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Revealing the hidden socioeconomic role of non-wood forest products for the European bioeconomy

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Abstract

Forest ecosystems are valuable assets providing not only wood material, but also non-wood material, bioenergy, and a number of regulating and cultural services that can support post-COVID economic recovery and help build more resilient local economies. To make the best forest choices for the society and the economy, one must understand which forest services can support economic development and social prosperity. Currently, the analysis has been limited to wood supply and uses, and do not include the supply and use of non-wood forest products and services. This represents a significant omission in understanding how forest ecosystem services (ES), currently having mainly a non-market value, can lead indirectly to economic transactions and/or purchase behaviour. To fill this gap, we proposed to rely on the calibration of a social accounting matrix (SAM) extended to forest ES, taking Non-Wood Forest Products as the first case of service under study. We named this new extended matrix EcosySAM. It will make possible to account for interactions between forest ecosystems, their services and the European forest-based bioeconomy. This can turn into future policy decisions that improve the economic benefits for societies on one side, while sustainably managing forest ecosystems on the other side.

Riassunto

Gli ecosistemi forestali sono beni preziosi che forniscono non solo materiale legnoso, ma anche materiale non legnoso, bioenergia e una serie di servizi regolatori e culturali che possono sostenere la ripresa economica post-COVID e aiutare a costruire economie locali più resilienti. Per fare le scelte forestali migliori per la società e l'economia, è necessario capire quali servizi forestali possono sostenere lo sviluppo economico e la prosperità sociale. Attualmente, l'analisi è stata limitata all'offerta e all'utilizzo del legno, senza includere l'offerta e l'utilizzo di prodotti e servizi forestali non legnosi. Ciò rappresenta un'omissione significativa nella comprensione di come i servizi ecosistemici (ES) forestali, che attualmente hanno principalmente un valore non di mercato, possano portare indirettamente a transazioni economiche e/o comportamenti di acquisto. Per colmare questa lacuna, abbiamo proposto di basarci sulla calibrazione di una matrice di contabilità sociale (SAM) estesa ai servizi ecosistemici forestali, prendendo i prodotti forestali non legnosi come primo caso di servizio oggetto di studio. Abbiamo chiamato questa nuova matrice estesa *EcosySAM*. Essa consentirà di tenere conto delle interazioni tra gli ecosistemi forestali, i loro servizi e la bioeconomia forestale europea. Ciò può tradursi in future decisioni politiche volte a migliorare i benefici economici per le società da un lato, gestendo in modo sostenibile gli ecosistemi forestali dall'altro.

Executive summary

The aim of the doctorate is to combine the economic evaluation of forest Ecosystem Services (ES) with the Social Accounting Matrix (SAM) methodology to analyze Non-Wood Forest Products' (NWFPs) role within the European bioeconomy. ES economic valuation has become a common starting point in ecosystem accounting, while the SAM methodology has been widely used over the last decades to explain the relationship between environment and human wellbeing, but the combination of the two methodologies has never been implemented to our knowledge.

The project can be divided into three main parts. The first one consists in the development of the theoretical framework. We propose an Ecosystem-extended SAM (EcosySAM) that represents the impact of ES flows. To validate the hypothesis that this approach is suitable, we performed a systematic literature review. It focused on environmental studies that use the SAM methodology to understand whether the EcosySAM would make it possible to analyze the effects of NWFPs on the bioeconomy. Results from the first part of the project show that the literature on SAMs has developed at a rapid pace over the last decades worldwide. SAMs are gaining attention because of their capacity to explain the relationship between the economy, the environment, and human wellbeing, as well as the increased availability of accounting data. The studies applying the SAM approach to the forest sector were able to quantify the value that the forest sector brings into the economy through its direct, indirect, and induced effects. Nevertheless, the non-market ecosystem services have not been represented so far. Thus, thanks to the flexible structure of a standard SAM, we propose an extension to account for the social component of NWFPs.

The second part of the doctorate focuses on the ecosystem service evaluation. A variety of valuation techniques can be used when market data are not already available and when it is not possible to estimate a market price. In this study, we use a choice experiment to explore individuals' preferences towards NWFPs and associated services in three European countries, namely Italy, Sweden, and Czechia. We estimate the individual marginal Willingness to Pay (WTP) for the supply and maintenance of NWFPs. We further investigate whether there is a relationship between moral motivation, public policy and private contributions to forest conservation and management, under the framework of the Moral Foundations Theory. Overall, we relied on a primary data collection. For each country, a sample size of 1000 respondents was selected, 3000 sample units in total. Samples are representative within the population according to gender, age, and regional origin. Data were collected between June and July 2021.

Results from the statistical descriptive analysis of the sample indicate that people visiting forests for recreational purposes are mostly motivated by seeking relaxation and a connection with nature. In addition, collecting NWFPs, when available, is a key activity during the visit. This confirms the importance of the recreational and cultural role this service provides, in line with previous studies. The analysis on the WTP of

people to increase forests conservation and sustainable management reports significant and positive values for all attributes in the three countries under evaluation.

In the third and final part of the doctorate we develop the new EcosySAM and perform a multiplier analysis. First, we want to highlight the part of those activities that can be traced back to NWFPs, thus showing the indirect effects of households' expenditure for the social component of NWFPs. These activities were identified as travel expenses and food and accommodation expenses. At the same time, we estimate the value of the household environmental services without payment, using the WTP. To show these services in the matrix, we added a different households' account on wellbeing. Finally, we added a natural capital account used for forest ecosystems. After the new EcosySAM was built, we proceed with the multiplier analysis to assess the wealth-generating properties of forest ecosystem as an agent of the economy.

Results from the upscaling at national level of survey data for the three countries under study show the value that forest ecosystems, in particular the social component of NWFPs, brings into the socioeconomic system. This result has been obtained by extending the structure of the SAM, considering the forest ecosystem as an agent of the economy, as well as the collection of NWFPs as a commodity. Although the share of expenses related to picking NWFPs is not so meaningful, it represents an added value that so far has not been attributed to forest ecosystems. Moreover, the analysis of multipliers shows the potential induced effect on other sectors, especially on the transportation sector and food and accommodation sector. Finally, including household environmental services without payment into the matrix makes possible to look beyond the monetary value forests produce, by also considering the wellbeing component.

It is critical to inform policy makers about the benefits that forest ESs can provide and the connection between ESs and economic activities, to justify actions to reduce the loss of those important services for the economy, society, and a healthy biosphere.

1. The role of forest ecosystem services and how to account for their value within the forest-based bioeconomy

Based on Di Cori, V., Robert, N., Franceschinis, C., Pettenella, D., and Thiene, M. 2022. Framework Proposal to Quantify the Contribution of Non-Wood Forest Products to the European Union Forest-Based Bioeconomy. Forests, 13(3). https://doi.org/10.3390/f13030362

Ecosystem services (ES) are defined as "multiple benefits provided by ecosystems to humans" (MEA, 2005) they constitute both the "direct and indirect contributions of ecosystems to human wellbeing" (TEEB, 2010). As a matter of fact, forest ecosystems can contribute to the socioeconomic system in many ways other than wood related products and services. They provide key ecosystem services such as cultural services (e.g., recreation, tourism, and health); regulating services (e.g., water, soil, air quality and noise reduction); and provisioning services (e.g., clean drinking water, non-wood forest products such as mushrooms and berries).

The European Union has nearly 182 million hectares of forests covering 43% of its land area, and these forest areas are among the most valuable natural resources in Europe. EU forests are extraordinarily complex, with a wide range of forest forms, characteristics, and systems of ownership. While being a major source of biodiversity, they have many benefits for society and the economy. They are, in addition, a vital resource for improving quality of life and job creation.

The New Green Deal gives to European forests a key role in the promotion of the bioeconomy, incentivising forest managers to preserve, grow and manage forests sustainably (European Commission, 2019). Despite this growing attention, the roles of some products and services in the extended forest sector have been so far neglected, while others have been attributed to different sectors of the economy. This represents a main limitation of the current research on the different components of the forest-based bioeconomy. Indeed, according to (Martinez De Arano et al., 2018), the importance of forests and the forest sector into the bioeconomy is mostly viewed as providing wood, pulp, paper and some bioenergy through a very conventional lens, accounting for a small percentage of global GDP and providing jobs.

An important step that has been made towards the valuation of ecosystem services into the System of National Accounts (SNAs) across countries is the System of Environmental-Economic Accounting - Experimental Ecosystem Accounting (SEEA-EEA), which focuses on accounts considering the role of ecosystems and their services (United Nations t al., 2014; United Nations et al., 2021). By applying national accounting principles, the SEEA-EEA framework allows for a unique integration of environmental and economic data to support decision making. Thus, by measuring ecosystem services, tracking changes in ecosystem extent and condition, and valuing ecosystem services and assets, it makes visible the contributions

of nature to the economy and people, and on better recording the impacts of economic and other human activity on the environment. To this end, ecosystem accounting incorporates a wider range of benefits to people than captured in standard economic accounts (United Nations et al., 2021).

However, its main limitation is that it considers only the value of the ecosystem service entering the economy in the first step of the value chain, without accounting for the added value that it might create along the entire value chain. To estimate how economic activities depends on forest ecosystems and to estimate the so-called contribution of forest ecosystem services to the GDP, one must look beyond the direct contribution to the forestry sector, trying to understand the comprehensive economic impact on other sectors, and the indirect and induced effects of the economy.

To fill this gap, this study aims to map out the beneficiaries and assessing the value added that depends on forest ES in the framework of the EU bioeconomy. The analysis considers both the social impact and economic welfare. In this chapter, a new theoretical framework is presented, supported by a literature analysis, to link flows of forest ES to the functioning of the economy. Thus, the new framework this doctoral project is proposing is linked to the SEEA-EEA framework to the extent that it includes benefits from forest ecosystems to the socioeconomic system going beyond the direct and tangible market value already available in the SNAs 2008 accounting tables. Furthermore, it applies the same methodology of supply and use tables, as well as ecosystem service evaluation methodologies used by the SEEA-EEA to assess ecosystems an their services.

We decided to use one service, being Non-Wood Forest Products (NWFPs) as case study; nonetheless, the methodology we propose can be utilized to assess the value of different ES.

KEY MESSAGES:

- Extended Social Accounting Matrices (SAMs) can be considered a relevant approach to study the relationships between forest ecosystems and the bioeconomy.
- Visible growing trend linking economic accounts with environmental accounts.
- Only few studies using SAMs to analyze forest sector and ES.

Introduction

European forests are multifunctional, providing a range of ecosystem services (Forest Europe, 2020), including food, water, shelter, raw material and energy, medicine, clean air, and water. The European Green Deal makes a point of this concept, linking the resilience of forests to the promotion of the circular bioeconomy (European Commission, 2019). Likewise, the new EU bioeconomy strategy (European Commission, 2018) places an emphasis on innovation, calling for new business models based on the valuation of forest ecosystem services (ESs).

Among different forest ESs, Non-Wood Forest Products (NWFPs) are gaining attention in relation to the European bioeconomy: they provide food, material, and services to the socioeconomic system. FAO defines NWFPs as being "goods of biological origin other than wood derived from forests, other wooded land and trees outside forests" (FAO, 2018). Lovrić et al. (2020) estimate that the value of harvested NWFPs in Europe amounted to 23.3 billion euros in 2016, which corresponds to about 71% of the value of annual round wood production. Despite the wide-ranging contributions made by NWFPs, their value is regarded as significantly underestimated (EEA, 2016; Forest Europe, 2020). Nevertheless, NWFPs and related services provide opportunities for the forest domain to connect with other sectors and disciplines. In Europe, some of these interactions are already taking place in a more or less organized way, opening opportunities for joint value chain development (Wolfslehner et al., 2019). The production of NWFPs, as a market product such as cork oak, chestnut, or truffle, is the specific objective of several forest management and agro-forestry activities. These products are then transformed in food and material industries. The health, personal care, and medical sectors also rely on numerous non-wood forest products. These economic activities generate added value and provide employment (Wolfslehner et al., 2019).

Besides their market (or private) component, NWFPs are also strongly connected to services such as recreation, local culture, wellbeing, and biodiversity conservation. This social (or public) component of NWFPs is less known because it is difficult to attach a value to it. Hence, the NWFPs contribution to wealth and societies is only partially known.

The real value of NWFPs is difficult to determine also due to sparse and incoherent data. One reason is that many of these products are sold on informal markets or are even not subject to transactions. Moreover, several economic activities use and transform NWFPs (e.g., in the cork oak value chain). Finally, the frequentation of rural areas by NWFP pickers benefit indirectly other activities such as local shops and restaurants. These effects are rarely quantified. This represents a major gap towards understanding the total economic value of NWFPs. Thus, in this study, based on a bibliographic analysis, we propose a framework to estimate the contribution of NWFPs to the economy and the society, as well as to evaluate how NWFPs can support a further development of the bioeconomy.

Our aim is not only to present a way to estimate the value of the NWFPs—both as commercial products and as socio-cultural services connected to tourism and recreation—but also to show the link between NWFP supply to the whole economy. This includes the impact of a change in NWFP supply on value chains making use of NWFPs (direct effect), products and services supplied to the NWFP value chains (indirect effect), and the consumption of households involved in the NWFP value chains and related sectors (induced effect). Finally, to liaise the supply of NWFPs to the economy, we propose two techniques among those already present in the field of ecosystem service evaluation (M. Masiero et al., 2019), for both the market and the social component of NWFPs.

To represent the link between the economy and the environment, the System of Environmental-Economic Accounting (SEEA) (United Nations et al., 2014) has been developed as a first step to extend the System of National Accounts (SNA). As part of the SEEA, the Experimental Ecosystem Accounting (SEEA EEA) (UN et al., 2014) focuses on accounts considering the role of ecosystems and their services. In the SEEA EEA, ecosystem services accounts present the physical and monetary supply and use of ESs in a way that complies with other SNA-derived economic indicators (La Notte and Rhodes, 2020). This framework has been implemented by the European Commission through the Knowledge and Innovation Project on an Integrated system of Natural Capital and ecosystem services Accounting (KIP-INCA) in the EU. Although this framework makes it possible to identify the flows of services from the ecosystem to the economy, it is still not able to provide information on NWFPs value chains and on upstream and downstream socioeconomic impacts. This particular link between ecosystems and human society is one of the current concerns, as highlighted in the latest Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019) released by the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES). This report emphasizes the need to understand the contribution of multiple values of ecosystem functions and of nature to people's wellbeing.

Social Accounting Matrices (SAM)—"a matrix presentation that elaborates the linkages between supply and use tables and the sector accounts" (Eurostat, 2013) —would be a possible tool to link flows of ecosystem services to the functioning of the economy. However, usual SAMs do not include information about flows of ecosystem services. Therefore, we propose an Ecosystem-extended SAM (EcosySAM) that represents the impact of ES flows, where the flows correspond to those estimated in ES supply and use tables.

The EcosySAM represents a novelty in the field of ecosystem service accounting. To validate the hypothesis that this approach is suitable, this study relies on a literature review. It focuses on environmental studies that use the SAM methodology to understand whether the EcosySAM would make it possible to analyze the effects of NWFPs on the European bioeconomy.

This paper is organized into five sections. After the first introductory section, the second section explains how the EcosySAM works, based on standard SAM, and how to calculate the monetary value of both the market and the social component of NWFPs and introduces the theoretical framework of ecosystem-extended SAM, as well as the methodological approach we used to perform the literature review; the third and the fourth sections present and discuss the results of the review, respectively; finally, the fifth section draws conclusions and highlights research gaps, their implications for policy-making, and future research needs.

