-Shineha 2017). Therefore, we believed that text mining would be appropriate for determining the overall trends of mass documents related to NBSAPs.

In this research, we used KH Coder 2.0 (http://khc.sourceforge.net/en/) (Higuchi 2016) – a freeware developed for quantitative content analyses, including text mining (Higuchi 2016). KH Coder has been utilized in various scientific arenas, including policy sciences (e.g., Cojanu, Gavris, and Popescu 2015; Murao and Sakaba 2016; Ishihara-Shineha 2017), for text mining. The developer of KH Coder proposed the following two-step approach to quantitative content analysis. Step 1 extracts words and terms automatically from original data (subject documents) using KH Coder; the words and terms are then statistically analyzed to obtain a whole picture and explore the features of the data, while avoiding any researcher prejudices (text mining). Step 2 specifies coding rules, such as, "If there is a particular expression, we regard it as an appearance of concept *A*." Concepts are extracted from the data; then, statistical analyses are conducted to examine the concepts, thereby deepening the analysis (Higuchi 2016).

We adopted this two-step approach; however, with Step 2, we employed an additional analysis to determine how concepts related to integrated approaches in production landscapes had penetrated NBSAPs. We also conducted statistical analyses to examine the co-occurrence of terms and codes to explore how they related to integrated approaches in production landscapes. Co-occurrence analysis is often used with text mining to identify relationships between concepts and terms (e.g., Amemiya, Hata, and Kikuchi 2014; Cojanu, Gavris, and Popescu 2015; Hara *et al.* 2016; Horbach and Halffman 2016).

Existing review studies of NBSAPs employed qualitative approaches, such as reading texts and conducting interviews (e.g., Prip *et al.* 2010; Adenle, Stevens, and Bridgewater 2015; Pisupati and Prip 2015; Sarkki *et al.* 2015). Such approaches can provide an understanding of practical implementation plans, budgets, progress, and achievements. However, they demand considerable effort and are not suitable for evaluating overall trends and handling large text volumes. By contrast, quantitative text mining allows the handling of many more NBSAPs and an easy grasp of overall trends.

Our analysis was implemented in the following stages. First, we prepared the data and selected the codes based on the concept review. Second, we conducted text mining analysis using these data and codes. Finally, we conducted a statistical analysis of the differences, relationships, and co-occurrences among references and appearance frequency related to the codes and groups. We did this to determine the overall trends for the global penetration of integrated approaches in production landscapes and their partial or comprehensive penetration.

4.2. Text and concept extraction

4.2.1. Data preparation and text extraction

The textual data set for this research was all CBD parties' latest NBSAPs written in English and posted on the CBD Web site as PDF files, as of 31 July 2016 (133 parties: 132 countries and the European Union [EU]). Some NBSAPs were not provided in English; we were unable to investigate many from Central and South America (in

Spanish and other languages) and Africa (in French and other languages). This linguistic factor may have affected the regional trend. However, our focus on the 133 NBSAPs covered 72% of the parties who had submitted NBSAPs by 31 July 2016.

We downloaded the PDF files and converted them to text files using Adobe Acrobat Reader DC (Adobe Systems Incorporated, San Jose, CA, USA). The image PDF data were processed using the software's Optical Character Recognition function to extract the text files. We then checked the spelling and dealt with any errors that arose during the conversion. We deleted figures, references, indexes, tables of contents, and appendices, leaving the main content of the NBSAPs. We conducted these processes manually using the original PDF files. The contents of tables inserted in the body text were converted into sentence format: many action plans or indicators were written as tables, and they constituted important NBSAP information. We used the following rule to convert table contents to sentence format. One line in a table was basically converted into one sentence. If multiple columns existed, we checked whether columns in the same line had a sentence-like relationship to one another: if so, we connected the text in the separate columns into a single sentence using commas. Following this process, we converted a table into a paragraph. We then counted and extracted frequently used terms with KH Coder.

4.2.2. Concept extraction by coding: selection of codes

We specified coding rules and extracted concepts from the data: the text files for the 133 NBSAPs processed in the previous stage. Coding is central to whole-text analysis. The fundamental tasks involved in coding are sampling, identifying themes, building code books, marking texts, constructing models (relationships among codes), and testing the models against empirical data (Ryan and Bernard 2004).

With these tasks, instead of sampling, we applied the concept review; we identified integrated approaches in production landscapes in terms of themes. We then classified the codes and sets of key words, i.e., we built code books. We first reviewed and examined the concepts related to integrated approaches in production landscapes to establish the codes; we then set the codes as a conceptual group of key words (Horbach and Halffman 2016).

The related concepts that we identified through our literature review for inclusion in our analysis were classified as follows: SEPLS, cultural landscapes, GIAHS, landscape approach, integrated landscape management, and ecosystem approach. We used integrated approaches in production landscapes as an umbrella concept. This included SEPLS, cultural landscapes, GIAHS, landscape approach, integrated landscape management, and related traditional production activities with specific local names (e.g., satoyama). We classified the ecosystem approach as a different type of concept from integrated approaches in production landscapes and their constituents: the former term is a much more basic and broad concept. It is often used, not in the management of production landscapes but for protected areas.

