How to Correctly Assess the Value of a Forest

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Cambridge Scholars Publishing

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This book first published 2025

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

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ISBN: 978-1-0364-4324-5
ISBN (Ebook): 978-1-0364-4325-2

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INTRODUCTION

The present theme of this work is a very topical one on a global level, in the context of climate change, of the intensification of the unsustainable exploitation of forests (especially of timber) and against the background of ignorance of the stocks of ecosystem assets and, consequently, the invaluable value of these assets. Over time, these trends can lead to the depletion of resources and, with them, the irreversible deterioration of the state of forest ecosystems in particular and of the quality of life in general. For these reasons, the present paper aims to address the current problems of the exploitation of forest ecosystems and to outline a model for the assessment of ecosystem that assets that, starting from a good knowledge and understanding of the specific terminology, leads to an increase of awareness about the multitude of ecosystem services that can be provided by the forests kept "on foot", compared to the almost exclusive exploitation of woody natural resources.

The case study that the current paper proposes for solving, following the research undertaken, is based on the inventory and evaluation of ecosystem assets and provides the foundation for an innovative model of forest assessment with a strict protection role, in accordance with the principles of sustainable development and of the circular economy, through an approach based on the identification and definition of risks and the appropriate inclusion of resilience measures with the aim of reducing the impact and duration of periods of return to normality. By means of this book, it is intended to demonstrate that the share of services provided by complementary products in the total value of a predominantly forest ecosystem-based asset is higher than that derived solely from the supply and use of wood resources.

This introductory part aims to highlight the hypotheses formulated, the purpose and objectives of the research, the working methodology, the expected results, and the author's original contributions to the knowledge in the field studied.

Assumptions

Currently, the fifteenth Sustainable Development Goal of the 2030 Agenda, unanimously accepted by all signatory countries, recognizes the need to integrate ecosystem values and biodiversity into international planning.

The analysis of the scientific literature specific to the field has highlighted the fact that, until now, there has not been consecrated a unanimously accepted approach, a methodology for evaluating the ecosystems, which would generate either the failure to perform the evaluation or its realization in a totally estimative and randomly declarative manner.

Thus, it establishe the existence of a major problem of the applicative research which, although it is sequentially found in the content of several research studies, has remained in the same stage, with the theoretical approach and without the practical completion of the calculations regarding the identification and evaluation of ecosystem assets. Biotope and biocenose assemblies continue to remain either physically undelimited and unvalued, or partially delineated and evaluated, both in terms of ecosystem type and in terms of considering all the specific elements of an ecosystem. Not fully aware of the stock and value of ecosystem assets may lead to overexploitation, above the annual regeneration rate and beyond the ability to discover new deposits or additional amounts of resources, a situation that could diminish the time horizon for the use of ecosystem services, thereby their exhaustion and the irretrievable impairment of the quality of life of future generations.

Purpose and objectives

Starting from the above-mentioned assumptions, the first objective of this work envisages bringing together under a single ”umbrella” all their ecosystem services provided by ecosystem assets, predominantly of forest-type assets (except for ecosystem-based supply services representing timber resources), under the name of ”complementary products” in an attempt to demonstrate that their economic, social, environmental and cultural value is superior to that generated by the supply and use of timber resources in particular.

The second objective seeks to highlight the fact, by means of applied-type research based on the experimental evaluation model SEEA (System of Environmental-Economic Accounting), that the benefits of complementary products may be significantly superior to those generated by the almost exclusively exploitation of natural wood resources.

The third objective proposes, by means of basic research, the inventory of the risk elements that may deteriorate the state of a predominantly forest ecosystem asset and the development, in the light of exposure to risks, of a model for the assessment of forests with a strictly protective role, designed to encourage forest owners to keep forests alive and healthy in order to prevent the occurrence of risks, diminishing their effects and preserving biodiversity.

Methodology used

The realization of this research paper is based on bibliographic research and analysis of conceptual models, research based on questionnaire and by means of satellite remote sensing, confirmed in the field, and on conceptual and descriptive modelling.

Through bibliographic research, this research document identifies the current state of knowledge and conducts a critical analysis of the way of exploiting ecosystem services generated by ecosystem assets, mainly forests. In order to ensure an overview and a basis for comparison, this work envisages a brief foray into the history of logging and addresses their information from the oldest studies to the most recent, on various stages of development of human society in general and of the forest domain in particular. The analysis of conceptual models must allow the development of a synthesis that extracts the essence of the process of physical delimitation and assessment of ecosystem assets and the key elements that define the sustainable development of a forest-type ecosystem.

Conceptual and descriptive modelling allows the formulation of personal views on the use of the designation 'complementary products' and the development of a model for the assessment of forests with a role of strict protection.

Foreshadowed results

The work aims to assess whether the value of complementary products is higher than wood products. Moreover, it was intended, through the conceptual synthesis of the EXPERIMENTAL METHOD OF SEEA evaluation – including the case study undertaken – to highlight the need to reconsider the forest economy from the perspective of capitalizing on complementary products, to exploit the sustainable situation of forest ecosystems and the integration of the circular economy as a concept.