Materials and Methods

Extending SAMs to Embed Ecosystem Services

An SAM presents "a series of accounts in each of which incomings and outgoings (or income and expenditure, in many cases) must balance" (Pyatt and Round, 1985). Thus, it contains information about the economic and

social structure of a country in a particular year, representing in a detailed manner the interaction and inter-dependences between sectors, activities, and products of an economy (Alfredo Jose Mainar-Causapé et al., 2018; Stone, 1947). It is a square matrix, in which each account is represented by a row and a column. Each cell shows the payment by column account to the account in the row. There are six basic groups of agents (i.e., activities and/or commodities; production factors; private institutions—households and corporations/enterprises; public institutions—government; saving–investments; the rest of the world) that can be disaggregated depending on which level of analysis is required. Data sources for developing an SAM can come from national accounts, input–output framework (with supply and use tables), and data on consumption patterns, among others. Micro-data use is also strongly recommended (primary data from survey interviews) (Alfredo Jose Mainar-Causapé et al., 2018).

An SAM represents an invaluable database for two main reasons: (1) it shows a complete but intuitive snapshot of the economy and (2) it provides data for economic modelling, particularly multi-sectorial linear modelling and/or Computable General Equilibrium models. Multipliers and CGE models can be used for the analysis of key socioeconomic issues, such as employment, value added, and growth and income distribution. Similarly to input–output tables, SAMs capture not only the direct effects (occurring in the economic activity that is analysed) and the indirect effects (occurring in backward-linked activities that supply the activity analysed), but also the "induced effects" that arise as employees of the analysed activity and the backward-linked activities spend their income (Li et al., 2019). Studying the total economic impact of an ecosystem service considering these three types of effects can provide robust information to decision-makers about the contribution of this service to the national economy.

The standard structure of the SAM, however, is not sufficient to explain the relationship occurring between environment and economy. For this reason, in the last 20 years the literature has developed different types of extended SAMs to study the effects of the socioeconomic system on the environment and vice versa (Gallardo and Mardones, 2013; Keuning, 1993; Resosudarmo and Thorbecke, 1996). These extended SAMs became tools that can connect national account data to data from satellite accounts such as the environmental accounts. These satellite accounts enable the linkage of physical data and analysis to the monetary accounting system, a key issue for environmental and ecological economics studies (Alfredo Jose Mainar-Causapé et al., 2018).

We hypothesized that an EcosySAM could highlight how society benefits from NWFPs, either with a direct flow from the supply of the ecosystem to the households, or through a value chain from the ecosystem to economic activities (industries and services) before arriving to the household. Both data concerning the market and the public component of NWFPs can be used as satellite accounts to extend the standard structure of an SAM and to analyze the effects of this forest service on different economic activities and actors.

In practice, in the EcosySAM, forest ecosystems appear as agents of the economy, supplying goods and services in interaction with economic agents. The calibration of an EcosySAM allows to understand the actual flow (i.e., the flow of ES used by the socioeconomic system) (United Nations et al., 2014; Vallecillo et al., 2019) of NWFPs from the forest to the socioeconomic system and to calculate indicators such as value added and employment related to this service both upstream and downstream.

Proposed Assessment of the NWFP Value following an Ecosystem Service Evaluation Approach

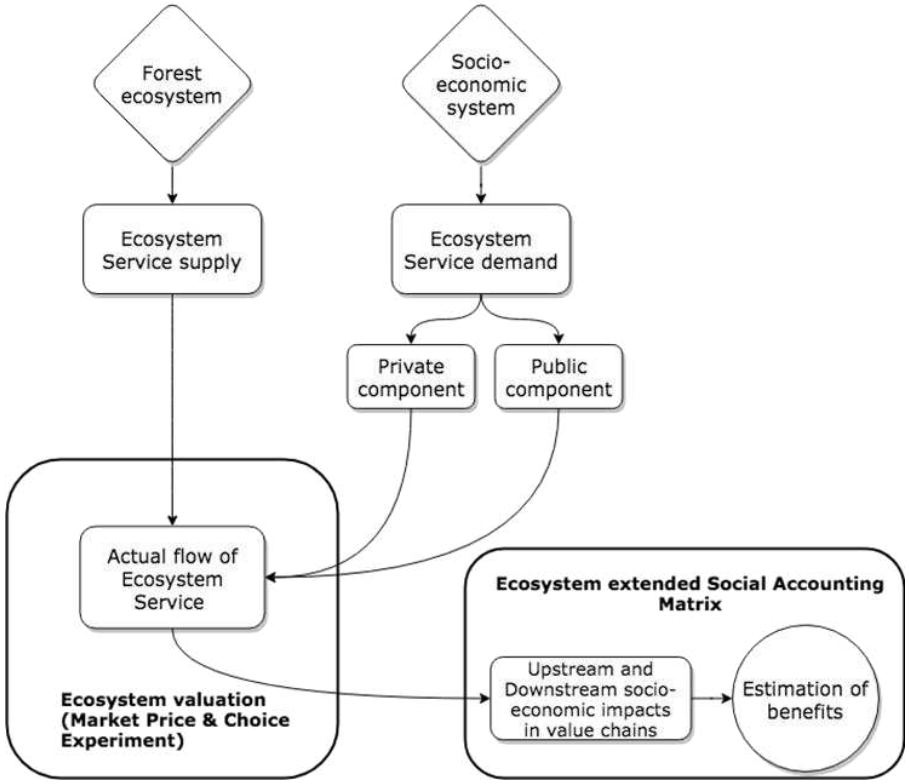
Following the SEEA EEA approach, physical and monetary data in the form of supply and use tables can allow detecting the actual flow of services from forests to the economy. The first way we propose to quantify the actual flow of ESs is to follow a fast-track approach (Vallecillo, La Notte, Ferrini, et al., 2019) based on officially published statistics. This is particularly the case for ESs that contribute to the supply of products already reported in the SNAs, such as timber. Similarly, this methodology can be applied to the market component of NWFPs (e.g., cork), considering its use along the entire value chain (i.e., direct effect from the ecosystem to final users) and investigating the data on quantity and volume and how this adds value into each step of the forest-based bioeconomy.

Alternatively, different valuation techniques shall be used when data are not already available and when it is not possible to estimate a market price (M. Masiero et al., 2019) like in the case of the social component of NWFPs. A widely used approach to estimate the value of such ESs is the choice experiment (Masiero et al., 2018; Morey and Thiene, 2017; Swait et al., 2020; Thiene et al., 2017) that can be employed to explore individuals' preferences towards NWFPs and services associated with them. Discrete Choice Models are used to derive individual marginal Willingness To Pay (WTP) values that provide an economic assessment of the ES under evaluation (Mariel et al., 2021; Masiero et al., 2019; Morey and Thiene, 2017; Pascual et al., 2010). The choice experiment questionnaire can include auxiliary questions to make it possible to also investigate some indirect effects. For example, beneficiaries of forest ecosystem services are likely to spend money in the area where forests are located (e.g., in local restaurants and shops) and therefore to influence non-forest sectors of the economy. Evaluating the social component of NWFPs under this perspective allows understanding people's behavior in terms of consumption, how much they are willing to pay for this environmental service, as well as which economic activities are stimulated by this service.

Ecosystem-Extended SAM (EcosySAM) Theoretical Framework

By combining extended SAMs and ES valuation techniques, we developed a theoretical framework to account for the socioeconomic impact of ecosystem services in value chains, as shown in Figure 1. This framework makes it possible to represent flows subject to transactions (i.e., market flows—private component) and flows without transactions (i.e., going directly to households—social component).

Figure 1. Theoretical framework to account for the socioeconomic impact of ecosystem services in value chains. Source: adapted from Vallecillo et al. (Vallecillo et al., 2019).



In the framework, the forest ecosystem represents the supply of ES, while the socioeconomic system represents the demand. The match between supply and demand represents the met demand and thus the actual flow from the forest ecosystem to the socioeconomic system (Vallecillo et al., 2019). The actual flow can be analysed by means of ecosystem service evaluation techniques, such as those we presented in the previous paragraph (market price and choice experiment). Up to this stage, the framework is aligned with the KIP-INCA, where the value of ES is recognized but is not distributed among the different stakeholders and the different steps of the value chain. Moving ahead, the ecosystem-extended SAM can be utilized for unlocking the upstream and downstream impacts in value chains and estimate the benefits.

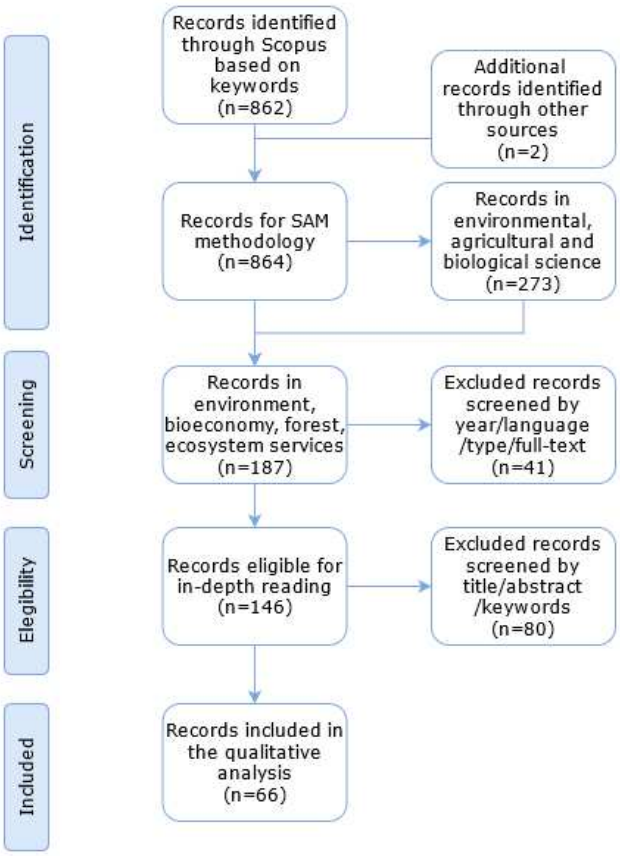
Literature Search: Suitable Keywords, Inclusion, and Exclusion Criteria

To demonstrate whether the SAM methodology would make it possible to analyze the effects of NWFPs on the socioeconomic system, we performed a literature review completed in January 2022, analyzing the different applications of SAM methodology. The first step of the analysis was performed with the R package "Bibliometrix" (Aria and Cuccurullo, 2017) and was based on studies published in journals included in the databases Scopus and Web of Science, using the string "social accounting matrix". Then, we narrowed the search focusing on records belonging to environmental studies as well as agricultural and biological studies. As a final step, we performed a systematic literature review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Doimo et al., 2020; Liberati et al., 2015; Sanz-

Hernández et al., 2019) for the screening and selection of relevant papers. The systematic review focused on empirical studies that uses the SAM methodology applied to environmental issues, with a focus on forest sector, ecosystem services, and bioeconomy. Here, we used the string: "('social accounting matrix' AND 'bioeconomy' OR 'environment*' OR 'forest*' OR 'ecosystem service')". By using this string, the database returned documents in which the term "social accounting matrix" was always present in the tile, abstract, and/or keywords, and at least one of the other words was included.

Figure 2 shows the approach to the screening and selection of relevant papers. The first set of excluded records did not meet the following criteria: (1) journal article, (2) papers published in English, (3) full text available, (4) from 1992 to 2022. Then, due to the many different applications of the SAM methodology, there was a second set of excluded records based on applications not in line with our research topic.

Figure 2. Flowchart showing the steps of the literature review. Source: adapted from Liberati et al. (2015).



Results

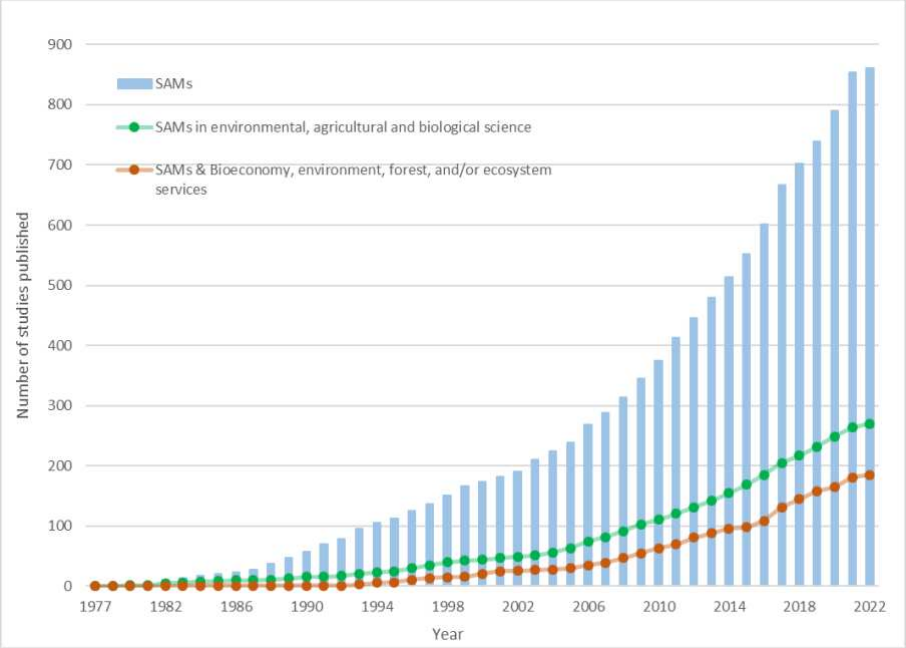
Descriptive Analysis

The initial number of records was 864. Regarding the temporal evolution of the studies, their number generally showed an increasing trend over time starting from the 1960s–1970s, with more than 50% of the studies published within the last 7 years. More in details, the maximum number of documents was published in 2017 (65) and 2021 (64), with an annual growth rate of 10% until 2021 (included). One reason could lie in

data accessibility and availability, since the SAM requires a substantial amount of data; in addition, technology development has sped up data processing and the calibration of the matrix.

Similarly, the number of studies on bioeconomy, environment, forest, or ecosystem services has recently increased, as shown in Figure 3. The concepts of 'bioeconomy' and 'ecosystem services' are relatively new, so studies using the SAM on these topics started from the 2000s, while studies with a focus on the environment came earlier.

Figure 3. Cumulated number of publications on SAMs and subfields. Source: authors' own elaboration.



Analyzing the documents by subject area, we can notice how the major fields were economics, econometrics, and finance (437 documents—29.7%), followed by social science (327 documents—22.2%), environmental studies (215 documents—14.6%), and agricultural and biological science (86 documents—5.8%). Taking into consideration the most 20 relevant sources (based on the number of publications), more than a half (11) of the studies somewhat belonged to the field of environmental studies, and 3 of them appeared to be among those with the highest h-index (e.g., Ecological Economics, Environmental and Resource Economics, Journal of Cleaner Production).

Narrowing the field to bioeconomy, environment, forest, and ecosystem services, Table 1 shows a descriptive analysis of the results. Regarding the geographical distribution of case studies, only 21% of the total records applied this methodology to countries belonging to the European Union. In particular, Spain was the most studied country (22 records), followed by the European Union (8 records, both for the EU as an aggregate and for each of its 28 Member States), while the remaining countries showed a frequency of 2 records or less.

Table 1. Summary of the results of the studies related to bioeconomy, environment, forest, and ecosystem services (N = 146). Source: authors' own elaboration., based on Scopus, last update: 6 February 2022.