We did not expect the concept of integrated approaches in production landscapes to be widely applied in the NBSAPs. Integrated approaches in production landscapes encompass complex constituent ideas. However, each idea can be applied widely, and we tried to evaluate the penetration of these constituent ideas. To determine the constituent ideas for text mining, an ideal way to derive the characteristics of "integrated approaches in production landscapes" might have been to compare the definitions or criteria of the concepts related to such approaches and identify their common characteristics. However, such an approach would be very difficult because there is no clear definition of "cultural landscapes," "landscape approach," or "integrated landscape management." The only clearly defined concepts are SEPLS and GIAHS. The GIAHS focus on globally significant landscapes; thus, we applied the definition of "SEPLS," which is not necessarily globally significant and clearly consists of four characteristics (i.e., dynamic mosaics, harmonious interaction between people and nature, providing ecosystem services, and local knowledge); we analyzed the frequency of these four characteristics. This enabled us to determine which characteristics had penetrated well and which had not. Identifying the characteristics that had been poorly accepted and suggesting measures to enhance them could promote acceptance of the whole concept.

4.2.3. *Concept extraction by coding: selection of key words for each code*

The coding rule in this study was that if we found a key word related to a concept listed in Table 1, we regarded it as the appearance of the concept listed in the "Code" column in that table. In addition, we established groups, which integrated the codes, for further analysis.

First, we classified the codes and key words related to the concepts of integrated approaches in production landscapes. Some of the key words were added from related research papers and UN publications searched using Google Scholar, such that the terms, phrases, or combination of terms could sufficiently express the codes. We

Table 1. List of group, codes and main key words.

Group	Code	Examples of keywords
A1	GIAHS	Globally Important Agricultural Heritage Systems, GIAHS
	SEPLS	SEPL, SEPLS, socio-ecological production landscape, social ecological production landscape
	Cultural landscape	Cultural landscape, biocultural landscape, high-nature-value farmland
A2	Traditional natural resource management	Dehesa, ahupua'a, satoyama,satoumi, muyong, community forestry, transhumance, agroforestry, homegarden, fruit garden, etc
A3	Landscape approach	Landscape approach, integrated landscape management
B	Dynamic mosaics of habitats and land and sea uses	Dynamic mosaic, mosaic land use, heterogeneous, and landscape
	Harmonious interaction between people and nature maintains biodiversity	Human influenced landscape, society harmony with nature, etc.
	Providing humans with the goods and services in a sustainable matter	Sustainable natural resource use, etc.
	Be deeply linked to local culture and knowledge.	Local knowledge, local culture, traditional knowledge, etc.
C	Ecosystem approach	Ecosystem approach
D	Landscape	Landscape
	Seascape	Seascape

established six groups for sorting the codes and key words based on the organization of the concepts using our assessment of the characteristics related to the concept of integrated approaches in production landscapes (Table 1).

We used Group A to analyze overall trends in the penetration of the concept of integrated approaches in production landscapes into NBSAPs. This group was based on the concept of these approaches.

Group A1 focused on production landscapes that adopted integrated approaches. This group comprised the following codes: SEPLS, cultural landscapes, and GIAHS. We extracted key words from the references in the Concept Review section.

Group A2 contained the local names where integrated approaches have traditionally been adopted. This group corresponds to the code "traditional natural resource management." The key words in this code involved multiple traditional and local names for land management. We extracted these names from IPSI publications, which had collected many cases of traditional natural resource management, as well as the references in the Concept Review section.

Group A3 focused on both integrated approaches and landscapes, but it was not limited to production landscapes. This group corresponds to the code "landscape approach." We extracted the key words from the references in the Concept Review section.

We used Group B to analyze how the concept of integrated approaches in production landscapes was accepted partially or comprehensively. This group comprised the main four characteristics of the concept of SEPLS and consisted of four codes. We employed four elements in the descriptions of SEPLS as representative of integrated approaches in production landscapes. We did so because SEPLS was clearly defined; that was in contrast to the ambiguity of cultural landscapes or the landscape approach. The concept of SEPLS covered the concepts of cultural landscapes with regard to biodiversity and the landscape with respect to production activities. Furthermore, SEPLS is much stricter because the concept explicitly focuses on production landscapes. In addition, the GIAHS definition included value judgments and thus was unsuitable for the broad perspective of the present study. We extracted the key words from related research papers and publications for each of the four SEPLS. The four codes in Group B were as follows: (1) dynamic mosaics of habitats and land and sea uses; (2) harmonious interaction between people and nature maintaining biodiversity; (3) providing humans with goods and services in a sustainable manner; and (4) being deeply linked to local culture and knowledge.