Scientific contributions

The scientific research underlying this research paper is to identify solutions to a major problem of applied research related to the identification and evaluation of ecosystem assets. Along with this, it has been tried to prove, scientifically, that the value of financial flows from the exploitation of complementary products is higher than that generated only from the exploitation of timber resources, because the share in the total value of an ecosystem asset, mainly forests, can be much more important compared to that resulting from the provision and use of ecosystem-based supply services based on timber exploitation. In addition, through the monetary evaluation that the present work envisages, for the first time, in order to develop the experimental ecosystem, the first steps will be taken to understand how the calculation of the value of the Romanian natural capital should be made. Last but not least, the development of a method for assessing forests with a protective role, starting from the inherent risks hanging over predominantly forest ecosystem assets, even if they could be challenged, represents a step forward for the development of other theoretical conceptual approaches to finding the most appropriate compensation formulas for forest owners. These compensation/incentives may be superior to the benefit currently received by forest owners for logging and the preservation of the entire forest ecosystem, in its entirety.

Originality

This work has a transdisciplinar character that derives from the complexity of the approached research theme, requiring, besides the use of globally recognized conceptual theoretical frameworks, the integrated use of economic, mathematical and statistical models. Based on this integrated approach, the innovative character of this work is also demonstrated by the model created to solve the problems constantly raised by forest owners, regarding the insignificant compensation they receive for forests with a protective role. The originality of the work is also supported by the use of the theoretical conceptual framework of experimental evaluation of ecosystem assets (SEEA) to demonstrate that the financial flows generated by complementary products are superior to those coming only from the exploitation of wood resources. This approach will provide, scientifically, in previews, a concrete example of sustainable exploitation, overcoming the eco-hysteria intensely promoted in domestic and international media.

The main beauty, but especially the estimated wealth of the forest, is represented by trees. Their multiplicity and, above all, the essence of the wood depends not only on the beauty, but also on the value of a tough part.

In the times we are beginning to live in, when the revolt of nature is increasingly fierce and harder to nimble, the forest – as a whole – will become much more valuable. But only in its entirety. Trees are, of course, the most important. And they're only going to be like that if they're standing and they're going to maintain that ecosystem that includes water, and air, and soil, and other plants, fruits and animals. All these and others that we have included in the new phrase 'complementary products' must be counted together as representing a value, true and honest economic value. Because that's how nature is: the elements of an ecosystem are so well interconnected and in an eternal state of interdependence that the mere impairment of one of the elements leads to the heavy disease of the entire natural circuit. In order to be able to protect both the life of the forest eco-system, in turn interconnected with the others, and our lives, we need to know the true value of the entire ecological system.

It's probably not a novelty to say that nothing is free on earth anymore. If in the past water or wood in forests were goods for which you did not pay, nowadays they represent valuable resources that must be exploited only on sustainable principles. The era of fossil fuel is at an end, and it must be taken seriously that the circular economy is the solution of the future, by recycling waste and finding alternative energies.

The economic model, based on traditional efficiency, needs to be rethought and an extensive model of environmental efficiency found.

No work considered the state and capacity of ecosystems to provide ecosystem services or the present the value of future revenue streams that may be generated by them. Therefore, the model proposed in this book, which is based on the EXPERIMENTAL SEEA evaluation system, is the starting point for many future scientific assessments and can be adapted to any type of natural ecosystem. Another novelty aspect is the assessment of forests with a protective role against floods and landslides, in terms of quantifying the positive externalities generated, a model that can be adapted to any type of natural disasters that can affect the state and integrity of the various assessed ecosystems. Moreover, all the calculations in the present work are based on primary data obtained through satellite remote sensing techniques, data collected locally through questionnaires and data taken from the official websites of some localities in Romania subject to evaluation of public institutions. This encourages scientific assessments leading to knowledge of the stock and the real value of natural capital.

The calculations confirm that the working assumptions and the proposed objectives have been achieved. The results of this research work fully confirm that the forest economy really needs to be reconsidered from the perspective of valuing complementary products. It is apparent from the calculations that the intrinsic contribution value of the remaining forests "on foot", through the efficient capitalization of the stored carbon and the positive externalities generated by the forests with a protective role, in the entire ecosystem asset, is significantly higher than that generated by the predominant exploitation of the timber. The efficient exploitation of cultural ecosystem services amplifies these benefits and determines that the share of all products complementary to the exploitation of wood resources exceeds 70% of the overall value of the ecosystem asset.

The bringing together under a single 'umbrella' all ecosystem services provided by predominantly forest-type ecosystem assets (less ecosystem supply services representing timber resources) under the phrase 'complementary products', as well as the value analysis in this context, confirm that their economic, social, environmental and cultural value is more important than that derived from the provision and use, in particular just wood resources. It has thus been scientifically demonstrated that the healthy forest is far more valuable than the benefits generated only by the overexploited timber resource. Knowledge of the true value of ecosystem assets, their condition and available stock broadens the time horizon for the use of ecosystem services, such as forestry.

The SEEA experimental evaluation model, used in the case study described in this paper, is an internationally recognized model that must also be adopted by Romania, as some European countries have already done. By implementing this system of economic evaluation, it will come to the knowledge of the real value of the natural capital that Romania has, but until the sustainable development premises are reached, there are still many steps to be taken. The results of the study undertaken can be a starting point to look at the country's natural capital from a completely different perspective, and the decision-maker has an extremely important role. It must facilitate access to sources of funding and create coherent public policies that facilitate the refocusing of the forest economy towards a different approach.