Criteria	Category	Results (N)
Publication year	Before 2003	24
	2003–2012	38
	2013–2022	84
Number of studies per different quartile	1st quartile	51
	2nd quartile	49
	3rd quartile	22
	4th quartile	17
	Not listed	7
Country	EU	35
	Non-EU	109
	Global	2
Level of analysis	National	85
	Regional	45
	Local	16
Focus / categories of the main indicators studied	Economy	38
	Environment	33
	Households	26
	GHG emissions	20
	Energy sector	11
	Economic Growth	11
	Employment	11
	Water	7
	Value added	7

Moreover, the flexibility in SAMs geographical structure was also confirmed by the descriptive analysis. The SAM methodology was applied at the national level in most studies. However, this approach was implemented at a regional or even local level in quite many cases.

Finally, we wanted to explore which aspects of the socioeconomic system were analysed. Due to its accounting accuracy, comprehensiveness in recording data, and flexibility, the SAM method (fixed-price linear models) has been used widely in the last three decades to evaluate (among others) the link between economy and environment in general; the impact on households (including income, consumption decisions, living costs and wellbeing); GHG emissions (the majority of studies focused specifically on CO2 emissions); the energy sector (including biofuels, energy prices, and use); economic growth; employment; water (including water quality, water pollution, and water resources); value added.

In-Depth Reading

After screening for title, keywords, and abstract, 66 records were considered for in-depth reading. In this section, we present those dealing with the more specific topics of bioeconomy, ecosystem and ecosystem services, and forestry sector.

A first group of studies worth mentioning focused on the European bioeconomy, based on the work of Müller et al. (Müller et al., 2009) who constructed a series of AgroSAMs for each of the EU Member State with detailed accounts for 30 agricultural activities and 11 food activities, benchmarked to the year 2000. These AgroSAMs were then updated to the year 2007 by Philippidis et al. (2014) who also generated EU regional clusters with comparable agricultural sector structures. Continuing this research line, a new set of SAMs specifically designed for the study of bioeconomy and natural resources, referred to as the BioSAMs (Mainar Causapé and Philippidis, 2018), further extended the accounts of the bio-based industry to include new sources of biomass and contemporary applications of biomass in the liquid fuel, energy, and chemical sectors (Mainar-Causapé et al., 2020; Philippidis et al., 2014). The resulting BioSAMs, recently updated to the year 2015 (Mainar-Causapé and Philippidis, 2021), were utilized to calculate output and employment multipliers (Fuentes-Saguar et al., 2017) as well as both backward-linkage (BL) and forward-linkage (FL) multipliers (Philippidis and Sanjuán-López, 2018).

These studies have all contributed to break down the EU bio-based sector, beyond the limited details of bioeconomy available from existing national accounts data (Philippidis et al., 2014). Despite their substantial contributions, the authors of these studies agreed on the lack of data being one of the main constrains to the use of a comprehensive SAM for evaluating the activities of a bioeconomy. More precisely, bioeconomic activities are usually defined in the context of the standard national accounts as large sectoral aggregates (i.e., agriculture, food processing, forestry, fisheries, wood, and pulp) or even in their parent sectors (e.g., chemical industries, clothing, energy) (Fuentes-Saguar et al., 2017) which include both bio-based and non-bio-based activities.

We found few studies using SAMs to analyze the forest sector. These studies presented a limited level of details on the forest sector, splitting it into forestry, wood sector (including lumber and wood products,

paper, and allied products), and wood furniture (Alavalapati et al., 1999; Tilley and Munn, 2007). The effects have been studied, among others, on enlarged economic impacts of changes both in the forest industry and in other sectors of the economy (Malahayati, 2018), distributional consequences for households (Alavalapati et al., 1999; Albornoz-Mendoza et al., 2019; Scouse et al., 2018), output, value added, and employment by forestry export value chains (McConnell and Altizer, 2019; McConnell et al., 2019), as well as carbon tax and subsidies on the forest sector (Liu and Wu, 2017). Going more into detail, interesting results concern the impact of productive linkages that the forest sector may have on other sectors of the economy. Indeed, especially in developing countries, the forest sector represents a key sector of the economy, meaning that it has the capacity to lever up other sectors of the economy through its backward or forward linkages. For example, according to (Gallardo and Mardones, 2013), the forest sector in Chile is a key sector and one with the greatest backward linkages. This means that the outputs from the forest sector are highly utilized by other sectors. This is confirmed by another study in Indonesia founding the forest sector to be the only one resulting in a higher multiplier effect on another sector, in this case the manufacturing sector, rather than on its own sector (Malahayati, 2018). Again, a recent study analyzing the forest sector of 58 countries, confirms how the contribution of the forest sector to national economy goes beyond the sector itself and extends to many other sectors of the economy through indirect and induced effects (Li et al., 2019), contributing to sustainable development, especially in rural areas, regardless of the development stage and region.

However, one must keep in mind that this big share of the economy is often paid for with a high rate of deforestation. Indeed, one limitation of studies analyzing the forest sector through SAMs is that they take into account market benefits and costs and not the non-market benefits and costs associated with environmental improvements or degradation linked to the state of forest resources (Malahayati, 2018). In the same way, the cultural services coming from forest ecosystems have not been yet analysed with the SAM methodology. Nonetheless, it is worth mentioning the study by (Campoy-Munoz et al., 2017), who assessed the economic impact of a cultural heritage site on the economy of the city of Cordoba. The authors performed the analysis via linear models based on regionalized SAMs to determine the heritage site's contribution to the host economy in terms of production and employment. In the same way, it could be possible to assess the cultural services coming from forest ecosystems (as well as other type of ecosystems), especially the recreational ones.

Moving to SAM and ecosystem services, few studies considered the value that ESs bring into the economy, using SAMs to trace the flow of services across the supply chains. Those studies focused mainly on provisioning services, providing a view of the links between the biophysical environment and the economic activities. For example, Arto et al. (2019) developed a dynamic Computable General Equilibrium (CGE) model to capture the impacts of climatic changes (e.g., reduction in crop productivity) on some critical variables affecting specific economic processes. Another service under study is water provision. For example, Zhou et

al. (2017) constructed a water resource embedded SAM to analyze the relationship between water resource utilization and socio-economic development; multiplier analysis was then applied to explore the economic structure, feedback mechanisms, and water flows among different sectors.

Finally, we found one study focusing on NWFPs. Specifically, Campoy-Muñoz et al. (2022) estimated the economic impacts of small-scale pine nut cooperatives in Southern Spain. Authors employed a SAM linear model and primary data to show the positive contribution to province's production, GDP, and employment levels.

Discussion

Based on the descriptive analysis and in-depth reading, we can outline some considerations. The chronological survey of publications, together with the geographical distribution of case studies, showed that the SAM approach has been widely used across the globe and that is has gained attention due to its capability to explain the relationship between the environment and human wellbeing. Moreover, the descriptive analysis of indicators showed the versatility of this methodology. Indeed, it can be applied to estimate the impact of exogenous shocks (e.g., effect of policies or climate change) on a wide range of socioeconomic characteristics.

The literature showed a visible growing trend linking economic accounts with environmental accounts. Several studies demonstrated how standard SAM can be extended to include the environmental dimension and how this effectively works. By using this methodology, is it possible to analyze a specific forest ES and its role within the socioeconomic system. As highlighted in the study by Mainar-Causapé et al. (2020), there is a need to fill gaps in the BioSAMs regarding, in particular, a comprehensive representation of the forest sector, as well as additional transactions accounts to capture non-market ESs within the SAM structure. In this perspective, the incorporation of both social and market components of NWFPs into the forest sector represents a novelty addressing both aspects.

Notwithstanding, the SAM methodology has its drawbacks. First, it does not allow substitution between factors of production; second, factor demands do not depend on relative changes in factor prices; third, the model assumes that the supply of factor inputs is unlimited in the economy (Alavalapati et al., 1999); finally, the SAM methodology provides only a snapshot of a certain economy during a specific period of time (usually one year), meaning that it could not represent adequately periods of disruption of the economy, such as the one we are experiencing now because of COVID-19. For example, during 2020 the transportation and storage sector shrank, while at the same time the information and communication sector grew. Even though it is possible to perform a sensitivity analysis of the matrix and make a hypothesis on how this will impact an entire economy, it is not possible to use previous data to balance the matrix without weakening of the information.

Conclusions

Forests can contribute to the European bioeconomy in many ways other than wood-related products. They supply key ESs such as cultural services (recreation, tourism, and health); regulating services (water, soil, air quality, and noise reduction); provisioning services (clean drinking water, non-wood forest products like mushrooms and berries). The knowledge of ES values and ES impacts on the economy must improve to support better economic and policy decision making (EEA, 2016; Martinez De Arano et al., 2018). In fact, despite a rapid improvement over the last decades, data on the supply of several ecosystem services and their value are still scarce (Forest Europe, 2020). Moreover, in order to estimate how economic activities depend on forest ecosystems and to estimate the contribution of forest ESs to the gross domestic product (GDP), one must look beyond the direct contribution to the forest sector, trying to estimate the economic impact on other sectors and the indirect and induced effects on the economy. In a natural resource-based bioeconomy, there is a need to understand more thoroughly the full spectrum of available resources, define opportunities and niches of those resources, explain rights of use as well as trade-offs and synergies between forests and other types of land use (Wolfslehner et al., 2019). In this study, we proposed a new theoretical framework that links ES supply to the whole economy and society. Based on a literature review, we showed that the SAM methodology is suitable to investigate the value that NWFPs brings to the bioeconomy in both their private and social components. Extending the SAM framework would represent a novelty in the field of forest ES. It will allow estimating the contribution of market and non-market forest ecosystem services to the economy and the society. We found that the literature on SAMs has developed at a rapid pace over the last decades worldwide. SAMs are gaining attention because of their capacity to explain the relationship between the economy, the environment, and human wellbeing, as well as the increased availability of accounting data. The studies applying the SAM approach to the forest sector were able to quantify the value that the forest sector brings into the economy through its direct, indirect, and induced effects. Nevertheless, the non-market ecosystem services have not been represented so far. The structure of a SAM being flexible, we proposed an extension to account for forest ESs other than wood (EcosySAM), making it possible to estimate the total economic value that forests bring into the socioeconomic system in terms of value added, employment, and other socioeconomic indicators. The calibration of EcosySAMs will provide estimates of the link between the ES flows and the economy and can become a tool to support IPBES reporting.

The main limitation of this study is that it considered only one possible approach. There might be alternative approaches to the SAM methodology for estimating the value forest ESs bring into the economy. Moreover, a literature analysis is not sufficient to prove the goodness of the methodology. There is a need for a case study to demonstrate its practicability.

Providing information on the relation between forest ecosystem services and the economy will support policy-makers in their decisions to invest and act to maintain ecosystem services. For this reason, we expect

a development of research on EcosySAMs in connection with the ecosystem valuation literature. Non-Wood Forest Products can be taken as a pilot to calculate Social Accounting Matrices extended to forest ecosystem services, including both a market and a social component.

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2. Evaluation of the social component of Non-Wood Forest Products

Based on: Di Cori, V., Franceschinis, C., Robert, N., Pettenella, D., and Thiene, M. 2021. Moral foundations and willingness to pay for non-wood forest products: A study in three European countries. Sustainability (Switzerland), 13(23). https://doi.org/10.3390/su132313445

FAO defines non-wood forest products (NWFPs) as being "goods of biological origin other than wood derived from forests, other wooded land and trees outside forests". This definition can be used as a reference, but since there is no official definition up to date, every study can use a slightly different definition depending on the objective and the data availability. Undoubtedly, NWFPs represent a very broad category. According to the Millennium Ecosystem Assessment, more than 150 NWFPs are of importance within international trade, and there is growing evidence that they constitute a significant and undervalued segment of forest goods and services (Lovrić et al., 2020; Wolfslehner et al., 2019).

Results from a study assessing the collection and value of marketed and non-marketed NWFPs for households in 28 European countries show that more than a quarter of households (26%) in Europe collect NWFPs, with a descendent trend from East to West (Lovrić et al., 2020). Authors found out collecting NWFPs is a contribution to livelihood in Eastern Europe, whereas in the West it is more a recreational component. Moreover, the study shows how a total of 86.1% of the collected weight of NWFPs is used for self-consumption, while the rest is sold. Finally, the value generated from the collection of such products and not yet included in the European bioeconomy is estimated at €23.3 billion(Lovrić et al., 2020), meaning that accounting for NWFPs in the European bioeconomy would undoubtedly increase the value of the forest-based sector, especially considering that there is a paucity of studies addressing the economic value associated to the public component.

Indeed, as most natural resources, NWFPs have two important components: the market and non-market (public/social goods) component. The latter, which could be particularly relevant, it is connected to services

such as recreation, tradition, wellbeing and biodiversity conservation. This value can be assessed via ecosystem service evaluation techniques. A variety of valuation techniques can be used when market data are not already available and when it is not possible to estimate a market price. In this study, we use a choice experiment to explore individuals' preferences towards NWFPs and associated services.

After the results of the literature review and the developing of the theoretical framework, both explained in the previous chapter, in this chapter the focus is on estimating the value of the social component of NWFPs from a socioeconomic perspective, to understand its contribution to the wellbeing of citizens as well as to infer the economic activity that is indirectly generated.

KEY MESSAGES:

- People are willing to pay for sustainable management practices that improve NWFPs production and conservation.
- Indirect expenses derived from the public component of NWFPs exist especially in the transport sector, and food and accommodation sector.
- NWFPs can not only provide new market opportunities for the European bioeconomy, but also cultural services that benefit people and enhance their recreational activities.

Introduction

Non-Wood Forest Products (NWFPs) are "goods derived from forests that are tangible and physical objects of biological origin other than wood" (FAO, 2020). Some NWFP species also act as keystones in ecological and cultural systems (Shackleton et al., 2018); for example, they can provide food, facilitate pollination and seed dispersal, protect animal health, contribute to the nutrient cycle, offer shelter and protection, or contribute to cultural symbolism. They contribute to wealth of the populations worldwide, accounting for approximately a quarter of rural household income in developing countries (Shackleton et al., 2018). They have been an important source of food, medicine, and income for their users for thousands of years (Sardeshpande and Shackleton, 2019). Finally yet importantly, they play an important recreational role, since people are used to going to the forest, often with family and friends, to collect these products and use them for their own consumption or as a gift to friends and relatives. Nevertheless, most of these roles are still not recognized and valued by the society and the economy.

In Europe, NWFPs are gaining attention thanks to new market opportunities whose development was supported by research and innovation projects such as INCREDIBLE, a Horizon 2020 project on Innovation Networks for Cork, Resins and Edibles (Brenko et al., 2018). In addition, in the new EU Forest Strategy post-2020, the European Commission commits to promoting the sustainable production of NWFPs and ecotourism (European Commission, 2021). Lastly, the European bioeconomy strategy acknowledges the multifunctional role of forests and their services as a source of innovation and resilience (European Commission, 2018).

Despite the political interest, the information and statistics currently available refer mainly to formally marketed NWFPs (Lovrić et al., 2020). The international System of National Accounts (SNA) partially accounts for the activities related to the collection of non-wood products, when these products are marketed or when their collection and consumption goes along with other registered economic activities such as transport or restaurants. However, NWFPs often have a much lower profile compared to timber production, as in many cases they are part of the informal economy and thus their economic value often goes unnoticed in official statistics (FAO, 2020; Sorrenti, 2017; World Bank, 2017). In addition, the social component is not visible and their services are partially captured in non-forest activities.

With this perspective in mind, it is important to recognize the dual component of this forest ecosystem service. On the one hand, the market component refers to products that are currently marketed—at least partially—and thus have a market price. On the other hand, NWFPs also have a social component that can be associated with the social and cultural services they provide. An example is the collection of products such as berries, mushrooms and herbs that can be classified both as a market product and as an intangible output as a part of the recreational function of the forests (Sisak et al., 2016).