Group C was based on integrated approaches and a more fundamental, broader concept, not necessarily focused on production landscapes. We established this group for a comparison of integrated approaches in production landscapes, and it corresponded to the code "ecosystem approach."

We used Group D to analyze basic concepts related to integrated approaches in production landscapes and for comparison purposes. This group corresponded to the codes "landscapes" and "seascapes."

The full list of key words appears in Table 1. We marked the texts of the 133 NBSAPs using our code books, and we calculated each code's references in sentences using KH Coder 2.0. We then performed a chi-square test of independence to examine the independence of each code. We set the significance level at $P < 0.05$. The number of key words differed for each code, and that difference could affect the appearance frequency of each code. Therefore, we attempted to select the necessary key words sufficient to express the codes.

4.3. Statistical analysis

Using the results of the text and concept extraction, we analyzed the number of NBSAPs and appearance frequency of each group and code. We conducted a statistical analysis to determine the overall trends of global penetration of integrated approaches in production landscapes. We then undertook co-occurrence analysis to identify how the concepts penetrated partially or comprehensively.

4.3.1. Overall trends of global penetration of integrated approaches in production landscapes

Our targeted 133 NBSAPs included one for each country plus the EU. We calculated and compared the number of countries (hereafter, including the EU) with reference to the codes, groups, and appearance frequency; we did so to analyze the references to integrated approaches in production landscapes in the NBSAPs. Then, to determine the overall trend of the global penetration of the concepts in the NBSAPs, we analyzed the following four aspects.

The first aspect was Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) region and sub-region. The IPBES region was based on such factors as biogeographic characteristics and geographic proximity; the sub-regional scale was set to assess the landscape-level characteristics (IPBES 2015). Thus, these region divisions were appropriate for determining the regional and sub-regional differences in the penetration of integrated approaches in production landscapes. We used the Steel-Dwass test as a nonparametric multiple comparison test to verify the differences between regions and sub-regions. We set the significance level at $P < 0.05$.

The second aspect was the relationship between the distribution and situation of production landscapes. The Satoyama Index (SI) reflects the heterogeneity of production landscapes; it serves as a proxy for biodiversity richness, and landscapes with a high SI are distributed worldwide, especially in East Asian and Southeast Asian paddy belts (Kadoya and Washitani 2011). We expected that countries having a high SI indicated deeper incorporation of the concept of integrated approaches in production landscapes. They appear to have incorporated the concept into their policies for encouraging biodiversity. The SI was originally computed with the methodology proposed by Kadoya and Washitani (2011) using global land-use data for 2013 provided by the Global Map data archives (computed results appear in Figure A1). We averaged these data for each country for use in the statistical analysis. We employed the Spearman rank correlation coefficient (ρ) for comparative analysis to verify the relationship between the average SI for each country and the appearance frequency of each group and the total for all groups. We set the significance level at $P < 0.05$.

The third and fourth aspects were the year of publication and versions of NBSAP for analyzing the relationship with time trends. Among the 133 NBSAPs, the oldest documents were published in 1995 (10 countries); the latest appeared in 2016 (26 countries), and 2009 was the average publication year. For our analyses, we used the latest version of the NBSAP for each country. The average number of revisions was 1.72; the lowest number was zero (60 NBSAPs), and the maximum was 5 (1 NBSAP). CBD promoted NBSAP revisions, and it had a supporting revision program based on COP decisions (CBD 2010). We expected that later, revised NBSAPs would more accurately describe a country's biodiversity, and we supposed that they would more fully incorporate the concept of integrated approaches in production landscapes. We used the Spearman rank correlation coefficient in comparative analysis to verify the relationship between years of NBSAP publication and versions, and the appearance frequency for each group and for all groups. We set the significance level at $P < 0.05$. In this regard, we statistically analyzed the average of the appearance frequency for groups 1–6 and for all groups using JMP 13 (SAS Institute Inc., Cary, NC, USA).

4.3.2. Trends of partial penetration of integrated approaches in production landscapes

To examine how the concept of integrated approaches in production landscapes penetrated partially or comprehensively, in Group B we compared the numbers of references for each code; we analyzed the co-occurrence of each code. Group B comprised four codes, with each corresponding to one of the four characteristics of SEPLS. We expected that differences in the number of references for each code and the relationship between the codes would indicate the penetration differences of the SEPLS characteristics. To determine the co-occurrence of codes and groups, we calculated the Jaccard coefficient of each code in a paragraph using KH Coder. The Jaccard coefficient has a value between 0 and 1: a value of 0 indicates no similarity; a value of 1 indicates similarity (Niwattanakul *et al.* 2013). Previous studies have used the Jaccard coefficient to find the co-occurrence of multiple codes in text mining using KH Coder. Amemiya, Hata, and Kikuchi (2014) identified codes when the Jaccard coefficient was greater than 0.1; Hara *et al.* (2016) found key words with the 10 highest Jaccard coefficients of 0.018–0.139; Horbach and Halffman (2016) determined themes using the 20 highest Jaccard coefficients in a co-occurrence network. In the present study, we identified combinations of codes using the 10 highest Jaccard coefficients.