In addition, it is necessary to consider resilience measures by incorporating risk elements that can damage natural ecosystems, because externalities, regardless of their nature, must be taken into account financially. Theoretical recognition, in all the literature, in the policies and in the entire legislative framework adopted, is good, but the next steps must also be taken to transform the regulatory framework into concrete achievements. The real implementation of these measures will be known only from the reduction in the number and effects of natural disasters. As long as their effects continue to be fully felt by the population, it means that the measures have been neither effective nor resilient. In such a context, the doctoral thesis proposes a model and an example of calculating the positive externalities that communities benefit from forests with a protective role in floodplains. According to the results, each household located in the risk zone, protected by the forest "on foot", should participate with a minimum of 500 euros annually, in the form of taxes applied by the local / central decision-maker, the amount to be directed to forest owners to cover the unrealized income from exploitation; this construction being similar to the Pigouvian taxes created for the negative externalities produced by a possible polluter.

Another aspect, not to be neglected, is new technologies, because they can help to save natural capital. Although Romania also has some examples of good forest management practices, in which it has been shown that the timber resource can be exploited as in Sweden or as in Finland, rudimentary exploitation, based on old technologies and estimation, is overwhelming. Hence those huge differences in the volume of raw timber, which have been attributed to illegal logging, and the modernization of the forestry sector, will bring benefits, both to the population and to the environment.

Exploitation in the informal environment must be brought, through these levers, to zero. Regarding from this perspective, the present work represents a pioneering model, which proves - scientifically - that the forest "on foot" is much more valuable than the raw wood exploited, all the problems identified constituting hypotheses for new objectives to be treated by means of future research papers.

THE ROL AND THE IMPORTANCE OF FOREST ECOSYSTEMS: WOODY FOREST RESOURCES AND COMPLEMENTARY PRODUCTS

The impact of the climate and the frequency of extreme weather conditions have increased and, with them, the frequency of natural disasters and the worsening quality of life because, for centuries, the exploitation of timber resources has been carried out with the neglect of the importance of the rest of the ecosystem services that can be provided by forests. In other words, exploitation has, for the most part, been based solely on the harvesting of timber resources, to the detriment of the rest of the biotic and abiotic resources that a healthy forest ecosystem can provide to humanity. On the basis of these premises, it is envisaged to carry out a journey, over time, in order to understand the way in which forest ecosystems have been exploited since ancient times until now. On this occasion, the scientific name 'complementary products' is introduced, in an attempt to facilitate an understanding of their role, importance and weight in the physical and value structure of ecosystem assets incorporating predominantly forest ecosystems.

1.1. Evolution of forest ecosystems

Since the beginning of human evolution and socio-economic systems, forest ecosystems have been usually viewed from the perspective of important natural resources, being used for shelter and exploited, mainly for wood raw material, fauna of hunting interest, berries, mushrooms and medicinal plants. The list of benefits obtained from these forest ecosystems has been supplemented over the last decades by derived products with great cultural value. Even though ecosystem regulating services have also been officially recognized, the benefits to humanity are not yet quantified. The role so important that they have in maintaining people's quality of life is recognized only in a declarative way, without being evaluated at its real value. Moreover, ecosystem assets, those providing ecosystem-based supply, regulation and cultural services, are still not recognized and accounted for physically and in value. Knowledge of physical and value stocks could lead to the exploitation of natural resources with much more care.

The neglect of the importance of ecosystem regulating services was tangentially explained by, which introduced in 1990 a conceptual model aimed at explaining the relationship between humans and forests, the dynamics of the relationship over time and the effects of this dynamic on the forests and societies that depend on them. The false abundance of forest resources has led to overexploitation, a situation which has affected the rest of the ecosystem services, apart from those of supply, which are strictly aimed at the wood resource and, implicitly, the quality of life of the people (Mather, 1990)[1]. The impact of the climate clock and the frequency of extreme weather conditions have increased, and with them, the frequency of natural disasters. Understanding that the exploitation of forest natural resources can only be done in a limited way, at present, societies are making the transition from the consumerist to the conservationist approach, the preservation of forests, the reduction in the amount of products exploited from forests and the import of these goods being the first signs of transition to a sustainable management mode. Given the dynamics of the population, the excessive use of forest ecosystems is no longer possible, even if over the millennia this aspect has been impermissible.

In the pre-agrarian period, the numerically restricted society depended mainly on biological natural resources (non-wood products). People have interacted with the landscape in which they found themselves, long enough to modify it since the time of Homo erectus, 1.4 million years ago. The agrarian period meant the shift towards increasing dependence on woody natural resources, as a raw material and energy, as well as the use of deforestation as a measure to modify land use for agricultural purposes. The Bronze Age and the Iron Age oriented the use of woody matter towards its transformation into caloric energy, necessary for the processing of ores. At the same time, effective tools were developed that could be used for tree felling, leading, of course, to an intensification of deforestation (Westoby, 1990; Price, 2000; Kaplan et al., 2009).

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[1] The model suggests that where a human population interacts with forest ecosystems for the first time, the tendency is to perceive the forest and its resources as limitless. The adoption of such a perception is determined by the apparent abundance of resources and the concept that they can regenerate, and this perception creates a predisposition to overlook the possible signs of overexploitation. As time passes and the effects of overexploitation of managed forest ecosystems are increasingly visible, administrative activities and strategies tend to change.

The expansion of the fortress cities of Greece (VIII century BC – IV century AD) increased the demand for coal, coming from the burning of timber extracted from forests (charcoal being used ever since as an energy resource). Overexploitation and free grazing limited forest resources, causing the management of the remaining resources with increased attention, in the case of Athens, wood or coal from wood ended up being imported from more than 350 kilometers away (Mather, 1990).