The social component of NWFPs has been so far the least investigated. Although several studies assessed the share of households collecting NWFPs in Europe, the quantity collected, and the corresponding market value, the final goal has been to recognize the importance of co-production of wood and NWFPs in the forestry sector (Lovrić et al., 2020); thus, the value people attach to NWFPs as a cultural service is only partially known.

The aim of this study is to estimate the value of the social component of NWFPs from a socioeconomic perspective, in order to understand its contribution to the wellbeing of citizens as well as to infer the economic activity that is indirectly generated.

Different valuation techniques can be used when data are not already available and when it is not possible to estimate a market price (M. Masiero et al., 2019). In this study, we use a choice experiment (Masiero et al., 2018; Morey and Thiene, 2017; Swait et al.,, 2020) to explore individuals' preferences towards NWFPs and associated services in three European countries, namely Italy, Sweden and Czechia. Choice experiment is a common approach for the estimation of non-market values and its use is particularly indicated for the economic valuation of multifunctional resources (such as forest), as it allows to investigate preferences (and estimate monetary values) towards each characteristic of a given good/service (Mariel et al., 2021). We estimate the individual marginal willingness to pay (WTP) (Mariel et al., 2021; Masiero et al., 2019; Morey and Thiene, 2017; Pascual et al., 2010) for the supply and maintenance of NWFPs. Going further, we add the moral dimension to the choice model with the aim to better understand the different determinants driving people's choices and thus improve the behavioural realism of the model. We investigate whether there is a

relationship between moral motivation, public policy and private contributions to forest conservation and management under the framework of the Moral Foundations Theory (Welsch, 2020).

This paper is organised into five sections. After the introductory section, the second section explains the conceptual and empirical frameworks; the third and fourth sections present and discuss the results; finally, the fifth section includes conclusions, research gaps as well as future research needs, and implications for policy-making.

Materials and Methods

Conceptual Background

Discrete Choice Experiment

The field of environmental economics has been utilizing Choice Experiment (CE) already for more than twenty years (Boxall et al., 1996; Hanley et al., 1998; Louviere, 1992). CE views complex goods, such as environmental resources, as made up of single attributes, each of which represents unique characteristics of the good. Therefore, CE can be used to determine which attributes are significant determinants of the values people place on (non)-market goods, as well as the implied ranking of these attributes among population, and finally the value of changing more than one of the attributes at once. A monetary indicator, the Willingness to Pay (WTP), represents this value (Mariel et al., 2021; Masiero et al., 2019; Morey and Thiene, 2017; Pascual et al., 2010). Within a choice scenario, normally composed of different policy alternatives, plus the status quo (SQ), respondents will compare and select one their favourite alternatives (Louviere, 1992).

CE data are usually analysed using discrete choice models, which are rooted on the random utility maximization (RUM) theory, based on the assumption that individuals, when facing a set of alternatives, choose the one that maximize their utility (Mariel et al., 2021). According to the RUM theory, the utility of choosing the alternative *i* for an individual *n* facing a set of *J* alternatives, denoted by *j* =1,…,*J*, is a function of the K characteristics of the alternative i. Two parts compose the utility function (Equation 1): a systematic part V_{ni}, and a random part ε_i standing for all unobserved variables. Therefore, the utility function is expressed as

$$U_{ni} = V_{ni} + \varepsilon_i \forall\, i\ in\ 1,\ldots, J \qquad (1)$$

The systematic part of the utility function of individual n associated with the selected alternative *i* is modelled as a linear function of the vector of the attributes x_i and associated parameters *n*. The Multinomial Logit Model (MNL) can define the probability of individual *n* choosing alternative *i* out of *J* alternatives:

$$\pi_{ni} = \frac{\exp\left(\beta_n x_i\right)}{\sum_{j=1}^{J} \exp\left(\beta_n x_j\right)} \qquad (2)$$

where β_n is a vector of coefficients. The main limitation of MNL is that assumes homogeneous preferences, i.e., β_n is the same for all members of the target population.

To overcome this limitation and account for heterogeneity of preferences towards services provided by forests, we estimated a Mixed Logit Model (MXL) specified in WTP space (Scarpa et al., 2008; Train and Weeks, 2005). In the MXL model, preferences within a population are assumed to follow a continuous distribution (specified by the practitioner), so instead of estimating only the mean coefficient (as in MNL model), the MXL allows to estimate the moments of the distribution of utility coefficients (e.g., mean μ and standard deviation σ). As such, the β_n coefficient in Equation (2) is expressed as shown in equation 3

$$\beta_n = \mu_n + \sigma_n \quad (3)$$

with both μ_n and σ_n to be estimated.

The main advantage of the specification in WTP space is that the estimated coefficients are a direct measure of WTP values (compared to standard specifications in preference space, in which WTP values are computed a posteriori from the model coefficients). This allows retrieving WTP values that are more accurate, as highlighted by the related literature (see (Mariel et al., 2021)). In such model, the utility function for alternative i is specified as

$$U_{ni} = \lambda_n^*(\omega_n' x_i - p_i) + \varepsilon_{ni} \quad (4)$$

where p is the cost attribute and ω_n' is a vector of marginal WTP values for each non-monetary attribute, following a continuous distribution. λ_n^* is defined as $\lambda_n \delta_n$, where λ_n is the scale of the i.i.d Gumbel error ε_{ni} and δ_n is the coefficient of the cost attribute for respondent *n*.

The model was estimated by simulated maximum likelihood with the R package Apollo (Hess and Palma, 2019). Choice probabilities were simulated in the sample log-likelihood with 500 Modified Latin Hypercube Sampling draws. All the coefficients for the non-monetary attributes were assumed to follow a normal distribution, whereas a log-normal one was assumed for the cost coefficient.

Moral Foundations Theory and the Link with Discrete Choice Analysis

The aim of the Moral Foundations Theory (MFT) (Haidt and Joseph, 2008) is to define "the universal cognitive modules upon which cultures create moral matrices" (Haidt, 2012; Welsch, 2020). The MFT was developed by defining the adaptive challenges of social life as identified by evolutionary psychologists and linking those challenges to virtues found across cultures. Care, Fairness, Loyalty, Authority, and Sanctity are the Moral Foundations (MFs) that correspond to those adaptive challenges; the endorsement of the MFs is assessed in psychological studies using a specially developed Moral Foundations Questionnaire (MFQ) (It is important to

note that the scale used in this study goes from 1 to 5, which is different from the scale used in the original MFQ that goes from 1 to 6.) (see Appendix A) (Graham et al., 2011).

Even though many of the choices people make have a moral component, very few discrete choice modelling studies explicitly acknowledge and explore the moral dimensions of choice behaviours (Chorus, 2015).

In this study, we investigate whether the MFs, in addition to standard explanatory variables, improve the explanation of the decision-making process regarding the endorsement of voluntary contributions to forest conservation and management (Dickinson et al., 2016; Welsch, 2020), specifically the presence of NWFPs. The general moral choice context would be the one for which people are willing to pay (e.g., higher taxes) not only for a personal service use, but also in favour of forest conservation for others and future generations. Following the considerations made by Chorus (2015), we try to infer which of the MFs apply when and for what.

To investigate whether MFs affect the value people attach to NWFPs conservation, we incorporated the scores retrieved from the questions reported in Appendix A in the Mixed Logit Model. Firstly, we computed the average score for the five MFs traits for each respondent. Then, to avoid using ordinal scores as continuous variables, we transformed the average scores in dummy variables, taking the value of 1 when the average trait score for a respondent is higher than the average score over the sample. Finally, we included the dummy variables in the utility function via interaction terms with the ω_n coefficients of the three NWFPs attributes. As such, ω_n in Equation (4) becomes:

$$\omega_n = \varphi_n + \gamma_{Care} * Care + \gamma_{Fairness} * Fairness + \gamma_{Loyalty} * Loyalty + \quad (5)$$

$$\gamma_{Authority} * Authority + \gamma_{Sanctity} * Sanctity + \sigma_n$$

where φ_n is the main effect, the γ parameters measure the interaction effect and σ_n is the standard deviation parameter. Such specification was adopted in all the sampled countries, to enable a comparison of MFs effects.

Empirical Framework

Study Area

The study area focuses on three European countries, namely Sweden, Czechia, and Italy. These three countries are located in different parts of Europe (north, centre, and Mediterranean area, respectively), have different ecosystems as well as socio-economic characteristics such as purchasing power (Eurostat), which makes them suitable to cover contrasted contexts in Europe.

In Czechia, forests cover 34.6% of the country (0.31 ha per capita). Apart from timber production, forests provide many other non-market goods and services including NWFPs for the society, not yet included into official statistics. After the end of the socialist regime, the share of state-owned forest has decreased from almost 100% of the forestland to 60% between 1990 and 2013. These changes have not substantially influenced neither NWFPs production nor collection by forest visitors, partly because NWFPs can be freely picked by forest visitors for their own use, irrespective of forest ownership (Sisak et al., 2016). According to recent literature (Lovrić et al., 2020), the most collected products in the country are wild mushrooms and wild berries; the median collected weight is 19 kg/household; and the share of households for which NWFPs represent income contribution is 7.2%.

In Sweden, forestlands cover more than 68% of the total area (2.16 ha per capita). In Swedish society, timber and pulpwood production is an important source of income, but nonetheless the Swedish Forest Act from 1993 (currently in effect) establishes that forests shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity (Nordén et al., 2017). Although Swedish forests are mainly private (77% in 2015), almost all forests are accessible to the public who can also freely pick up berries, mushrooms and wild flowers. Once again, the most collected non-wood products are wild mushrooms and wild berries; the median collected weight is lower compared to Czechia (11 kg/household); the same goes for the share of households for which NWFPs represent income contribution (5.3%). Finally, the share of collected weight sold by household is less than 3% (Lovrić et al., 2020).

In Italy, forests cover 31.8% of the total area (0.27 ha per capita). Nonetheless, only 15.7% of the Italian forests (1.3 million ha) are under a multi-year management plan, an essential tool for ensuring the provision of non-market ecosystem services in balance with that of commercial products (mainly timber for industrial use and firewood). NWFPs' property rights are well regulated. Both professional and non-professional pickers should have a licence and pay for a daily fee to collect products like mushrooms, truffles, medicinal and aromatic herbs. In such a way, products are from a fiscal and heath regulation regularly entering the market and their traceability is assured. Regardless the Italian law on NWFPs, it is still common to find households collecting them in small quantities for self-consumption and recreational purposes, without any specific permission. Differently from Czechia and Sweden, the collection of forest nuts is also very popular in the country, together with mushrooms and berries.

Finally, in countries like Czechia and Sweden that are under the "every person's right" system, NWFPs collection can affect the forestry sector as forest externalities, both in the context of a non-market (recreational) forest service and in the context of a market (production) forest service.

Selection of the Attributes for the Choice Experiment

To understand which attributes to select for the CE, we carried out a literature review based on articles published in Scopus. We first focused on studies using non-market valuation techniques to estimate the value of NWFPs. The search returned 70 articles. The most frequent methodologies utilized were travel cost (de Frutos et al., 2019; Marini Govigli et al., 2019; Martínez de Aragón et al., 2011), contingent valuation (De Frutos et al., 2016; Vieira et al., 2016; Wu et al., 2006), and choice experiment (Bocci et al., 2020; Giergiczny, et al., 2011; Soliño et al., 2018).

After narrowing the search, we proceeded with an in-depth analysis of the studies using only CE as methodology and dealing specifically with NWFPs and/or forest protection and recreation. We gather information from 25 studies about the attributes and their levels, the sample size, the scale of the survey and the study area, the experimental design, and the data analysis. The models most frequently used in the literature are the mixed logit model (Engelman et al., 2018; Soliño et al., 2018; Yao et al., 2014), the latent class model (Brahic and Rambonilaza, 2015; Masiero et al., 2018; Mieno et al., 2016) and the conditional logit model (Carson et al., 2015; Kang et al., 2019).

The literature review helped us understand that NWFPs are often included in studies dealing with recreation, biodiversity, and environmental conservation. In these studies, the collection of mushrooms, berries and other NWFPs is usually only represented by one single attribute when present. Moreover, only the presence or absence of NWFPs in the forest is considered, and not the quantity (Brey et al., 2007). As far as we know, with game meat being the only exception, no study has focused more deeply on NWFPs within a choice experiment. For this reason, we decided to have three out of the six attributes specifically dealing with the presence of NWFPs into the forest, using a quantitative level scale. We decided to study people's attitude towards the presence in the forest of berries, mushrooms, and wild herbs. We chose these products because they are the most frequent wild food products collected by households in Europe (Lovrić et al., 2020). Regarding berries and mushrooms, we used the yield per hectare as a unit of measure, which we found to be very easy to understand for pickers; while for wild herbs we used the percentage of forest area suitable for picking which was acknowledged as most intuitive to pickers (Enrico Vidale, personal communication).

The three other attributes were related to the conditions of picking. First, different levels of payment are proposed. We chose to have a national tax as the payment vehicle in order to estimate WTP values that also include the social component of NFWPs, given that a tax is not solely linked to the picking activity. The second corresponds to the experience within the forest in terms of facilities, since we found this feature to be common in the literature (Bartczak, 2015; Carson et al., 2015; Christie et al., 2007). This is in line with the purpose of the study that wanted to test also people's general experience within the forest. Finally, because biodiversity conservation is a heavily debated topic, and it is well understood by the general public, we include one attribute on protected forest areas, following the literature (Górriz-Mifsud et al., 2016; Hoyos et

al., 2012; Rambonilaza and Brahic, 2016; Soliño et al., 2018) and the new EU Biodiversity Strategy for 2030 (European Commission, 2020).

The total number of six attributes is in line with studies in the literature and with the CE theory (Mariel et al., 2021).

Finally, to reflect the different features in the three countries, at least one expert per country was contacted to provide insights on the realistic levels for each attribute (Enrico Vidale; Ragnar Jonsson; Marcel Riedl; personal communication). Attributes and levels for each country are reported in Table 1.

Table 1. Attributes and levels in the choice experiment. Source: authors' own elaboration.

Attribute	Description to Respondents	Country	Levels
Presence of berries	The production of berries can be increased thanks to specific forest practices such as extensive weed removal.	Italy	0.8–26–55 kg/hectare/year
		Czechia	1–35–70 kg/hectare/year
		Sweden	2–40–80 kg/hectare/year
Presence of wild herbs	Herbs growing spontaneously in natural or semi-natural ecosystems and can exist independently of direct human action. The production of wild herbs can be increased by more extensive weed removal in the forest area suitable for wild herbs picking	Italy	1.6–4–8% of forest area suitable for wild herbs picking
		Czechia	3–8–15% of forest area suitable for wild herbs picking
		Sweden	1.6–4–8% of forest area suitable for wild herbs picking
Presence of mushrooms	The production of mushrooms can be increased by practices such as lighter forest thinning	Italy	0.8–3–6 kg/hectare/year
		Czechia	1–5–10 kg/hectare/year
		Sweden	1–5–10 kg/hectare/year
Biodiversity protection	The EU Biodiversity Strategy for 2030 intends to protect and restore EU's biodiversity, and in particular (but not only) the remaining primary and old-growth forests	Italy	3–10–20% of protected forest area
		Czechia	
		Sweden	
Access points	The government wants to equip forests with more access points, with parking areas.	Italy	0–1–3 additional access points
		Czechia	
		Sweden	
Cost		Italy	5–10–25–50–100–150 EUR

	To implement programmes aimed at maintaining and/or improving the provision of environmental services, citizens will have to contribute through an annual tax for 5 years specifically earmarked for this purpose	Czechia	100–200–500–1000–2000–3000 Kč
		Sweden	60–120–300–600–1200–1800 SEK

Survey Design and Data Collection

The questionnaire reported in this study is divided into four sections. The first section aims to understand people's experience with forests and the collection of NWFPs. Respondents indicated: their motivation to go to the forest; whether or not they collected NWFPs and if so, which products they collected; as well as the influence that the pandemic of COVID-19 had on their frequency to go to the forest and collect NWFPs. The second section is the choice experiment. In this section, the respondents were first provided with the description of the attributes; then, they faced ten different scenarios, each of which had two different alternatives plus the status quo; finally, there was a question to detect whether or not the respondents chose randomly. The third section includes the Moral Foundations Questionnaire (Appendix A), plus a question to account for the variable "Nature caring", where the respondents rated the importance for them to care for nature and the environment. Finally, the fourth section provides socioeconomic information including gender, age, level of education, employment status, number of family members, household income, and place of residence.