5. Results and discussion

5.1. Overall results of text and concept extraction

The results of the text extraction analysis with KH Coder were as follows: the number of countries was 133, number of paragraphs 39,503, and number of sentences 167,945. The number of sentences differed for each country: minimum 89, maximum 5,024, median 1,123, quartile range 660.5–1,704. The term that most frequently appeared was “biodiversity”: it appeared 31,209 times and was followed by “species” (23,801), “area” (21,604), and “conservation” (18,113). The results of the concept extraction by sentences with numbers of references to each of the 12 codes appear in Table 2. The most referred code was “being deeply linked to local culture and knowledge,” followed by “landscape”; the least referred was “GIAHS.” All the codes except for “GIAHS” were significantly independent of countries and regions using the chi-square test (11, $N = 133$; $^{**}P < 0.01$, $^{*}P < 0.05$) (Table 3). GIAHS was not significantly independent because the number of references to this term was very low. However, among targeted countries, 11 had GIAHS-designated sites (19 countries, 47 sites) as of 5 February 2018.

5.2. Overall trends of global penetration of integrated approaches in production landscapes

Most of the countries (132, 99%) referred to one or more of the four SEPLS characteristics (Group B). Many countries referred to “landscapes” (Group D, 116 countries, 87%). About half of the countries (59) referred to Groups A1–A3 (Figure 1).

Not all the key words were referred to well in the NBSAPs. Some of them appeared only once or twice per NBSAP, if at all (Figure 2).

Table 2. Number of sentences referring to each code.

Group	Code	Number of sentences referred to the codes
A1	GIAHS	3
	SEPLS	11
	Cultural landscape	49
A2	Traditional natural resource management	306
A3	Landscape approach	21
B	Dynamic mosaics of habitats and land and sea uses	26
	Harmonious interaction between people and nature maintains biodiversity	266
	Providing humans with the goods and services in a sustainable matter	810
	Be deeply linked to local culture and knowledge.	1,996
C	Ecosystem approach	312
D	Landscape	1,960
	Seascape	117

Table 3. Chi-square scores for each code.

Group	Code	The chi-square score
A1	GIAHS	96.889
	SEPLS	443.417**
	Cultural landscape	969.845**
A2	Traditional natural resource management	1275.354**
A3	Landscape approach	329.105**
B	Dynamic mosaics of habitats and land and sea uses	175.801**
	Harmonious interaction between people and nature maintains biodiversity	653.196**
	Providing humans with the goods and services in a sustainable matter	801.261**
	Be deeply linked to local culture and knowledge.	2216.437**
C	Ecosystem approach	1624.186**
D	landscape	4222.298**
	seascape	941.062**

**$P < 0.01$.

The appearance frequency of the code for integrated approaches in production landscapes (Group A) was very low. However, 59 countries (about half) referred to Group A. This was almost the same proportion as the number of countries that referred to the "ecosystem approach" (Group C, 61, 46%); the inclusion of ecosystem approaches was recommended in the NBSAP training modules (Secretariat of the Convention on Biological Diversity 2011) (Figure 1).

5.2.1. Regional trends

We analyzed the trends regarding concept penetration from four aspects: IPBES region and sub-regions; SI; published years; and versions. We found small but significant geographic differences. Europe's NBSAPs referred less to Group A2; more referred to

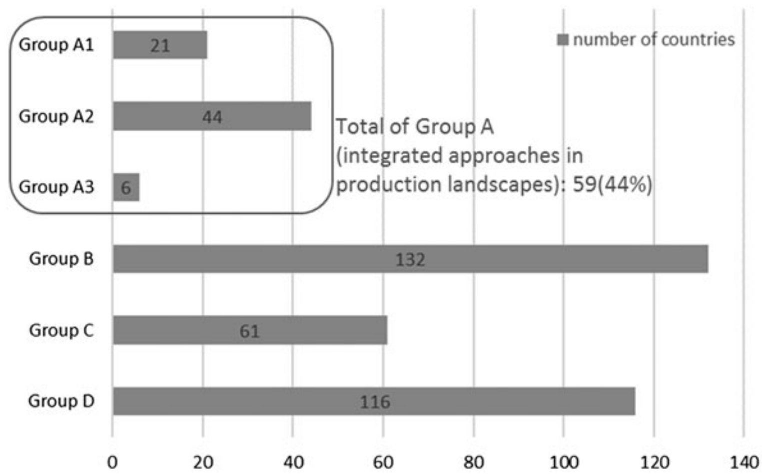

Figure 1. Number of countries refer to each group in total (total: 133 countries).