In the Roman Empire, natural wood resources were mainly exploited to feed the war apparatus (manufacture of ships or weapons) or as energy resources for metalworking. At the same time, the forests on the border of the empire had a more strategic role, the woody natural resources being used both for the construction and development of fortifications, and for the occupation of some territories, in which case it was necessary to clear the local forests. As woody natural resources began to gain limited valence, actions were implemented to minimize their use, such as recycling glass, to reduce the consumption of wood needed for its primary processing. Overexploitation and deforestation in (Westoby, 1990; Perlin, 1989) European areas, with their climatic and bio-geo-chemical peculiarities, led to serious alteration of soils as a result of erosion processes, and the effects of this mode of administration are still visible today (Butzer, 2005).

In the era between the Classical Period and the Middle Ages, in Central and Western Europe, part of the wooded land was converted into agricultural land, and in the early period of the Renaissance (XIV century), when the demand for metals and glass increased, woody natural resources were used mainly in the form of fuel. In the XVII century, the introduction in Eastern Europe of grass-based agriculture hastened the conversion of forest-covered areas into agricultural areas, and the effects of deforestation of mountainous regions manifested themselves on a small scale of time in the form of soil loss, landslides and floods (Laarman and Sedjo, 1992; Westoby, 1990; Westoby, 1990).

Between the nineteenth and twenty first centuries, the industrial revolution generated the acceleration of the loss of forested areas. From 1990 to 2020, the global area covered by forests was reduced by 178 million hectares, an area comparable to that of the North African state of Libya. Despite the efforts of some countries to make a transition to the sustainable management of forest resources and to reduce the rate of loss of their area (FAO, 2020), the need to use the area for agricultural purposes in developing countries is the main cause of forest loss. Currently, the rate of deforestation of forest areas at global level is 10 million ha / year, while the rate of expansion of forest ecosystems, either naturally in abandoned agricultural ecosystems or through ecological reconstruction efforts, represents about half of them, respectively close to 5 million ha / year (FAO, 2021).

Regardless of the stage of socio-economic development, the exploitation of forest ecosystems has been limited to the achievement of immediate goals, decisions based on reasoning of a strictly economic nature. Therefore, the exploitation of woody natural resources, without understanding the importance of the rest of ecosystem supply services (non-woody products), regulation and cultural products, has led to the deterioration of climatic conditions, the accentuation of extreme weather events, the alteration of the state of ecosystem assets (by affecting forest biodiversity), the occurrence of fires, diseases and pests and other environmental disturbances. The average area of forest affected by severe weather phenomena, globally, was 5.96 million ha, most of the events taking place in Central and Eastern Europe, as well as in Central and North America. In 2015 alone, fires destroyed nearly 100 million hectares of forest in tropical areas, and defoliating insects, diseases and extreme weather events affected (FAO, 2020)[2]another approximately 40 million hectares of temperate and boreal forests. This increases the net loss rate of forest areas, which can also negatively affect the provision of other ecosystem services, causing a loss of water quality or an increase in greenhouse gas emissions. Compared to 1990, forest areas have seen a reduction from 4.13 to 4.06 billion hectares. The population growth rate in recent decades, its spatial dynamics, industrialization, the need for land for agriculture, unsustainable exploitation, as well as other socio-economic factors have increased the dramatic pressure on forest ecosystems, thus emphasizing the alteration of their state and stability. Massive deforestation in both tropical and temperate forests is recognized as a global problem. Looking ahead, it can be said that, in the coming decades, achieving sustainable development at the global level is crucially conditioned by how socio-economic systems choose to harness and manage the services provided and resources exploited by forest ecosystems ((Meyfroidt and Lambin, 2011).

Forest ecosystems are not mere natural resources of wood. Through ecosystem-based supply, regulation and cultural services, multiple solutions to today's challenges are provided, in terms of poverty eradication, environmental sustainability, food security, energy, river basin protection, clean water, biodiversity conservation, climate change, as well as the reduction of natural disaster risks. Forest ecosystems store about a third of global anthropogenic carbon emissions, while three-quarters of the world's freshwater is supplied by forest watersheds. More than 80% of the world's

[2] According to the global forest resources assessment in 2020.

terrestrial biodiversity is concentrated in forests, and almost a quarter of the global population (more than 1.8 billion people worldwide) depend on it for food, fuel, medicines, jobs and livelihoods. More than 380 million people depend directly on forest natural resources for subsistence. The growth of the human population, the technological evolution and the depletion of natural resources will certainly change the ecosphere and metabolism of socio-economic systems. ((United Nations, 1993).

In the last three centuries, the Earth has lost over 35% of the area of forest ecosystems, and of the entire area of forest ecosystems, 82% is estimated to be degraded as a direct result of the actions of socio-economic systems, through industrial exploitation, urbanization, agriculture and infrastructure. In recent decades, the rate of forest loss and the potential effects that these ecosystem changes can have on the ecosphere have led to a wide range of international measures to preserve and improve the ecological status of forest ecosystems ((FAO, 2015).

The current global context calls for the rethinking of the entire set of values underlying exploitation decisions. There is a need to understand the complexity of forest ecosystems and the emerging characteristics of the interaction of their components, with or without anthropogenic intervention. In a reductionist way, forest natural resources can be regarded as limited to the timber, but the ecological crises of the Anthropocene force us to dedicated planning in the management of forest natural resources, in a holistic way, thus integrating all the tangible and intangible components of ecosystem[3]services that can be provided by the ecosystem assets, predominantly forests.