A d-efficient design (Scarpa and Rose, 2008) was used to create the choice scenarios, with priors obtained from the pilot study. The design consisted in 40 choice scenarios, divided in four blocks.

The draft questionnaire was pre-tested twice, firstly with an international group of 14 experts on forest economics and forest biomass, and secondly with a pilot survey of 100 respondents from each country (300 in total), using the on-line layout of the questionnaire. The purpose of the pre-testing (Mariel et al., 2021) was to account for shared understanding and credibility of the questionnaires, respondent fatigue, and missing categories of possible answers.

For each country, a sample size of 1000 respondents was selected, 3000 sample units in total. Samples are representative within the population according to gender, age, and regional origin. Data were collected between June and July 2021.

Results

The Experience with Forests and Collection of NWFPs

The descriptive statistics of our sample along with information about recreational habits are presented in Tables 2 and 3. Significance of differences among countries were tested using ANOVA for continuous variables and chi-square tests for categorical ones.

Table 2. Main qualitative variables. Source: authors' own elaboration.

Variable	Frequency (%)			Chi-Square Test
	Czechia	Italy	Sweden	
Respondents who visited forests in the last three years	95.1	65.8	94.0	<0.001
Respondents who collected NWFPs (out of those who visited forests in the last three years)	87.2	50.2	78.3	<0.001
Increase in NWFPs collection during COVID-19 (out of those who collected NWFPs)	7.29	−51.04	13.75	<0.001
Female	49.4	48.5	51.3	0.006
Employed, full time	51.6	47.7	45.7	<0.001
Level of education, university degree or higher	31.73	35.32	41.16	<0.001

Table 3. Main quantitative variables. Source: authors' own elaboration.

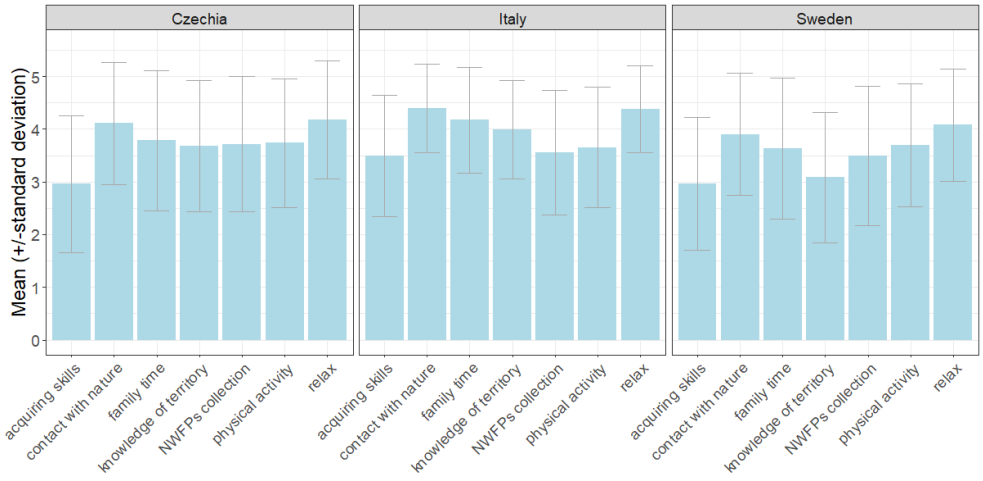
Variable	Mean (Sd)			Anova Test
	Italy	Sweden	Czechia	
Number of forests visited	2.7 (1.7)	4.2 (2.8)	4.6 (3.0)	<0.001
Age (>17)	48 (13.6)	46 (17.7)	45 (16.8)	<0.001
Number of household members (other than yourself)	3 (1.3)	2 (1.5)	2 (1.4)	<0.001

The percentage of people who visited a forest in the last three years is high in all three countries, especially in Czechia and Sweden (95% and 94% respectively). This suggests that a strong connection between people and forests exists, regardless of their place of living (urban cities or rural areas). Respondents from Sweden and Czechia visited on average almost twice as many different forests as those from Italy.

Considering only those visiting forests, the percentage of respondents collecting NWFPs is also substantial. This practice seems to be more diffused among residents of Sweden and Czechia compared to Italy, for which only half of those who visited forests collect NWFPs. Concerning the change in NWFPs collection habits before and after the breakout of COVID-19, the table shows how in all the three countries there was an increase in the fraction of residents collecting NWFPs. This could be explained by the fact that some people during the pandemic felt the need to reconnect with nature. On the other hand, in countries where severe mobility restrictions against COVID-19 were implemented, there was a very little increase of people collecting NWFPs (e.g., in Italy less than 10% of the sample experienced an increasing in the collection rates, while 60% of the sample experienced a decrease).

We also investigated people's motivation to visit forests (Figure 1). The most important motivations are 'contact with nature' and 'relax' in all countries. In Sweden, right afterwards we find 'collection of NWFPs', along with 'spending time with family' and 'physical activity', whereas 'acquiring skills' and 'knowledge of the territory' have the lowest scores. In Czechia and Italy, the only motivation having a lower score is the acquisition of skills.

Figure 1. Reasons for visiting forests. Source: authors' own elaboration.



Knowing people's motivation for visiting forests is critical to better understand the cultural services forests provide and their importance for European citizens.

The motivations driving people to collect NWFPs are investigated further. We analysed the motivation and the objectives of NWFP pickers (Figures 2 and 3, respectively). The main finding is the importance of the social component regarding NWFPs collection in all countries. Respondents mostly pick NWFPs when they are with family or friends. The majority of them are occasional pickers or collect NWFPs as a hobby. Moreover, the most important reasons for picking NWFPs are self-consumption and recreation.

Figure 2. Motivation to pick NWFPs on a scale of 1 to 5. Source: authors' own elaboration.

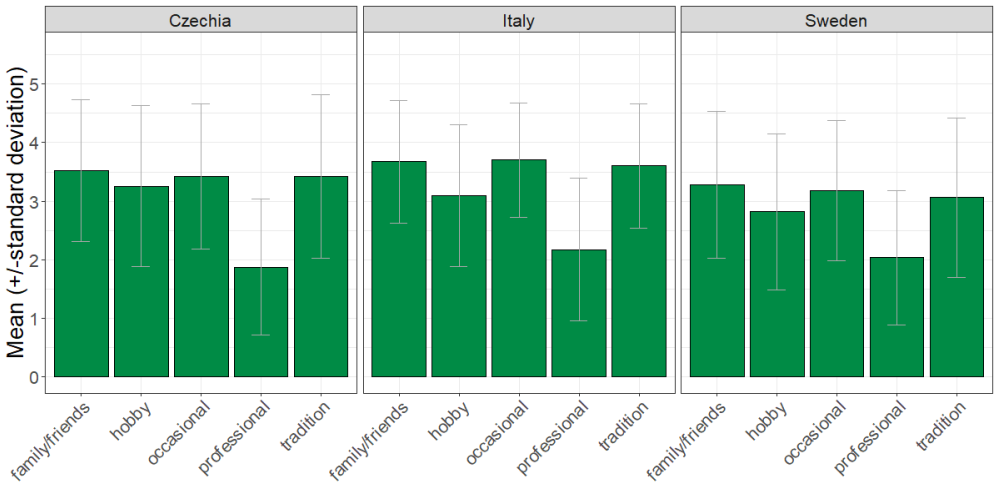
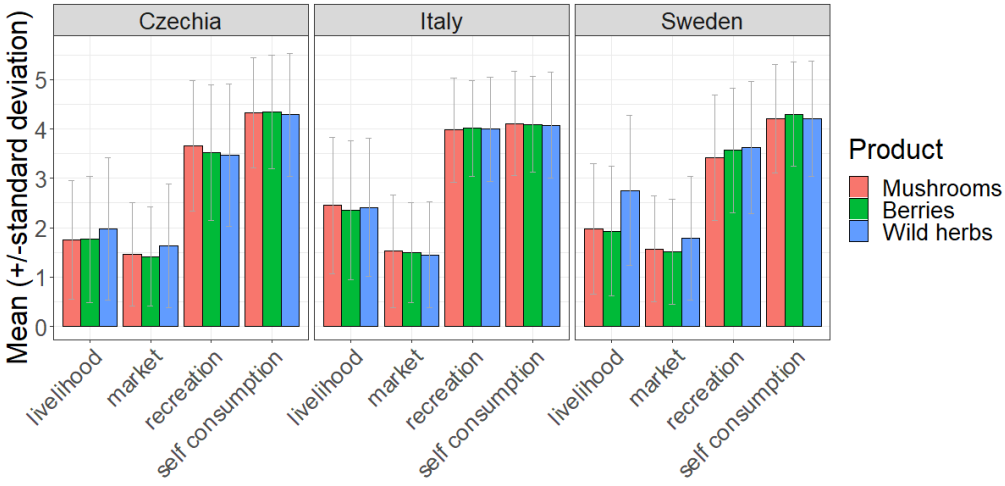


Figure 3. Reasons to pick NWFPs on a scale of 1 to 5. Source: authors' own elaboration.



Finally, we found some differences in Moral Foundations by country, although not significantly different (Table 4). Overall, Care and Fairness have the highest scores in all countries, with Italy having higher scores compared to Sweden and Czechia. This can be explained by the different cultural context that can shape people's morality. In particular, Care and Fairness are individual-focused MFs, which apply to all individuals regardless of their membership to one's group, while Loyalty, Authority, and Sanctity are group-focused foundations; also, the former are endorsed more in Western than in other societies (Haidt, 2012).

Table 4. Moral Foundations Score by countries. Source: authors' own elaboration.

Moral Foundation	Mean (Sd)		
	Czechia	Italy	Sweden
Care	3.64 (0.76)	4.01 (0.70)	3.52 (0.73)
Fairness	3.64 (0.77)	3.92 (0.65)	3.48 (0.72)

Loyalty	3.29 (0.69)	3.63 (0.70)	3.12 (0.69)
Authority	3.33 (0.71)	3.43 (0.66)	3.12 (0.70)
Sanctity	3.29 (0.70)	3.36 (0.75)	2.92 (0.75)

Willingness to Pay and the Interaction with Moral Foundations

Responses to the survey were used to estimate the parameters of the Mixed Logit Model presented in Section 2.1 for the three countries (Table 5). Before analysing the results, it is worth noting that WTP values for different attributes are not comparable, since different measurement units were used (e.g., kg/hectare for herbs and berries, share of forest area suitable for wild herbs picking, and share of protected area for biodiversity). In addition, the WTP values for Sweden and Czechia were converted to Euros using the OECD exchange rates. All the attributes were coded as continuous, which implies that the estimated marginal WTP values represent the amount of money that people are willing to pay for an increase by one unit of each attribute.

Table 5. Estimated parameters of the Mixed Logit Model for the three countries. Source: authors' own elaboration.

	Czechia	Italy	Sweden
Mean parameters φ			
Berries	0.291 ***	0.051 ***	0.178 ***
Herbs	0.020 ***	0.144 *	0.727 *
Mushrooms	0.896 ***	0.088 **	0.620 ***
Biodiversity	0.397 ***	0.102 ***	0.182 **
Access points	5.072 ***	5.293 ***	4.196 ***
Price/scale	−1.794 ***	−3.742 ***	−0.259 *
Status quo	−1.778 ***	−2.058 ***	−2.209 ***
Standard deviation parameters σ			
Berries	0.136 ***	0.001	0.167 ***
Herbs	0.034 ***	0.078 ***	0.542 **
Mushrooms	0.373 ***	0.004	0.265 ***
Biodiversity	0.205 ***	0.013 ***	0.181 ***
Access points	4.461 ***	1.153 ***	4.465 ***
Price/scale	3.587 ***	2.780 ***	3.912 ***

Interaction terms γ			
Berries × Care	0.149 ***	0.022	0.040 ***
Berries × Fairness	0.265 ***	0.029 ***	0.020 ***
Berries × Loyalty	−0.044 *	−0.032 ***	−0.092
Berries × Authority	0.099 ***	0.045	0.017
Berries × Sanctity	−0.064 ***	−0.037 ***	0.011
Herbs × Care	−0.015	0.021 ***	0.082 ***
Herbs × Fairness	0.063 ***	0.013 ***	0.047 ***
Herbs × Loyalty	−0.021	0.002	−0.324
Herbs × Authority	−0.004	0.012	−0.815
Herbs × Sanctity	−0.101 ***	−0.051	−0.492 *
Mushrooms × Care	0.130	0.023 ***	0.049 ***
Mushrooms × Fairness	0.475 ***	0.005	0.210 ***
Mushrooms × Loyalty	0.195	0.021	-0.345 ***
Mushrooms × Authority	0.063 ***	0.044	-0.382 ***
Mushrooms × Sanctity	−0.235	−0.022 ***	-0.345 ***

Note: ***, **, * = 99%, 95%, 90% significance.

The first result of interest concerns the status quo option coefficients: in all countries, these are statistically significant (at 99% level) and negative. This suggests that citizens, on average, prefer the improvement alternatives to the status quo option, thus indicating an interest in supporting policies aimed at improving the current supply of forest ecosystem services. Moving to the mean parameters φ, which are a direct measure of marginal WTP values, we note that all the estimated coefficients are statistically significant at 90% level or higher. This suggests that in all the three countries, every attribute is a determinant of the choice of forest management programs. Moreover, all the coefficients for the non-monetary attributes are positive, which suggests that citizens are willing to pay to support forest management practices aimed at increasing the level of forest services. Moving to examine the WTP values in detail, starting from berries, the highest WTP value was estimated for Czechia (€0.291/kg/hectare), followed by Sweden (€0.178/kg/hectare) and Italy (€0.051/kg/hectare). In the case of wild herbs, instead, the value estimated for Sweden (€0.727 for 1% more forest area suitable for wild herbs picking) is substantially higher compared to Italy (€0.144) and especially Czechia, in which we have a value rather close to zero (€0.020). Concerning mushrooms, Czechia is again the country associated with the highest WTP value (€0.896/kg/hectare), followed by Sweden (€0.620/kg/hectare) and Italy (€0.088/kg/hectare). When comparing the WTP values between berries and mushrooms (which share the same measurement unit), it can be seen how—on average—in all the three

countries citizens value 1 kg of mushrooms more than 1 kg of berries. This is particularly evident in Sweden and Czechia, while the two values are closer in the case of Italy.