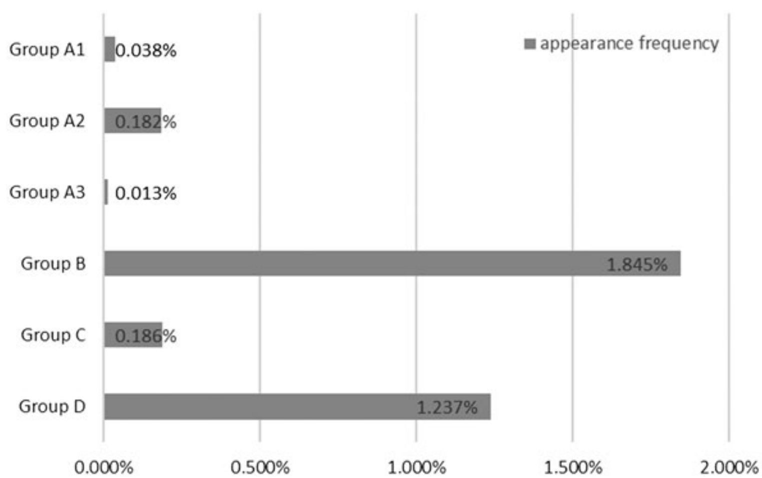

Figure 2. Appearance frequency of each group in total (%).

Group D. However, the other regions showed no significant differences among any of the groups. We did not observe a significant correlation between biodiversity richness of agricultural mosaic landscapes and references to related concepts in the NBSAPs. The analysis of published years and versions identified a significant increase in appearance frequency for half the groups and for all the groups considered together. This finding indicates that the concepts related to the groups penetrated the NBSAPs with time and the NBSAPs were revised accordingly. The details of these results are explained below.

In terms of regions, we divided 132 countries (excluding the EU) into four IPBES regions: Africa, 29 countries; Americas, 17; Asia-Pacific, 44; and Europe and Central Asia, 42). Compared with the appearance frequency for each of the six groups and all the groups together, the reference to Group A2 was significantly lower in Europe and Central Asia than in Africa and Asia-Pacific: Africa, $P < 0.0001$; Asia-Pacific, $P = 0.0003$: Steel-Dwass. In addition, the reference to Group B in Europe and Central

Asia was significantly lower than in Asia-Pacific ($P = 0.0042$). However, the reference to Group D in Europe and Central Asia was significantly higher than in other regions: Africa and Asia-Pacific, $P < 0.0001$; Americas, $P = 0.0002$. We found no significant differences among Africa, Americas, and Asia-Pacific for any of the groups. We observed no significant differences among any of the regions for Groups A1, A3, and C as well as for all the groups together ($P > 0.05$).

In terms of sub-regions, we divided 132 countries (excluding the EU) into the 18 IPBES sub-regions listed in Table 4. Compared with the appearance frequency for each of the six groups and all the groups together, reference to Group A2 in Central Europe was significantly lower than in West Africa, Mesoamerica, and Central Africa: West Africa, $P = 0.0006$; Mesoamerica, $P = 0.0225$; and Central Africa, $P = 0.0225$; Steel-Dwass. In addition, reference to Group B in Central Europe was significantly lower than in Oceania ($P = 0.0250$). Reference to Group A2 in Western Europe was significantly lower than in West Africa ($P = 0.0043$). Reference to Group D in Western Europe was significantly higher than in Oceania, East Africa and adjacent islands, Western Asia, West Africa, and the Caribbean: Oceania, $P = 0.0064$; East Africa and adjacent islands, $P = 0.0114$; Western Asia, $P = 0.0143$; West Africa, $P = 0.0178$; and the Caribbean, $P = 0.0254$. There were no significant differences between any of the regions for Groups A1, A3, and C and all the groups together ($P > 0.05$).

These regional and sub-regional results indicate that Central and Western Europe showed significant differences compared with the other regions. Central and Western Europe preferably used landscapes or seascapes (Group D) but not traditional local names (Group A2). This finding may be due to differences in approaches: European countries focus on landscapes, whereas other regions focus on specific local sites as expressed in local names. However, the regions apart from Central and Western Europe, showed no significant differences among any of the groups.

Table 4. Numbers of countries in IPBES sub-regional groups.

IPBES region groups	IPBES sub-regional groups	Number of countries in this research	Total countries in IPBES
Africa	East Africa and adjacent islands	8	15
	Southern Africa	10	10
	Central Africa	1	9
	North Africa	2	8
	West Africa	8	15
Americas	North America	1	2
	Mesoamerica	1	8
	The Caribbean	11	14
	South America	4	12
Asia-Pacific	Oceania	14	22
	South-East Asia	10	11
	North-East Asia	5	5
	South Asia	7	9
	Western Asia	8	10
Europe and Central Asia	Central Europe	16	18
	Western Europe	17	24
	Eastern Europe	5	7
	Central Asia	4	5
Total		132	204

Thus, we observed small but significant differences between Europe and other regions. In some countries, additional key words or local names must exist that specifically express the concept of integrated approaches in production landscapes. Furthermore, even if the concept is expressed using the same word, the meaning may differ owing to the ambiguity with "cultural landscape" (Jones 2003; Plieninger and Bieling 2012). Summarizing and categorizing all the related concepts would demand an enormous amount of cultural anthropology work. However, a practical integrated approach to enhance, maintain, or revitalize socio-ecologically valued production landscapes may differ for each site (even within the same country) – just as there are various local names and differences in different regions. Compilation of local case studies on the concepts and practices, such as by IPSI (e.g., UNU-IAS and IGES 2015; UNU-IAS and UTIAS/UTIAS 2016), would help to provide a deeper understanding of the concepts and assist in implementing an appropriate approach.