Forest ecosystems can be regarded as having utilitarian, intrinsic, aesthetic, cultural and religious value, but the fact that this value is often reflected only at the level of local communities, makes this side often omitted from the public discourse when talking about the management of forest natural resources (Drăgoi, 2008).

The role and importance of forest ecosystems in the sustainable development of mankind is evident and can be strengthened by the superior, responsible and efficient capitalization of the rest of the eco-systemic supply services (non-lethal products), regulation and cultural. Under the aegis of the principles of sustainable development, the valorization of those (Zaman and Geamănu, 2006)'complementary' products could successfully compensate for the loss that could be caused by a possible reduction in the

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[3] The effect of man on the exploitation of the earth, on the ecosystems, biodiversity and extinction of certain species.

exploitation of woody natural resources, that is to say, by reducing the quantity of ecosystem-based supply services provided in the form of timber.

1.2. The Role and importance of forest ecosystems

Forest ecosystems are the most diverse and performant units of functioning and organization of the ecosphere, from a biological point of view, and form the basis of subsistence for approximately 8 billion people globally. Forest ecosystems cover a third of the Earth's land area (over 4 billion hectares), of which (FAO, 2021) about 30% are mainly used to provide ecosystem-based supply services (woody and non-wood), generating financial resources for the forest economy. The percentage can go up to 47% if the multi-purpose forest area, which often includes production, is also taken into account (FAO, 2020).

Its forest systems are not limited to just tangible economic resources that can be exploited by man. Forests have multiple functions and offer a wide range of intangible resources, with a key role to play in maintaining life, by contributing to the protection of water and soil, improving air quality and preserving biodiversity, the value of public utility being increasingly evident in the current conditions. Although forest ecosystems contribute through beneficial bio-geo-chemical and climate processes on a large scale, from carbon sequestration and soil formation to the global hydrological cycle, only a share of about 20% of the world's forests have the role of protecting soil, water and biodiversity. But these services that forest ecosystems provide to mankind, apart from ecosystem sourcing services, generically referred to as ecosystem regulating services and cultural ecosystem services, are still highly recognized and economically quantified, only by a small number of the most developed countries that have implemented the SEEA experimental evaluation system ((Dixon et al., 1994); (FAO, 2020).[4]

For these reasons, the characterization of the ecosystem or forestry has often been reduced to the tree species with the highest frequency in the ecosystem, the other plant species, distributed on the vertical floor, from trees and shrubs to herbaceous plants, not being considered of major importance. However, the differences in light capture created by the canopy, as well as the presence of plant species from the lower floors, favor the

[4] System of Environmental-Economic Accounting (SEEA) is an environmental economic accounting system, an international standard conceptual framework that integrates economic and environmental data to provide an overview of the state of stocks of environmental assets and their changes as they are provided to humanity as ecosystem benefits.

development of biotope within the forest ecosystems. These biotopes contribute to local biodiversity through the support created for nesting, mating or feeding areas of populations of animal species. The size of forest ecosystems and their framing in the landscape significantly influences the attractiveness of habitats for certain species.

Looking from this perspective, and not only from the perspective of harvested tree species, the importance of forests, as a whole, for the sustainability of terrestrial ecosystems is obvious, which is why, in 2015, in order to address this shortcoming, sustainable forest management and halt biodiversity loss were included, in the 2030 Agenda, within the UI objective of sustainable development aimed at "life on earth". In this formula, the sustainable exploitation of forest ecosystems aims to combat desertification and land degradation through sustainable management plans to halt deforestation, restore degraded forests and substantially increase afforested and reforested areas globally. Sustainable management can be monitored through areas of certified forests that provide information in compliance with national or international standards. Equally, sustainable management involves monitoring forested areas, biomass stored in the forest and a series of actions to protect forests and maintain biodiversity and other natural and cultural resources (Rey and Ionașcu Gh., 2008).

Understanding the role and importance of forest ecosystems, at the end of 2020, over 700 million hectares of forest were in protected, legally defined areas, and the area of forests under management plans exceeded 50% of the total (2.05 billion hectares), increasing in all regions of the world. However, sustainable forest management requires a balance between the economic, social and environmental dimensions, between the exploitation of natural woody forest resources and understanding the role of complementary products to them.

1.2.1. Exploitation of woody forest natural resources

Today, roundwood is the main natural wood resource that is exploited from the world's forests and offered for use as an ecosystem supply service, preserving the "template" established over millennia. According to the globally recognized definition, roundwood is wood extracted from the forest, with or without bark, including round stems, trimmed or branches, roots or stumps. Although more than half (54%) of the world's forests are in only five countries, more than 60% of the world's roundwood production comes from eight countries, which do not necessarily follow the order of the share in the global area of forests. Thus, it is noted that, although Europe owns around 5% of global forest ecosystems (215 million hectares) ((FAO, 2018a); (FAO, 2020);[5] (FAOSTAT, 2016),[6] more than 12% of the total round timber harvested globally is harvested on this continent, being only the first place in the world in terms of this indicator. It is unnatural for 70% (150 million hectares) of forests to be considered available for logging. The same can be (FOREST EUROPE, 2015) seen in the case of China and India, countries where the share of round timber exploitation in global production is higher than the share of forests in the total global forest ecosystems. At the end of 2019, the volume of roundwood harvested globally was about 3.9 billion cubic meters. The average growth rate of global roundwood production is about 0.5% per year. Although the volume of raw wood harvested increased between 1990 and 2020, the number of people employed in forestry and logging decreased, as a result of the increase in mechanization and the increase in labor productivity, in some regions of the world.