Moving to the attributes not directly related to NWFPs, we note how—on average—citizens of all countries are willing to pay for both an improvement of biodiversity protection and additional access points. For the former, the estimated marginal WTP values for an additional 1% of protected forest area are €0.397 for Czechia, €0.182 for Sweden and €0.102 for Italy. In Italy, instead, we have the highest WTP value for an additional access point (€5.293), followed by Czechia (€5.072) and Sweden (€4.196).

As it concerns the standard deviation parameters σ, we note that in almost all cases the estimated coefficients are statistically significant at least at 90%, thus suggesting the existence of unobserved preference heterogeneity towards forest services and variation of sensitivity to the tax. The only exceptions are berries and mushrooms in Italy.

Finally, we turn to the interaction terms γ measuring the effect of MFs on WTP values for the three NWFPs. Starting from berries, we note that Fairness consistently has a significant and positive effect in the three countries. More in detail, citizens with a strong sense of Fairness are willing to pay €0.265/kg/hectare (Czechia), €0.029/kg/hectare (Italy) and €0.020/kg/hectare (Sweden) more those who do not. Then, Care has a significant effect in Czechia and Sweden (positive in both cases) and Loyalty in Czechia and Italy. In this case, the effect is negative, which suggests that citizens with this trait are willing to pay €0.044/kg/hectare and €0.032/kg/hectare less, respectively. A similar result was obtained from Sanctity (significant in Czechia and Italy). Finally, Authority only affects (positively) preferences in Czechia. Moving to wild herbs, Fairness is again the only trait to affect WTP values in all countries (€0.063 for Czechia, €0.047 for Sweden and €0.013 for Italy). Care has a significant effect in Sweden and Italy, again positive in both cases. Sanctity, instead, has a significant effect in Sweden and Czechia, negative in both cases. Finally, in the case of mushrooms, Care and Fairness have again a consistently positive effect and Sanctity a negative one. In the case of Authority, instead, we have a positive effect in Czechia (€0.063/kg/hectare) and a negative one in Sweden (€−0.382/kg/hectare). Finally, Loyalty significantly affects WTP values only in Sweden (€−0.345/kg/hectare).

Discussion

The results of this study indicate that people visiting forests for recreational purposes are mostly motivated by seeking relax and connect with nature. In addition, collecting NWFPs, when available, is a key activity during the visit. Most people collect NWFPs for self-consumption and recreation, often with friends and family, rather than selling them on the market or for livelihood. This confirms the importance of the recreational and cultural role this service provides, in line with previous studies (Lovrić et al., 2020).

It is worth mentioning also that the current pandemic of COVID-19 changed the relationship between people and the collection of NWFPs. In countries were hard measures against COVID-19 were implemented, with

extended periods of mobility restriction, there was a net decrease in the frequency of people going to the forest and collecting those products (e.g., Italy). For countries experiencing softer lockdowns, with minor or no mobility restrictions, the frequency of people collecting NWFPs increased. This might be explained by the fact that people were seeking alternative ways of recreation when it was not possible (or at least not advisable) to undertake indoor activities.

Our analysis on the WTP of people to increase forests conservation and sustainable management reports significant and positive values for all attributes in the three countries under evaluation. The emphasis on NWFPs, specifically targeting berries, mushrooms and wild herbs, suggests that people are willing to contribute for this service even in countries where picking NWFPs for free is traditionally a right of every person, like Czechia and Sweden. It is not easy to compare this study with previous literature, because so far studies have focused more on whether or not it was possible to pick those products, without looking at their availability in quantitative terms. Besides that, we can find in the literature a similar positive attitude of people with regard to NWFPs (Brey et al., 2007; De Frutos et al., 2016). On the other hand, if we look at the attribute addressing biodiversity conservation, our study is in line with the literature, confirming the positive attitude of people towards this service (Górriz-Mifsud et al., 2016; Hoyos et al., 2012; Soliño et al., 2018).

Concerning the moral dimension of choice behaviours, results highlight that overall the most significant MFs driving people to contribute actively to NWFPs management are Care and Fairness. This is in line with literature seeing these two Foundations as strong moral predictors of climate-friendly behaviours (Welsch, 2020), individual-focused, and endorsed more in Western than other societies (Haidt, 2012). Moreover, the triggers for these foundations are the need for cooperation in the case of Fairness, and distress and neediness in the case of Care (Welsch, 2020). This would explain why people having these traits are willing to pay for NWFPs as a cultural service, given that the different policy alternatives were inserted in the framework of the relationship between humans and nature for present and future generations, and justified by the need to take action against climate change. Adding the sociological component to our analysis helped us to gain a better understanding of the variety of factors influencing people's decisions and so to increase the behavioural realism of the model.

The fact that the questionnaire was filled online may have induced biased results. However, the bias is likely limited since the age, gender, and regional balances were respected and the study was run in countries where almost everyone has internet access. Although we selected three European countries with contrasted contexts, our study provides partial coverage of the socio-economic and environmental conditions of NWFP picking in Europe. This is due to a limited number of questionnaires that were filled in in three EU countries only. For these reasons, results cannot be upscaled to the entire European Union. It would be worth to develop a systematic data collection at European level, since data regarding the social component of NWFPs are rather scarce, although, according to our results, this service is valuable.

Finally, we see some links between the moral foundations and the preferences and level of willingness to pay to pick up NWFPs. In the same way, a further investigation concerning the moral dimensions of choice behaviours would be needed to improve the explanation of the decision-making process.

Conclusions

NWFPs are important forest ecosystem services that are supplied by multi-functional forest management. Thanks to their dual component, both market and social, NWFPs can not only provide new market opportunities for the European bioeconomy, but also cultural services that benefit people and enhance their recreational activities. Our study shows that there is a demand for both the products and the experience. The nature of the demand and the characteristics of the pickers are pieces of information that can be used to understand the conflicts between forest owners and NWFP pickers in countries with free right to pick up NWFPs even on private land (Sténs and Sandström, 2013) and look for solutions.

Having a complete picture of the value people attach to this service could provide information to develop future policies and support decision-making towards the design of forest management plans that properly account for the benefits of wild forest products. This study underlines that both the social and the market dimensions of NWFPs must be accounted for when designing sustainable land management plans. Moreover, if a system of payment can be developed, NWFPs could provide a complementary source of income, in particular in areas where timber value is low, such as in the Mediterranean region. Moreover, enhancing the forest area managed with NWFPs as a co-product can offer opportunities to finance the maintenance of forests with high levels of biodiversity and of habitat types of European interest (Martinez De Arano et al., 2021). Thanks to this study, we contributed to a better understanding of the current and potential economic value of NWFPs that often escapes statistics and foresight.

The results of this paper will be used as input for future analysis on forest-based value chains within the European bioeconomy, using an extended Social Accounting Matrix approach.

Appendix A. Moral Foundations Questionnaire

The Moral Foundations Questionnaire (MFQ) was developed by Graham et al. (2011) to measure the full range of moral concerns, on the basis of the five universally available sets of moral intuitions: Harm/Care, Fairness/Reciprocity, Ingroup/Loyalty, Authority/Respect, and Purity/Sanctity.

In this study, we used the MFQ to explore the moral dimensions of choice behaviours.

Part 1: Moral Relevance

When you decide whether something is right or wrong, to what extent are the following considerations relevant to your thinking? Please rate each statement using this scale:

[1] = Not relevant at all (This consideration has nothing to do with my judgments of right and wrong)

[2] = Slightly relevant

[3] = Somewhat relevant

[4] = Very relevant

[5] = Extremely relevant (This is one of the most important factors when I judge right and wrong)

	1	2	3	4	5
Whether or not someone suffered emotionally	◯	◯	◯	◯	◯
Whether or not some people were treated differently than others	◯	◯	◯	◯	◯
Whether or not someone's action showed love for his or her country	◯	◯	◯	◯	◯
Whether or not someone showed a lack of respect for authority	◯	◯	◯	◯	◯
Whether or not someone violated standards of purity and decency	◯	◯	◯	◯	◯
Whether or not someone was good at math	◯	◯	◯	◯	◯
Whether or not someone cared for someone weak or vulnerable	◯	◯	◯	◯	◯
Whether or not someone acted unfairly	◯	◯	◯	◯	◯
Whether or not someone did something to betray his or her group	◯	◯	◯	◯	◯
Whether or not someone conformed to the traditions of society	◯	◯	◯	◯	◯
Whether or not someone did something disgusting	◯	◯	◯	◯	◯
Whether or not someone was cruel	◯	◯	◯	◯	◯
Whether or not someone was denied his or her rights	◯	◯	◯	◯	◯
Whether or not someone showed a lack of loyalty	◯	◯	◯	◯	◯
Whether or not an action caused chaos or disorder	◯	◯	◯	◯	◯
Whether or not someone acted in a way that God would approve of	◯	◯	◯	◯	◯

Part 2: Moral Judgments

Please read the following sentences and indicate your agreement or disagreement:

[1] = Strongly disagree

[2] = Slightly disagree

[3] = Slightly agree

[4] = Moderately agree

[5] = Strongly agree

	1	2	3	4	5
Compassion for those who are suffering is the most crucial virtue.	◯	◯	◯	◯	◯
When the government makes laws, the number one principle should be ensuring that everyone is treated fairly.	◯	◯	◯	◯	◯
I am proud of my country's history.	◯	◯	◯	◯	◯
Respect for authority is something all children need to learn.	◯	◯	◯	◯	◯
People should not do things that are disgusting, even if no one is harmed.	◯	◯	◯	◯	◯
It is better to do good than to do bad.	◯	◯	◯	◯	◯
One of the worst things a person could do is hurt a defenceless animal.	◯	◯	◯	◯	◯
Justice is the most important requirement for a society.	◯	◯	◯	◯	◯
People should be loyal to their family members, even when they have done something wrong.	◯	◯	◯	◯	◯
Men and women each have different roles to play in society.	◯	◯	◯	◯	◯
I would call some acts wrong on the grounds that they are unnatural	◯	◯	◯	◯	◯
It can never be right to kill a human being.	◯	◯	◯	◯	◯
I think it's morally wrong that rich children inherit a lot of money while poor children inherit nothing.	◯	◯	◯	◯	◯
It is more important to be a team player than to express oneself.	◯	◯	◯	◯	◯
If I were a soldier and disagreed with my commanding officer's orders, I would obey anyway because that is my duty.	◯	◯	◯	◯	◯
Chastity is an important and valuable virtue.	◯	◯	◯	◯	◯

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3. Revealing the socioeconomic role of Non-Wood Forest Products – insights from three European countries

Based on: Di Cori, V., Robert, N., Mainar-Causapé, A.J., Franceschinis, C., Pettenella, D., and Thiene, M. Revealing the hidden socioeconomic role of non-wood forest products for the European bioeconomy.

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A Social Account Matrix (SAM) (Mainar-Causapé et al., 2020; Mainar-Causapé et al., 2018; Eurostat, 2013) is a database recording data on transaction between economic agents in a certain economy and during a certain period of time. Its usefulness consists in providing data for economic modelling, such as multi-sectorial linear modelling (multipliers) and/or computable general equilibrium models (CGE); moreover, it represents an extensive database, showing a complete but intuitive snapshot of the economy. Multipliers and CGE models can be used for the analysis of key socioeconomic issues, such as environmental issues, employment, value added, growth and income distribution, etc. Moreover, a SAM can be increased by the extension of its structure, adding information by satellite accounts associated. Satellite accounts enable the linkage of physical data and analysis to the monetary accounting system, a key issue for environmental and ecological studies (Alfredo Jose Mainar-Causapé et al., 2018).

The literature shows that so far examples of SAMs including environmental data are ESAMs, AgroSAMs, and BioSAMs. In particular, the BioSAMs are a new set of SAMs specifically designed for the study of the Bioeconomy and natural resources. In the third and final chapter of the doctorate, we developed the new EcosySAM, starting from the BioSAMs for the year 2015 in Italy developed by Mainar-Causapé and Philippidis (2021). First, we wanted to highlight the part of those activities that can be traced back to NWFPs, thus showing the indirect effects of households' expenditure for the social component of NWFPs. These expenditures occur when, to enjoy an ecosystem service - in this case the possibility to collect NWFPs - households consume other services subject to economic transactions. These services, as we identified them in the study, are food, restaurants, accommodation, renting of tools/equipment for sport activities, purchase of local products, travel costs. Once the accounts related to these services were identified in the BioSAMs 2015, we opened them and added an account for the part of these services linked to NWFPs. At the same time, we estimate the value of the flow from forest ecosystems to the households using the WTP. This value represents the households' environmental services without payment. In order to show these services in the matrix, we added a different households' account on wellbeing, which is composed of their income and other benefits from nature. This value does not correspond to a monetary transaction from the ecosystem to the households. Nevertheless, we included this value in the matrix to have a complete picture of the

socioeconomic benefits derived from forest ecosystem services. Finally, we added a "natural capital" account in the matrix (independent from the already present "capital" account) used only for ecosystems.

Finally, we employed a type of multiplier index called backward linkage (BL), measuring the relationship within different sectors of the economy. Particularly, BL is demand driven, meaning that it examines the network of upstream linkages with intermediate input suppliers (Mainar-Causapé et al., 2017).

KEY MESSAGES:

- Expenses on travel and food and accommodation activities, as well as households' environmental services without payment, are upscaled at national level and inserted into the EcosySAM
- Both travel and food and accommodation sectors are the elements of the multipliers showing the highest induced effects
- Improving NWFP management can be of interest also to other sectors of the economy

Introduction

Forest ecosystems are valuable assets providing not only wood material, but also non-wood forest products (NWFPs), and a number of other non-priced ecosystem services (ES), such as regulating and cultural services (EEA, 2016) that can support post-COVID economic recovery and help building more resilient local economies (FAO, 2022). To make choices on the relationship between forest ecosystems, the society and the economy, one must understand which forest ES can support the economic development and social prosperity. This analysis should not be limited to wood supply and uses, but it should also include the supply and use of non-wood forest products and services (Robert et al., 2020). So far, the attempts to understand the Total Economic Value forests bring to the European socioeconomic system have been limited by data scarcity, both on going monitoring of forest uses and one-time studies that highlight the cause-and-effect relationships between forests and many valuable environmental services (Croitoru, 2007). Nonetheless, forests provide many benefits to the countries in which they are located, not only directly to those managing forests, but also to other actors of the socioeconomic system. It is important, therefore, to develop accounting systems that can made explicit their values for society.

The need to promote the contribution of multiple values of ES on people's wellbeing is one of the current topics highlighted by several international institutions and organizations, such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in its latest Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019). In the same way, the European Commission in the new EU Forest Strategy post-2020 (European Commission, 2021), as well as in the European bioeconomy strategy (European Commission, 2018), acknowledges the multifunctional role of forests and their services as a source of innovation and resilience. Despite that, there hasn't been a concerted attempt to explore alternative

solutions to remove the barriers preventing the supply of various Forest ES, including cultural and regulating services (Hernández-Morcillo et al., 2022).

Among other forest ES, NWFPs are an important component of the services that forests provide beyond the domain of wood-based products. They include several products - such as mushrooms, truffles, herbs, cork, etc. - which often have a strong link to local economies and traditional forest management practices. Moreover, they represent a particular category of forest products, due to their dual component, as provisioning services and cultural ones (see the Common International Classification of Ecosystem Services) (Czúcz et al., 2018). On the one hand, the market component applies to the provision of commercial products that are currently marketed and – as such - have a market price. Examples of well establiseg NWFPs markets are cork, resin, saps, some nuts and berries, and herbs for medicinal, aromatic and cosmetic uses. These products contribute to rural economy development, through income generation/diversification, added value creation downstream the value chain with positive impacts on employment opportunities.(Wolfslehner et al., 2019). On the other hand, the social component can be linked to the cultural services that NWFPs provide, such as: recreation and tourism; ecological knowledge, maintenance of collective forest culture and personal wellbeing. From this point of view, NWFP development is part of ongoing dynamics of rural adaptation to changing needs of increasingly urban and relatively wealthy users, which sits outside the domain of traditional forest management (Lovric et al., 2021).