In promoting further incorporation of the concept of integrated approaches in production landscapes, it is necessary to consider that many countries already understand the concept. However, their understanding may be based on their own ideas, as expressed in different local names. Thus, it seems that different approaches will be needed to promote further incorporation of the concept in different countries.

5.2.2. SI trends

We found no significant correlations between the average SI of each country and the appearance frequency for each group and all the groups together: Spearman ρ –0.1 to 0.9; $P > 0.1$).

5.2.3. Trends in publication years and versions

With regard to publication year (earliest, 1995; latest, 2016; median, 2011; quartile range, 2004–2015; total, 133) and number of versions (1 version, 60; 2 versions, 54; 3 versions, 15; 4 versions, 3; 5 versions, 1; total, 133), the two indicators showed a significant positive correlation (Spearman $\rho = 0.5989$; $P < 0.0001$). We found significant positive correlations between the publication year of each NBSAP and the appearance frequency for Group D and all the groups together: Group D, $\rho = 0.2313$, $P = 0.0074$; total, $\rho = 0.2815$, $P = 0.0010$. We also observed significant positive correlations between the number of versions of each NBSAP and the appearance frequency for groups A1, C, and D and all the groups together: Group A1, $\rho = 0.2227$, $P = 0.0100$; Group C, $\rho = 0.2014$, $P = 0.0201$; Group D, $\rho = 0.2911$, $P = 0.0007$; all the groups, $\rho = 0.3107$, $P = 0.0003$.

To summarize the results of the publication years and number of versions, the NBSAPs embraced part of the concept of integrated approaches in production landscapes (Group A1), the ecosystem approach (Group C), and landscapes (Group D) as revisions. Only with landscapes (Group D) was there a significant difference with both the publication year and number of versions. Groups A1 and C did not show significantly later publication years, but they did evidence a significant increase in the number of versions. This occurred owing to differences in the first developed NBSAP and timing of revisions in different countries. These results indicate that penetration of the concept of integrated approaches in production landscapes has increased globally to some extent.

5.3. Trends in partial penetration of integrated approaches in production landscapes

To determine comprehensive and partial penetration, we compared the numbers of references for the four codes of Group B, which described the four characteristics of SEPLS. We applied SEPLS characteristics to evaluate the partial penetration of integrated approaches in production landscapes, instead of creating original categories based on a comparison of all the related concepts; we did so because, as noted above, most integrated approaches in production landscapes were not clearly defined. Group B was the group most referred to in this study: almost all the countries (132, 99%) referred to at least one of the four codes (Figures 1 and 2). However, there was divergence in the number of references for the four Group B codes (Figure 3). "Being deeply linked to local culture and knowledge" received many references; conversely, "dynamic mosaics of habitats and land and sea use" was rarely referred to. Likewise, the code for SEPLS, upon which concept the four codes were largely based, rarely received references (Figure 3).

To examine how each code received references, we extracted a high co-occurrence of terms for each code in a paragraph using KH Coder. The 10 terms with the highest relationship to each code based on the Jaccard coefficient are listed in Table 5. The Jaccard coefficient was overall high for related terms that received many references: "providing humans with goods and services in a sustainable manner" and "being deeply linked to local culture and knowledge." Many related terms indicating promotion of activities at the local level are listed in Table 5. However, many related terms in the code "dynamic mosaics of habitats and land and sea use," which received few references, were proper nouns; their Jaccard coefficients were generally low. Thus, we were unable to identify a trend. The term "promote" was listed for two highly referenced codes. This indicates that many governments noted the need to promote activities related to those two codes. In contrast, the co-occurrence of terms related to SEPLS included "sanctuaries," "coverage," and "threats"; these terms indicated that SEPLS tended to be described as a situation of biodiversity rather than activity.