About half of the amount of timber harvested globally is used as firewood, the other half being industrial roundwood. The global amount of wood fuel amounted to over 1.9 billion m^3 in 2020. Wood has a stock of potential energy that can be released through the combustion process, and firewood is the concept that incorporates wood obtained in order to obtain heat. This category may include wood in the raw state or processed as pellets or retort coal. In order for this natural resource to be able to be stored and processed for energy generation without large capital investments, it is necessary that firewood has cross-sectoral potential to maintain itself as an energy source. In general, firewood is consumed in the country of origin (United Nations, 2019a) and very little is traded internationally. Firewood is used for heating and cooking, especially in rural areas and developing countries. Most of the production of firewood is concentrated in Asia (39%) and in Africa (36%), with the average growth rate of production hovering around 0.3% per annum[7]. In recent years, the uptake of wood in modern biomass-based cogeneration plants has increased as a result of incentives in some countries (in particular EU Member States) for renewable energy.

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[5] According to the data available at http://www.fao.org/forest-resources-assessment/2020/en/ accessed on 07.02.2021, out of the total area of global forests, the Russian Federation occupy 20%, Brazil 12%, Canada 9%, the United States of America 8% and China 5%. Total 54%.

[6] According to FAOSTAT data available at http://www.fao.org/faostat/en/#data/FO for 2019 the order of exploitation of timber resources was as follows: EU 12.3%, USA 10.8%, India 9.5%, China 8.9%, Brazil 6.9%, Russian Federation 5.7%, Canada 4.4%, Indonesia 3.2%. Total 61.7%.

[7] https://www.un.org/esa/forests/wp-content/uploads/2018/04/UNFF13_BkgdStudy_ForestsSCP.pdf

However, most of the raw material used in these cogeneration stations are wood residues and waste, which are not classified as firewood (from industrial roundwood processing).

Industrial roundwood is the natural wood resource extracted from the forest that is used for purposes other than energy (firewood), comprising: cellulose wood, furniture logs and veneer logs and other uses of industrial roundwood (e.g. roundwood used for fencing poles and telephone or electricity poles). According to the FAO classification, industrial round wood can come from coniferous and deciduous species. Wood, as an organic matter, is a natural compound of cellulose created by photosynthesis from carbon, hydrogen and oxygen. The properties of wood, as a material, favor it as a raw material in construction, being easy to handle, process and function as a good insulator of electricity, heat and sound. By storing carbon, the porous nature allows the wood material to absorb varnishes and paints, giving it a relatively long service life and a greater value of its benefit over time for small constructions compared to products derived from metal or plastic materials.

The cut wood includes: planks, sleepers, beams, planks, rafters, slats, timber, etc. Wood-based panels include: plywood (including timber and laminated veneer), particle board, oriented boards (OSB) and fiberboard. Wood pulp used for the manufacture of paper and paperboard includes recovered paper (spent paper), other pulp fibers and wood pulp used in the manufacture of paper. The chemical pulp of wood is subdivided, in statistics, into white or unaltered pulp and wood pulp, sulphite or sulphate, and various other combinations of these different products. The paper and paperboard product group shall comprise graphic papers (newsprint, printing and writing paper), packing paper and paperboard, household and toilet paper and other paper and paperboard not otherwise specified. Round wood used as fuel (but not in the category of firewood, shown above) for cooking, heating or producing electricity includes wood used, from the main stems, branches and other parts of trees, to make charcoal and pellets (FAO, 2019).[8]

In 2018, the global production and trade of most timber harvesting products recorded the highest values ever recorded since 1947, the year in which the FAO began reporting the first global statistics on forest products. Both the production and imports and exports of roundwood, sawn timber, wood-based panels, wood pulp, charcoal and pellets have reached their maximum levels, exceeding 2014, also considered a historical landmark.

[8] FAO, (2019). Global forest products/facts and figures, 2023.

As can be seen from the available statistical information, the fastest growth occurred in the Asia-Pacific, North America and Europe regions, due to the probable positive economic growth in these areas. The production of wood pellets recorded the highest increase in recent years, mainly due to the demand generated in the context of the bioenergy targets set by the European Commission. In 2018, global production reached a level of 37 million tons, more than half (24 million tons) of the total quantity being traded internationally. Europe (55%) and North America (28%) recorded the bulk of global pellet production, while global consumption of pellets was concentrated in Europe (75%) and Asia-Pacific (18%). Imports of wood pellets increased in Japan, and in 2016 the Republic of Korea became the third largest importer of wood pellets, an increase in the production of wood pellets was also recorded in Vietnam, Malaysia, Indonesia and Thailand. At the level of the European Union[9], in 2020, the value of round wood recovered on the market was 11.5 billion euros, and the logging and processing industry employed about 3.5 million people (Ciornei and Munteanu, 2020).