Due to the scarcity of data, we have only partial knowledge of the economic value of NWFPs (FOREST EUROPE, 2020). Thus, their value is still not entirely represented in the System of National Accounts (SNA), along with many other forest ecosystem services (e.g. regulating services such as water purification or soil fertility) (Sorrenti, 2017). Nonetheless, a complementary accounting relying on satellite accounts has been developed, the Ecosystem Accounting (United Nations et al., 2021) developed by the United Nations (UN), together with the European Commission (EC) and the World Bank (WB) in the framework of the System of Environmental-Economic Accounting, with the aim of representing the link between the economy and the environment. The EC implemented this framework through the Knowledge and Innovation Project on an Integrated system of Natural Capital and ecosystem services Accounting (KIP-INCA) in the EU (Vallecillo et al., 2019). However, it does not allow for a deeper analysis of which economic activities benefits from the ecosystem services directly or indirectly.

In particular, the social component of NWFPs is merely represented in economic accounts and statistics, since it is often not subject to market transactions (Lovric et al., 2020). Furthermore, the presence of NWFP pickers in rural areas can benefit other activities such as shops and restaurants in the picking areas. However this (indirect) connection between economic activities and the availability of NWFPs remains largely unknown, also in the most advanced economies, like in Europe. This represents a significant omission in understanding how ES which currently have mostly a non-market value can lead indirectly to economic transactions and/or

purchase behaviour (Di Cori et al., 2021). To fill this gap, we built a Social Accounting Matrix for a selected number of NWFPs. We named this new extended matrix EcosySAM (Di Cori et al., 2022). EcosySAM has allowed to quantify the contribution of the flow of NWFPs to households' wellbeing and the induced economic activities. In this way, we have been able to analyze the interactions between forest ecosystems, their services and the bioeconomy, taking three European counties, namely Italy, Czechia, and Sweden, as case studies. We chose these countries to explore the variety of supply and uses of NWFPs in Europe. Located in the Mediterranean area, centre, and north of Europe respectively, these countries have different ecosystems as well as different socio-economic characteristics which make them suitable to cover differentiated contexts in Europe.

ES economic valuation has become a common starting point in ecosystem accounting (Vysna et al., 2021) while the SAM methodology has been widely used over the last decades to explain the relationship between environment and human wellbeing, but the combination of the two methodologies has never been implemented, to the best of our knowledge (Di Cori et al., 2022).

This paper is organized as follow. After the introductory section, the second section presents the initial datasets and explains how we built the new EcosySAM; the third and fourth sections present and discuss the results; finally, the fifth section contains conclusions, research gaps as well as future research needs, and implications for policymaking.

Methods

Construction of the new EcosySAM

A SAM contains information about the economic and social structure of a country in a particular year. It is structured as a square matrix, in which each account is represented by a row and a column. Rows show the income, while columns show the expenditure. Each cell shows the payment by column account to the account in the row. Accounts in the SAM are generally grouped into six basic groups: activities and/or commodities; production factors; private institutions (households and corporations/enterprises); public institutions (government); saving-investment (combined capital accounts); and the rest of the world. These six basic groups can be then disaggregated depending on which level of analysis is required. The development of a SAM requires a significant volume of statistical information that can be derived from the Input-Output tables or from more complex supply-use tables (Mainar-Causapé et al., 2018). However, usual SAMs do not include information on environmental accounts. For this purpose, a SAM can be increased by the modification or extension of its structure or simply by adding additional information by associated satellite accounts.

To build the new EcosySAM, we started from the BioSAMs for the year 2015 for the three countries under study developed by Mainar-Causapé and Philippidis (2021). The BioSAMs have a highly disaggregated agricultural sector, as well as bio-based industry to reflect the new sources and different utilization of biomass. Since this study focusses on forest ecosystems, we reaggregated the agricultural sector accounts.

Once we aggregated the two sectors, the next step was to identify the activities linked to the collection of NWFPs. For this purpose, we collected primary data on the social component of NWFPs, given the lack of available data. Therefore, in 2021 we conducted a study to assess two main threads: 1) direct and indirect costs related to NWFPs; and 2) the willingness to pay (WTP) of citizens for NWFPs. For the latter, the assessment relied on a choice experiment (Di Cori et al., 2021). The reference year for the collection was 2018-2020. with a focus on individuals' pre-COVID pandemic behaviour, to avoid misrepresentation of NFWP picking habits caused by the restrictions on travel. A sample of 1000 people representative of the population of adult residents in each country filled in the survey (the total sample was therefore 3000 units).

The first thread was meant to highlight the part of those activities that can be traced back to NWFPs, thus showing the indirect effects of households' expenditure for the social component of NWFPs. These expenditures occur when to enjoy an ecosystem service, in this case the opportunity to collect NWFPs, households consume other services subject to economic transactions. These services, as we identified them in the study, are food, restaurants, accommodation, renting of tools/equipment for sport activities, purchase of local products, travel costs.

At the same time, we included into the SAMs monetary indicators (WTP value) that represent the value that households' attach to non-marketed services (Di Cori et al., 2021). This value represents the households' environmental services without payment. In order to show these services into the matrix, we added a different households' account on wellbeing, which is composed of their income and other benefits from nature. This value does not correspond to a monetary transaction from the ecosystem to the households. Nevertheless, we included this value in the matrix to have a complete picture of the socioeconomic benefits derived from forest ecosystem services. Finally, we added a "natural capital" account in the matrix (independent from the already present "capital" account) used only for ecosystems. Figure 1 represents the structure of the EcosySAM. The colored accounts are the ones we added to the original matrix.

Figure 1. EcosySAM basic structure highlighting the interaction between forest ecosystems, NWFPs and the society. Source: authors' own elaboration.

	Forest ecosystem	Activities	Commodities	NWFPs	Margins	Labour	Capital	Natural capital	Factors	Households	Household wellbeing	Corporations	Government	I-S	Rest of the World
Forest ecosystem															
Activities															
Commodities															
NWFPs															
Margins															
Labour															
Capital															
Natural Capital															
Factors															
Households															
Household wellbeing															
Corporations															
Government															
I-S															
Rest of the World															

The reasoning is the following: forest ecosystem expends from natural capital, transport, and the food and accommodation sector. This total value goes entirely to the commodity NWFPs. The consumption of NWFPs is split between households and household wellbeing. Natural capital expends from household wellbeing.

Before inserting the data collected from the survey on NWFPs into the matrix, we first needed to upscale them at national level1. At the same time, to calculate the value of household wellbeing, we multiplied the share of Italian adult picker population for the total WTP. We obtained the total WTP by adding up the WTP of each attributes in the choice experiment and multiplying by the number of pickers.

The list of accounts we identified for the EcosySAM, with focus on the social component of NWFPs, is shown in table 1. Most expenses on travel are on carburant (classified in the retail sale sector G47 in the NACE rev. 2) and car services (G45) when the transportation means is the car (most cases), or on land transport (H49) when the transportation means is bus or train. Non-travel expenses are mainly for food and beverage service activities (I56, including restaurants and bars), although some accommodation services (I55, including hotels and camping services) might be embedded.

Table 1. Activities and commodities classification in EcosySAM. Source: Adapted from (Mainar-Causapé and Philippidis, 2021).

Forest ecosystem	Motor vehicles and parts	Recreational and other services
Agriculture	Transport equipment nec	Dwellings

[1] To estimate the average expenses on transport and non-transport activities, we estimated the parameters of a gamma distribution of the costs per visit per participant minimizing the least square error between the real cumulative distribution and the cumulative gamma distribution. We then multiplied the data obtained for the share of the picker population > 18 years old in each country. We chose the gamma distribution after performing a kernel density plot of the variables, as well as using the R package EnvStats (Millard, 2013) to perform a series of goodness-of fit tests from a set of candidate probability distributions, to determine which one provided the best fit for our data.

Forestry	Electronic equipment	Margins
Fishing	Machinery and equipment nec	Labour
Coal	Manufactures nec	Capital
Food industry	Water	Natural capital
Textiles, wearing, leather	Construction	Taxes less subsidies on production
Wood products	Trade	Taxes less subsidies on products
Paper products, publishing	Restaurants and accommodations	Households
NWFPs	Transport equipment nec	Household wellbeing
Petroleum, coal	Land transport	Enterprises/Corporations
Chemical, rubber, plastic products	Water transport	Direct taxes Government
Mineral products nec	Air transport	Government Investment-Savings
Metals	Communication	Investment-Savings Rest of the World
Metal products	Financial services nec	Rest of the World

Statistical analysis

To assess the wealth-generating properties of forest ecosystem as an agent of the economy, we proceeded with a multiplier analysis (Li et al., 2019; Mainar-Causapé et al., 2017; Malahayati, 2018; Philippidis et al., 2014). For this purpose, we employed two main types of multiplier indices: Backward linkage (BL) and Forward linkage (FL), measuring the relationship within different sectors of the economy. Particularly, BL is demand driven, meaning that it examines the network of upstream linkages with intermediate input suppliers, while FL is supply driven, meaning that it follows the distribution chain through subsequent layers of end users (Mainar-Causapé et al., 2017).

The BL and FL multipliers are based on the Leontief inverse $M = (I - A)^{-1}$ where the matrix A is the matrix of technical coefficients, whose elements are the elements of the EcosySAM excluding the exogenous accounts such as ecosystem, the government, saving-investment and the rest of the world, divided by the total of their corresponding column. The aggregate multipliers by columns and rows (Rasmussen, 1956) are expressed as:

$$M_{\cdot j} = \sum_{i=1}^{n} m_{ij} \qquad \forall\, j = 1,2,\dots,n \qquad (1)$$

$$M_{i\cdot} = \sum_{j=1}^{n} m_{ij} \qquad \forall\, i = 1,2,\dots,n \qquad (2)$$

Where n is the dimension of A and each element in mij in M represents the output needed by account i to increase the final demand of account j by one unit, and the input requirements of account i to produce one unit by account j, using the same reasoning.

Therefore, BL and FL multipliers are described as:

$$BL_{\cdot j} = \frac{\sum_{i=1}^{n} m_{ij}}{\frac{1}{n}\sum_{j=1}^{n}\sum_{i=1}^{n} m_{ij}} \quad (3)$$

$$FL_{i\cdot} = \frac{\sum_{j=1}^{n} m_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} m_{ij}} \quad (4)$$

BL and FL are important to show the value of an economic sector. If a BL (FL) multiplier is greater than one, every euro of intermediate input demand (output supply) brings more than one euro of economic activity to the upstream input suppliers (downstream end users) (Mainar-Causapé et al., 2017). Therefore, economic sectors are defined backward-oriented when they have a BL greater than unity and a FL smaller than unity. The other way around goes for forward-oriented sectors. Finally, sectors that have both BL and FL greater than unity are defined as "key sectors", while if neither linkage is greater than unity, the sector is defined as "weak".

Results

EcosySAM

Out of the adult population of 49.7 million inhabitants in 2021 (Eurostat), about 16.5 (±0.5) million people in Italy went to pick up NWFPs at least once over the last three years, with an estimated average number of visits of 3.8 over the last three years. We therefore estimate that the total number of visits by Italian residents picking NWFPs is 20.8 million per year. At the same time, out of an adult population of 8.1 million inhabitants in 2021 (Eurostat), about 6.0 (±0.1) million people went to pick up NWFPs at least once over the last three years, with an estimated average number of visits of 11.4 over the last three years. We therefore estimate that the total number of visits by Sweden residents picking NWFPs is 23 million per year. Finally, out of an adult population of 8.7 million inhabitants in 2021 (Eurostat), about 7.2 (±0.1) million people went to pick up NWFPs at least once over the last three years, with an estimated average number of visits of 11.6 over the last three years. We therefore estimate that the total number of visits by Czech residents picking NWFPs is 28 million per year.

The expenses in euro per visit is reported by classes: 0. 1-25, 26-50. 51-75, 76-100. 101-125, 126-150. and more than 150 euros. Figure 2 and 3 represent, respectively, the average of food and accommodation and travel expenditure reported by classes for the three countries.

Figure 2. Food and accommodation expenses in euros reported by classes. Source: authors' own elaboration.

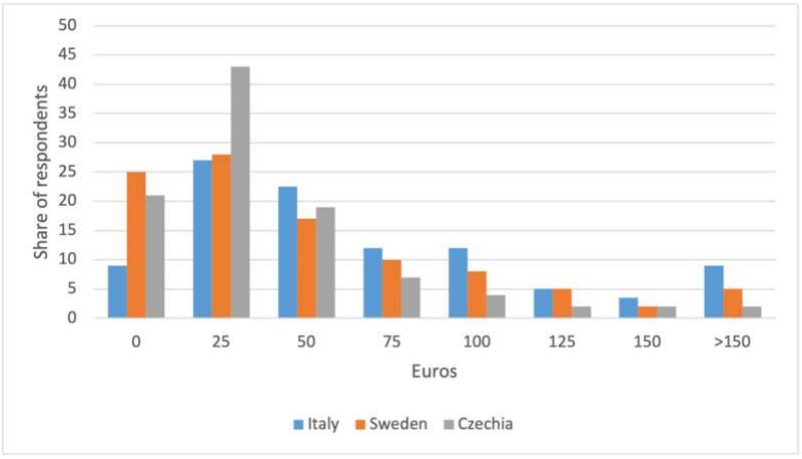
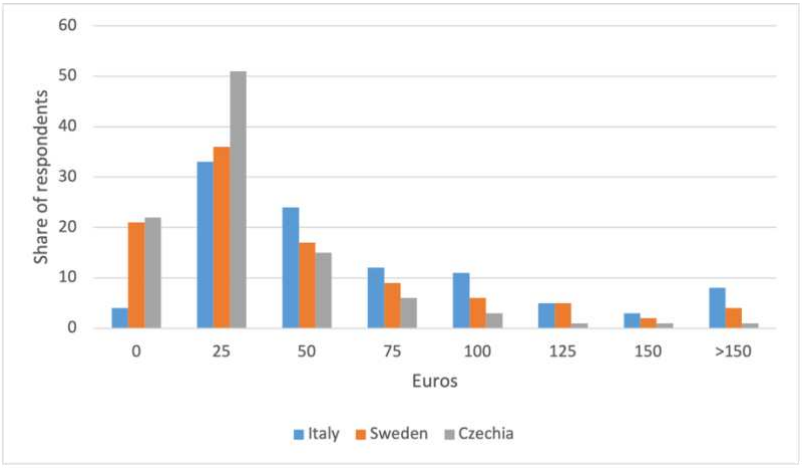


Figure 3. Transport expenses in euros reported by classes. Source: authors' own elaboration.



On average, in Italy in 94% (±1.3%) of their trips, the visitors picking NWFPs spend money to travel to the forest (car, bus, etc.), and in 92.7% (±1.5%) of their trips, they pay for non-transport services (such as restaurants). In Sweden, in 84.7% (±1.4%) of their trips, pickers spend money to travel to the forest, while in 82.7% (±1.5%) of their trips they pay for non-transport services. Finally, in Czechia in 82.6% (±1.5%) of their trips, pickers spend money to travel to the forest, while in 83% (±1.5%) of their trips they pay for non-transport services. The number of persons participating in the trip is indicated in the questionnaire.