To analyze the co-occurrence of codes, we calculated the Jaccard coefficient for all codes in a paragraph using KH Coder. For comparison purposes, we included other

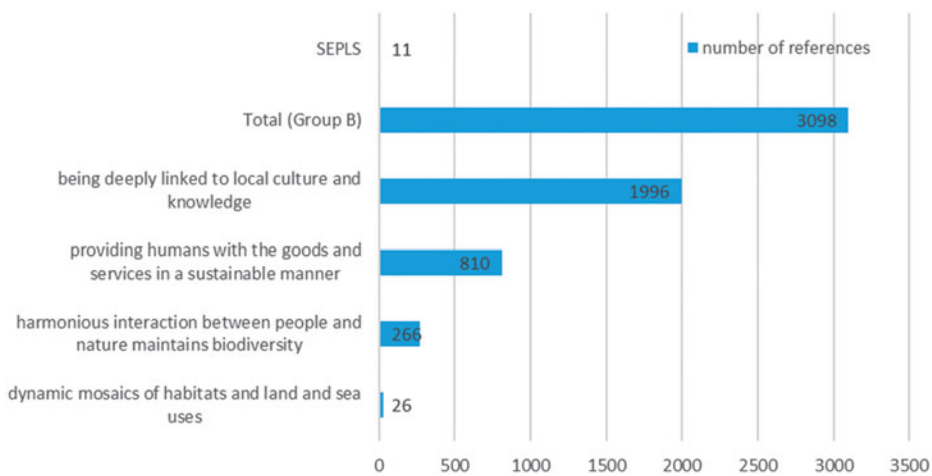

Figure 3. Number of references about four Codes of Group B and SEPLS in total.

Table 5. Ten highest related terms for the four codes in Group B.

	Dynamic mosaics of habitats and land and sea uses		Harmonious interaction between people and nature maintains biodiversity		Providing humans with the goods and services in a sustainable manner		Be deeply linked to local culture and knowledge		SEPLS	
	High related terms	Jaccard coefficient	High related terms	Jaccard coefficient	High related terms	Jaccard coefficient	High related terms	Jaccard coefficient	High related terms	Jaccard coefficient
1	Riverside	0.038	Restore	0.0935	Promote	0.1158	Community	0.1746	Satoyama	0.1556
2	Tall	0.0375	C	0.0886	Ensure	0.1108	Indigenous	0.1489	landscape/_/seascape	0.1429
3	Trewia	0.0364	woman	0.084	Benefit	0.1091	Use	0.1211	sanctuaries/_/conservation	0.1111
4	Clup	0.0357	well-being	0.0815	Conserve	0.1046	Benefit	0.1179	reduction/_/prevention	0.1111
5	Nudiflora	0.0357	GOAL	0.0805	Incentive	0.1033	Sustainable	0.1167	with/_/agreements	0.1111
6	Jambolana	0.0357	vulnerable	0.0779	Integrate	0.1032	Awareness	0.1161	Coverage/_/Extent	0.1111
7	PAMBs	0.0357	Livelihood	0.0757	Policy	0.0992	Promote	0.1154	CALM	0.1111
8	NM	0.0351	Equitably	0.0748	Development	0.0976	Resource	0.1134	e-module	0.1111
9	Florican	0.0351	Culturally	0.0708	Practice	0.0971	Research	0.11	threats/_/pressures	0.1111
10	Biodiversity-friendly	0.0351	Underlie	0.0706	Implement	0.097	Participation	0.1094	universally-agreed	0.1111

Table 6. Code combinations with the 10 highest Jaccard coefficients in paragraphs.

	Code	Code	Jaccard coefficient
1	*Providing humans with the goods and services in a sustainable manner	*Be deeply linked to local culture and knowledge	0.123
2	*Landscape	*Seascape	0.069
3	*Landscape	*Providing humans with the goods and services in a sustainable manner	0.056
4	*Harmonious interaction between people and nature maintains biodiversity	*Providing humans with the goods and services in a sustainable manner	0.054
5	*Harmonious interaction between people and nature maintains biodiversity	*Seascape	0.054
6	*Ecosystem approach	*Seascape	0.051
7	*Be deeply linked to local culture and knowledge	*Landscape	0.050
8	*Harmonious interaction between people and nature maintains biodiversity	*Be deeply linked to local culture and knowledge	0.045
9	*Harmonious interaction between people and nature maintains biodiversity	*Landscape	0.041
10	*Harmonious interaction between people and nature maintains biodiversity	*Ecosystem approach	0.036
10	*SEPLS	*Seascape	0.036

codes. Among the 10 highest combination of codes (Table 6), the co-occurrence of "providing humans with goods and services in a sustainable manner" and "being deeply linked to local culture and knowledge" were especially high. Only their Jaccard coefficient (0.123) was greater than 0.1; the others were lower than 0.069. Three characteristics of SEPLS (not "dynamic mosaics of habitats and land and sea uses") showed high co-occurrence with one another and with "landscapes." In addition, "harmonious interaction between people and nature maintaining biodiversity" was not a highly referenced code; however, it was well connected with "landscape," "seascape," and "ecosystem approach." The codes for Group A did not display high co-occurrence with other codes: only "SEPLS" and "seascapes" are listed in that regard in Table 6. "SEPLS," which comprised four characteristics, did not show co-occurrence with any of these four characteristics or with "landscapes."