Overall, about 70% of the world's woody forest resources are exploited in underdeveloped or developing countries in Asia and Africa, areas where they are considered to be a basic need, with the demand for this type of resource increasing, especially due to population growth. There are many countries where population growth has an accelerated pace (Nigeria, Mexico, Philippines, India), and (FAO, 2019) woody natural resources are used predominantly for energy purposes. For these reasons, developing countries are expected to experience imbalances due to resource depletion, while energy alternatives are physically or financially inaccessible. At the same time, in developed countries, such as those in the European economic area, which have understood that wood is a slow renewable resource, firewood comes largely from indirect sources, as a result of the processing of wood, and is mainly used in the industrial sector (47%) (Schulte et al., 1999).

As mentioned earlier, around half of the timber harvested in forests is used, worldwide, only for energy purposes. Moreover, some of the forests are cleared for the expansion of agricultural land, which leads to the installation of imbalances and the alteration of forest ecosystems. In recent years, South America has lost on average, annually, about two million hectares of forest, Africa has lost about 2.8 million hectares, Asia has expanded its forest area by 0.8 million hectares per year, but has lost about one million hectares of natural forest, while Central and North America has

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[9] FAO, (2019). Global forest products/facts and figures, 2023.

expanded its forested area by 0.1 million hectares, although the natural forest has decreased by 0.4 million hectares per year. Oceania gained about 0.3 million hectares of forest, and Europe about 0.4 million hectares.

Over the past decade, action to combat deforestation and illegal logging has been stepped up. These actions are aimed at seeking evidence that the timber traded is harvested legally. As a result, repercussions have also been found on many timber-producing countries in the rainforests, which must make appropriate efforts to ensure compliance with legal requirements. Many other recent regulations concern a number of mechanisms to reduce emissions from deforestation and illegal exploitation, and as part of these mechanisms, countries are required to implement measures (FAO, 2020a)[10] to prevent illegal hunting and to protect, as a whole, the entire terrestrial biodiversity, through a series of conservation objectives.

Throughout this whole process of protecting forests from overexploitation of the woody natural resource, it is necessary to consider ensuring a balance between the needs of local communities, the demand for resources that support livelihoods and conservation objectives. The conservation of biodiversity and the enhancement of ecosystem services must be integrated into sustainable forest management practices for all categories of forests. The adoption of sustainable production practices needs to be speeded up on a large scale, and these actions in most cases require a review of current policies, in particular fiscal policies and the regulatory framing; this will be revealed in the next chapter. In order to achieve the Sustainable Development Goals, it is necessary to make better use of the other categories of ecosystem supply services (non-wood products in particular), to recognize and evaluate ecosystem-based regulatory and cultural services in accordance with their importance in maintaining forest ecosystems.

If throughout the history of mankind, forest resources that have had value in socio-economic systems have been considered mainly woody natural resources, the strategic need of this reservoir for storing carbon dioxide forces towards a rethinking of the potential for sustainability and sustainable development of the forestry sector. From this perspective, the contribution of complementary products, as defined above (by including non-wood products and ecosystem-based regulatory and cultural services in a unified (Meyfroidt and Lambin, 2011) whole) is essential and must complement the logging of raw timber, in full accord with the normal rate of forest growth and regeneration.

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[10] FAO and UNEP, (2020). The state of the world forest 2020. Forests, biodiversity and people. Rome. https://doi.org/10.4060/ca8642en

In the context of the new transformations at the level of the four pillars of sustainable development, of the changes in the report and humanity's reference to the future, generated by climate change, the term non-wood products in forests no longer fully reflects the importance of the elements that make it up. Even though the name is also present in the international literature, it makes only a technical distinction between the exploitation of woody natural resources and the rest of the biotic resources that can be extracted from a forest, both of which fall within the category of ecosystem supply services. Next, it is also necessary to bear in mind that forests are home to most of the Earth's terrestrial biodiversity providing habitats for 80% of amphibian species, 75% of bird species and 68% of mammal species. It is not enough to approach this (MEA, 2005)[11] (Vié et al., 2009)[12]standard of logging solely in terms of differentiation from gross logging, although the transition from the terminology of 'ancillary products' to 'non-wood products', in the literature, has been a huge leap in this respect. Because, by definition, non-wood products are no longer regarded as secondary elements, they continue not to be placed on the stepping stone they deserve. Moreover, there are even specialists who confuse the exploitation of non-wood products with the ecosystem services that can be provided by the forest fund in its entirety. More than 60,000 tree species are recorded in the Global Tree Search database, each of which is of paramount importance in maintaining the balance of the ecosystems in which these species live. As a result of overexploitation of timber, more than 20,000 of these species are included in the IUCN Red List and more than 8,000 are under threat globally. Along tropical coasts, mangrove forests are the perfect habitat for many species of crustaceans, thus helping to capture sediments that could adversely affect coral reefs and, in turn, habitats for many other marine species. Around 60% of vascular plants are found in tropical forests. Deforestation in tropical and subtropical forests has altered ecosystems, causing the loss of many plant species, living things, as well as coral reefs (affected in a proportion of over 30%). All these aspects, listed as an example and which are much more important than logging, must be taken into account because they increase the importance of biodiversity, in all its complexity, and of ecosystem services ((UNSD, 2015)[13] which can

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[11] MEA, (2005). Ecosystems and human well-being: current state and trends. Washington, DC, Island Press.

[12] Life, J.-C., Hilton-Taylor, C. & Stuart, S.N., (2009). Wildlife in a changing world: an analysis of the 2008 IUCN Red List of Threatened Species. Gland, Switzerland, IUCN.