Table 2 reports the average expenses on transport and on non-transport activities per person and per visit of NWFP pickers, as well as the total expenses at country level (considering the annual number of visits of pickers to the forest per year, and the share of visits that induce expenses). Due to the chained processing of the original data, the confidence interval can be hardly estimated.

Table 2. Average and total expenses related to travel and food and accommodation activities by NWFP pickers. Source: authors' own elaboration.

Country	Average travel expenses per person and per visit (euros)	Average food and accommodation expenses per person and per visit (euros)	Total travel expenses per year (million euros)	Total food and accommodation expenses per year (million euros)
Italy	17.47	19.36	351	374
Czechia	11.78	14.04	272	325
Sweden	19.12	18.80	373	358

Coming to the households' environmental services without payment, we estimated a total WTP of 94, 48, and 35.6 million euros for Italy, Czechia, and Sweden respectively, represented in the matrix in the new household wellbeing account.

Once we computed the data as described above, we added them in the BioSAMs 2015. According to the final consumption expenditure of households by consumption purpose (Eurostat, 2022), in Italy expenses related to picking NWFPs are responsible for 0.6% of the 97.9 thousand million euros of overall expenses from households to operate personal transport equipment or to use transport services, and 0.5% of the 101.3 thousand million on food and beverage service activities (e.g. hotels and restaurants) in 2015. In the same year, in Sweden, expenses related to restaurants and hotels are about 12.9 thousand million euros and the part linked to NWFPs represent the 2.1%, while for transport 17.6 thousand million euros have been spent overall, of which 2.1% represent the NWFPs component. Finally, in Czechia the expenses on restaurants and hotels are about 6.9 thousand million of which 4.7% belong to the social component of NWFPs, as well as 5.3% of the 5.1 thousand million on transport.

Multiplier analysis

In all three countries the backward multipliers for NWFPs are greater than one (1,54; 1,65; 1,60 for Sweden, Czechia, and Italy respectively), suggesting that the generation of economic activity exceeds the average of the rest of the economic accounts, thus generating wealth. The transportation sector and food and beverage sector (A_H49,H52,N79 and A_G,I55,S, respectively) show the greatest induced effect, meaning that an increase in input on NWFPs would have also an increasing of value in these two sectors.

At the same time, the multipliers related to NWFPs are greater than the ones related to the forestry sector (A02) in all three countries, while the difference between NWFPs and forestry multipliers varies depending on the country, e.g., in Italy this difference is wider compared to Czechia.

Table 3. Multipliers for NWFPs and the forestry sector. Source: authors' own elaboration.

	Sweden	Czechia	Italy

Multiplier	1,54	1,18	1,65	1,55	1,60	1,17
Economic sector	C_E_NWFPs	C_A02	C_E_NWFPs	C_A02	C_E_NWFPs	C_A02
A_G,I55,S	0.43	0.03	0.53	0.11	0.48	0.22
A_H49,H52,N79	0.62	0.02	0.55	0.06	0.56	0.06

A more extensive table with multipliers for NWFPs and the forestry sector can be found in the appendix A.

Discussion

The results of this study highlight the value that forest ES, in particular the social component of NWFPs, brings into the European bioeconomy. This has been possible by extending the structure of the SAM, considering the forest ecosystem as an agent of the economy, as well as the collection of NWFPs as a commodity. Moreover, including households' services without payment into the matrix allows to look beyond the direct monetary value forests produce, considering the wellbeing component.

Although the share of expenses related to picking NWFPs is not so meaningful if compared to the overall expenses of each country, it represents an added value that so far has not been attributed to forest ecosystems. Therefore, improving forest management practices towards the production and maintenance of NWFPs can be of interest not only for the forestry sector, but also to other sectors of the economy.

Moreover, the analysis of multipliers shows how the potential induced effect of NWFPs on other sectors, especially on the transportation sector and food and beverage sector, is greater than unity, meaning that these sectors depend on forest ecosystems to some extent. In addition, one interpretation for having different gaps among the three countries between NWFP multipliers and the ones related to forest sector can be that in countries where the wood-based value chains using domestic wood are more developed, the multiplier related to the forestry sector is higher while the one related to NWFPs is lower.

At the same time, the value of household wellbeing represents an additional novelty of the EcosySAM, especially because this is not a real monetary translation we can find in the economic system, but nonetheless we think it is critical to stress how forest ecosystems contribute to the wellbeing of citizens, which is something as important as the economic value they can bring into the economy, especially regarding the role forests can play in the cultural and social aspects of human welfare. These results are particularly interesting for those countries where collecting NWFPs is considered to be a right of every person (i.e. Czechia and Sweden), thus citizens could choose to have this service for free, but still they are willing to pay for its conservation and maintenance.

This study can be considered as a step forward of the literature on forest management for multiple ecosystem services. Indeed, literature agrees that timber production is still the main management objective, even though there is an increasing attention towards the socioeconomic role of non-wood forest products,

especially in the Mediterranean area (Nocentini et al., 2022). The cultural services, however, remain the less investigated. This is also because so far their economic value has not being fully understood. A forest management that is not too much timber-oriented and also considers the social component of NWFPs would have a positive effect not only for the human wellbeing, but also for the European bioeconomy. Thus, shifting towards this kind of management does not necessarily imply the need for a direct payment to collect these products, or at least the payment could be equal if not lower than the price citizens are willing to pay for this kind of service (Di Cori et al., 2021).

This study comes with limitations, being a first attempt to estimate an EcosySAM and including only one forest ES. In order to understand the full connection and exchanges happening between forest ecosystems and economy, more forest ESs must be included in the matrix. In addition, data should be collected for an increasing number of European countries. The findings of this study are merely preliminary and may change as more services are considered.

Conclusions

In this study, we made a first attempt to emphasize the hidden economic value that NWFPs in their social component brings to the European bioeconomy, using Italy, Sweden, and Czechia as case study. We estimated that NWFPs have a direct effect on transport services, as well as food and accommodation services. Using a new extended Social Accounting Matrix for ES (EcosySAM), we estimated the induced effects on the economy. At the same time, we estimated the value of households' environmental services without payment, using the WTP of people to go to the forest and collect NWFPs. Even though it does not represent a real monetary transaction, we inserted it into the matrix to highlight the benefits that forest ecosystem services can bring into the socioeconomic system.

The results of this study are important to emphasize the role of forest ES other than wood within the forest-based value chains. Especially when it comes to cultural services, there is still poor understanding of the value they bring into the economy, mainly because their values often comes as indirect and/or induced effects for economic sectors other than forestry.

In an economy that will be increasingly relying on the use of land-based natural resources, it is necessary to better represent the complete range of forest-related services and how economic activities depend on forest ecosystems. A clear picture on the values of the forest ES can inspire policy decisions that improve the economic benefits for societies on one side, while sustainably managing forest ecosystems on the other side. This work is an attempt to address the issues of raising importance related to the role forests can play in a bioeconomy strategy, understanding and balancing the different economic role that forest can cover in the supply of ES.

Appendix A. Multipliers for NWFPs and the forestry sector, extended version.

	Sweden		Czechia		Italy	
Multiplier	**1.54**	**1.18**	**1.65**	**1.55**	**1.60**	**1.17**
Economic sector	C_E_NWFPs	C_A02	C_E_NWFPs	C_A02	C_E_NWFPs	C_A02
E_forest	1.00	0.00	1.00	0.00	1.00	0.00
A_A01	0.00	0.00	0.01	0.02	0.01	0.00
A_A02	0.00	0.85	0.00	0.95	0.00	0.60
A_A03	0.00	0.00	0.00	0.00	0.00	0.00
A_B	0.01	0.00	0.01	0.00	0.00	0.00
A_C10-C12	0.01	0.00	0.02	0.01	0.02	0.01
A_C13-C15	0.00	0.00	0.00	0.01	0.01	0.00
A_C16	0.00	0.03	0.01	0.07	0.00	0.00
A_C17,C18,J58,J59p	0.02	0.11	0.01	0.01	0.02	0.01
A_C19	0.02	0.01	0.02	0.01	0.02	0.01
A_C20.C21,C22	0.02	0.01	0.02	0.02	0.02	0.01
A_C23	0.01	0.00	0.01	0.01	0.01	0.00
A_C24	0.01	0.00	0.01	0.01	0.01	0.00
A_C25	0.01	0.00	0.02	0.01	0.02	0.01
A_C29	0.04	0.00	0.05	0.02	0.02	0.01
A_C30	0.01	0.00	0.01	0.00	0.01	0.00
A_C26	0.00	0.00	0.01	0.01	0.00	0.00
A_C27,C28,C33	0.02	0.01	0.03	0.03	0.03	0.01
A_C31_C32	0.00	0.00	0.00	0.00	0.00	0.00
A_D	0.01	0.00	0.03	0.01	0.04	0.02
A_E36	0.00	0.00	0.00	0.00	0.00	0.00
A_F	0.02	0.01	0.05	0.05	0.02	0.01
A_G,I55,S	0.43	0.03	0.53	0.11	0.48	0.22
A_H49,H52,N79	0.62	0.02	0.55	0.06	0.56	0.06
A_H50	0.01	0.00	0.00	0.00	0.01	0.00
A_H51	0.01	0.00	0.01	0.00	0.01	0.00
A_H53,J61	0.02	0.01	0.01	0.01	0.02	0.01
A_K64,K66	0.02	0.02	0.03	0.02	0.05	0.03
A_K65	0.00	0.00	0.01	0.00	0.00	0.01
A_J62,L,M,N77,N78,N80-N82	0.16	0.04	0.14	0.08	0.16	0.09
A_R,S96,T97,J59p	0.01	0.00	0.01	0.00	0.01	0.00

A_E37-E39,O,P,Q,S94	0.03	0.01	0.04	0.02	0.02	0.02
A_L68p	0.00	0.00	0.00	0.00	0.00	0.00

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4. Science for policy implications, further development of the study

It is clear now that forests provide so much more than what we can see: food, water, shelter, raw material, medicine, clean air, and employment opportunities are just few examples. Traditionally, timber is recognized as the main product extracted from forests and, consequently, constitutes the primary element in the traditional productive function of forestland. However, the first part this doctorate points out how literature on forest economics has long realised that the wood production function is only one of the functions performed by forests, which are actually multi-output production systems (Goio et al., 2008). Together with timber, Non-Wood Forest Products represent a different category derived from forests, even though with a much lower profile and sometimes attributed to different sectors of the economy (e.g. agriculture). Thus, in the International System of National Accounts (SNA), which represents the benchmark for economic accounting, the value of the productive function of a forest equals the value of timber products and non-timber products. Standard national accounting makes a clear distinction between productive functions and other functions performed by forests (e.g., protective, aesthetic-recreational, ecological). These latter functions are defined as non-SNA functions (Goio et al., 2008; Eurostat, 1999). As a consequence, taking into consideration only forests' marketable output (i.e. timber and non-timber output with a market value) means not reflecting completely well-being and changes in the quality of life, as well as income and its growth. Especially when it comes to cultural services, there is still poor understanding of the value they bring into the economy, mainly because their values often comes as indirect and/or induced effects for economic sectors other than forestry.

Thanks to their dual component, both market and social, NWFPs can not only provide new market opportunities for the European bioeconomy, but also cultural services that benefit people and enhance their recreational activities. The second part of this doctorate shows that there is a demand not only for the products, but also for the experience. The nature of the demand and the characteristics of the pickers are pieces of information that can be used to understand the conflicts between forest owners and NWFP pickers in countries with free right to pick up NWFPs even on private land (Sténs and Sandström, 2013) and look for solutions.

The third and final part of this doctorate contribute to unlock the current and potential economic value of NWFPs that often escapes statistics and foresight. The share of expenses related to picking NWFPs represent an added value that so far has not been attributed to forest ecosystems, showing the induced effect of NWFPs on other sectors, especially on the transportation sector and food and beverage sector, meaning that these sectors depend on forest ecosystems to some extent. At the same time, this doctorate also emphasises how this service contribute to citizens' wellbeing, which is just as meaningful as the economic value that forests

can have for the economy, particularly in light of the role that forests can play in the cultural and social aspects of human welfare.

In compliance with the frameworks of circular economy and sustainable food systems, this doctorate wants to highlight how forests, if managed in a sustainable way, can provide different goods and services that add value into each step of the value chain across different sectors of the socioeconomic system, promoting livelihoods, economic growth and nature wealth. In this way, the value chain approach can be considered as a tool to support decision-making on forest management, promoting business growth, good quality of life and sustainable use of resources. In particular, both the social and the market dimensions of NWFPs must be accounted for when designing sustainable land management plans. Moreover, if a system of payment can be developed, NWFPs could provide a complementary source of income, especially areas where timber value is low, such as in the Mediterranean region. For example, the assessment of the willingness to pay (WTP) in the second chapter of this doctorate might be used as a proxy of entrance fees forest owners could request to citizens to enjoy the collection of NWFPs as recreational service. In the same way, the WTP might be used by policy makers as a proxy of subsidizes to forest owners in order to shift from an intensive timber production to the protection of biodiversity and recreational services in their forests, and this could be applied by proposing a tax to the general population, especially meant for the protection of biodiversity in national and/or European forests and provision of recreational services. This is true also for those countries where collecting NWFPs is considered to be a right of every person (i.e. Czechia and Sweden), thus citizens could choose to have this service for free, but still they are willing to pay for its conservation and maintenance, as shown from our results in chapter two. To sum up, enhancing the forest area managed with NWFPs as a co-product can offer opportunities to finance the maintenance of forests with high levels of biodiversity and of habitat types of national and European interest (Martinez De Arano et al., 2021).

In the same way, indirect benefits of NWFPs entering the economy can be considered by policy makers regarding, for example, rural development plans. As shown in chapter three of this doctorate, NWFPs produce value in the food and accommodation sector of the area nearby a forest that is managed to maintain NWFPs production. This happens because citizens who go to collect NWFPs for recreational purposes spend their money in the nearby in local shops, restaurants, hotels, and so on. By highlighting these results, policy makers could go towards rural development policies aiming to requalify areas affected by depopulation due to the increasingly frequent phenomenon of people moving to urban centres. This could be done by e.g., investments in tourism and access to resources, local food markets, labelling and/or branding of NWFPs coming from a specific area or region – so-called territorial marketing.

NWFPs is just one of the many examples showing the importance and actual value of forest ecosystem services, other than provisioning of wood products and bioenergy. Indeed, each forest ecosystem service belongs to a chain of values in which it contributes or is the input to the value of benefits (World Bank, 2017).

Despite a rapid improvement over the last decades, data on the supply of several ecosystem services and their value are still scarce (Forest Europe, 2020). Further developments of the study may consist in estimating the contribution of more forest ES to the gross domestic product (GDP), trying to estimate the economic impact on other sectors and the indirect and induced effects on the economy.

Water conservation is one of the best examples of non-market ecosystem services that controls and helps avoid flooding, provide clean water, and mitigate droughts. By storing excess rainwater, forest ecosystems absorb water and avoid flooding from run-off and destruction. Forests also contribute to improve water quality by minimizing soil erosion, as well as treating nutrients and pollutants that are transported in water, allowing the urban water supply sector to reduce or speed up many expensive water treatment procedures, and thus save operational costs (Millennium Ecosystem Assessment, 2005).

In an economy that will be increasingly relying on the use of land-based natural resources, there is a need to understand more thoroughly the full spectrum of available resources, define opportunities and niches of those resources, explain rights of use as well as trade-offs and synergies between forests and other types of land use (Wolfslehner et al., 2019). A clear picture on the values of the forest ES can inspire policy decisions that improve the economic benefits for societies on one side, while sustainably managing forest ecosystems on the other side.

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