The results about the partial penetration of the concepts are as follows. At least one of the four characteristics of SEPLS received references in almost all the NBSAPs. Some of these characteristics showed co-occurrence with the terms of promotion. However, the code "dynamic mosaics of habitats and land and sea uses," which represents a landscape characteristic of SEPLS, was rarely described. SEPLS itself was also rarely referred to and tended to be described as a situation of biodiversity. These results indicate that many countries considered the needs of activities related to sustainable production, ecosystem services, and local culture and knowledge. However, they did not also consider the dynamic mosaic of production landscapes. Thus, the concept of SEPLS as a whole did not display good penetration. The concepts of SEPLS, cultural landscapes, GIAHS, and landscape approaches have been identified as important to integrated approaches at the landscape level in many research papers (e.g., Plieninger and Bieling 2013; Sayer *et al.* 2013; Gu and Subramanian 2014). However, we did not find that these concepts showed good penetration as whole concepts in the NBSAPs.

One possible way of promoting penetration of the concepts is supporting the acceptance of rarely referenced characteristics. That could help penetration of the concepts as a whole. It is not clear why "dynamic mosaics of habitats and land and sea uses" was rarely referenced in the NBSAPs. Neither is it clear how this characteristic could be promoted. Some studies have demonstrated that landscape heterogeneity strongly related to biodiversity – positively under certain conditions – in agricultural landscapes (e.g., Benton, Vickery, and Wilson 2003; Bennett, Radford, and Haslem 2006; Wilson *et al.* 2017). Regarding the relationship between policies and dynamic mosaics or landscape heterogeneity, one assessment of policy impacts on the mosaic of agricultural landscape found that improving agri-environment schemes could offset the negative consequences of support payments for the landscape mosaic (Brady *et al.* 2009). In addition, policy measures to enhance biocultural diversity in production landscapes, which comprise dynamic mosaics of diverse land-use patterns, have been proposed in the context of local food networks (Plieninger *et al.* 2017). However, no policy measures that are effective in enhancing both heterogeneity and biodiversity in production landscapes have been clearly suggested. This could be one reason for dynamic mosaics being rarely referenced in the NBSAPs. It is necessary to examine effective policy measures for enhancing both heterogeneity and biodiversity so that governments can introduce such measures in their NBSAPs.

5.4. Limitations and future study

In this study, we attempted to make a comprehensive identification of globally used concepts. However, we were able to review only the English-language literature. There would, therefore, have been deficiencies in Latin America (with Spanish and Portuguese), French Africa, and Arabic-speaking parts of North Africa and Asia. Text extraction analysis is a means for automatically picking up preset key words from target textual data. Thus, terms or concepts that do not appear among the key words are not selected - even if they are actually related to the codes. In addition, changes in the codes or key words could affect the results. In this study, we identified the key words by reviewing relevant research papers or publications. However, it is necessary to assess our results with care because there are methodological limitations to text extraction analysis. The results of quantitative text mining analyses depend on the use of specific terms or codes (and the co-occurrence among them) in NBSAPs; but that use does not correspond to the respective NBSAPs actually implementing policies related to those terms or codes. A further detailed study is necessary to determine practical implementation plans, budgets, progress, and achievement.

6. Conclusion

Production landscapes with high biodiversity have been shaped by human–nature co-evolution. They have provided multiple benefits to humans and require integrated approaches for sustainable management. However, hitherto, the extent to which such integrated landscape approaches had been applied in national policies was largely unknown. Few quantitative studies had been undertaken in this field. Thus, using quantitative analysis, we examined to what degree national-level biodiversity policies had incorporated integrated approaches in production landscapes. Our study began with a review of related concepts. We examined the many concepts related to integrated approaches in production landscapes. We then analyzed 133 NBSAPs (the highest national policy documents on biodiversity) using text mining and statistical analysis (including co-occurrence analysis) to determine the penetration of terms that expressed these concepts. Our analysis focused on both overall global trends, incorporating the concepts and trends for partial incorporation.

Regarding overall global trends of incorporation, we found that about half of the NBSAPs referred to the concepts of integrated approaches in production landscapes. We observed more references to the concepts with time, as strategies were updated. We found significant regional differences between Central and Western Europe and other regions in the use of related terms: Western Europe preferably used the term "landscape", but not local terms related to traditional management. With respect to partial incorporation, some characteristics of SEPLS showed good penetration and connected well with one another. However, an exception was the characteristic related to dynamic mosaics of habitats and land and sea use.

Conserving biodiversity and maintaining healthy ecosystems in production landscapes is crucial for sustainable agriculture and future human well-being worldwide. It is necessary to promote the further incorporation of integrated approaches in production landscapes. Establishing effective policy measures to enhance both heterogeneity and biodiversity would appear to be one way of promoting the incorporation of these concepts. In addition, it is necessary to promote both acceptance and practical implementation of measures based on the concepts. Further detailed studies on the situation in different countries, broader research involving languages not covered in our investigation, and practical consultation about incorporation and implementation of the concepts in different countries are required. The results of the present study offer basic information about the current situation regarding incorporation of integrated approaches in production landscapes in national-level biodiversity policies.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Supplemental Data

Supplemental data for this article can be accessed here.

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