[13] IUCN. 2019a. The IUCN red list of threatened species. Version 2019-2. http://www.iucnredlist.org.

play an important role for the future of mankind. The preservation of most of the world's biodiversity is completely dependent on how we interact and use the world's forests. Or, it is the eco-systemic regulatory and cultural services that can attract the financial resources from the remaining forest standing, by contributing to the preservation of biodiversity, the improvement of air quality, the purity of water, the sequestration and storage of carbon dioxide, the control of soil erosion, tourism and recreation, etc.

Therefore, this paper deals with non-wood products (the rest of the ecosystem supply services that the forest provides) and ecosystem regulating and cultural services as a whole, brought together in the concept of complementary products, this aspect representing a new approach that encompasses everything that the forest can produce and outside the exploitation, in particular, of raw wood. These elements must complement the effective exploitation of the services which ecosystem assets, predominantly forest assets, provide for use and consumption, in a harmonious manner, without disturbing the ancestral natural biodiversity, and thus ensure the continuity of life on earth. The importance of complementary products is obvious, and increasing their share of the exploitation of the entire global forest fund must become a permanent concern refocusing on the current report resulting from the use of raw wood in particular.

A purpose may reach the point where it will be willing to provide as many financial resources as necessary to restore the state of predominantly forest ecosystem assets and the environment, but this will no longer be possible. The "pure gold", the natural forest and the biodiversity it offers, will no longer be able to be reconstituted, not even with gold.

a. Complementary products from the perspective of non-wood forest products

As recalled in the previous section, the emergence of agrarian civilizations has led to a change in the perception of resources and their management, with the main activities focusing on the use of timber and the land available as a result of deforestation. Human permanence depends fundamentally on how we consume resources and produce food. Much of the deforestation concerned the large-scale conversion of forests into agricultural production, resulting in the loss of forest biodiversity and the irreversible alteration of some ecosystem services. Another part of the overexploitation of the forest fund concerned the natural wood resource only from an energy perspective, without taking into account the rest of the benefits that the "standing" forest brings to humanity. In this respect, a realistic balance must be struck between food security, human well-being and the objectives of conservation and protection of forests, requiring a new, innovative approach based on effective governance, coherent and integrated policies, security of land tenure, respect for rights and knowledge to the real needs of the local communities, as well as the increased capacity to monitor biodiversity and ecosystem services that are offered and used through intermediate or final consumption. Last but not least, finding appropriate financing solutions and transforming food systems can help stop deforestation and overexploitation of forests, which can favor the preservation of biodiversity and the enhancement of the remaining ecosystem products and services that healthy forest ecosystems can offer to mankind.

In this regard, forestry, as a modern practice, has adopted an administrative model centered around maximizing the production of wood biomass and streamlining its extraction. At the same time, the imminent depletion of woody natural resources and the effects of the disappearance of forest ecosystems at local, regional and global level are forcing forest managers to make the transition to a conservationist perspective of these resources. In this way, in recent decades, the term non-wood forest products (NWFP) has come to be introduced into the vocabulary specific to forestry and acquire different shades.

1.3. Theories and concepts for the identification and assessment of forest ecosystems

The MEA analysis indicates that nearly two-thirds of the services provided by natural ecosystems are in decline globally. The development of the capital of socio-economic systems was made mainly on the basis of natural capital. The assessment of ecosystem services is necessary in order to integrate the true value of ecosystems into the decision-making process, both at local and national level. The quantification and monetary and qualitative assessment of these services should be reflected in the analyses underlying any decision influencing their rate of supply. If (2005) this assessment omits from the decision-making process, the sustainable use of resources and sustainable development cannot be achieved (Boyd and Banzhaf, 2006).

The assessment of ecosystem services can serve a generous range of objectives. The assessment of the benefits, both current and future, that socio-economic systems enjoy from interacting with natural capital, becomes imperative in the context of policies, indicating whether a particular intervention, strategy or programme has a net benefit to society.

Such an integrated analysis in the policy-making process could lead to a better prioritization of conservation actions and the directions of their allocation of funds, create markets for payments for ecosystem services (PES) and help to better communicate with the public and natural resource managers (DEFRA, 2007).

The economic contribution of ecosystem services is often considered through VET (Total Economic Value), made up of the sum of the use and non-usable values, or the net sum of the WTP and WTA, thus measuring the total marginal cost of the ecosystem service (DEFRA, 2007).

The assessment contains the value of direct use, the one of indirect use and the optional value. Direct use corresponds to the value of the natural resources consumed, whether they are extracted from the ecosystem (as in the case of ecosystem production services, in which the biomass extracted per unit of area is assessed) or are non-consumable, or are not intended for consumption, in which case, no products result from the interaction with the environment (as is the case of cultural services, in which the value of tourism can be quantified by the number of visitors /year).

The value of indirect use of ecosystem services is often perceived and made aware only when their quantity or quality has been diminished. They are those ecosystem-based regulating services, the final product of which can be considered as water, air quality, climatic effects, carbon sequestration, soil formation or erosion, nutrient circuit and pest control. Quantifying these values is more difficult than in the case of quantifying direct use values, this is due to the difficulty of transferring value to the market, monitoring changes in the supply rate and understanding the long-term effects.

The optional value is assigned by people to dispose of or use a resource in the future, and the possible use can be direct or indirect.

Non-reusable (or passive) values are those intrinsic values of nature and related to the conservation of the environment through three components: the inheritance value (where the beneficiaries attach a value of the conservation of the natural elements for a future generation), the altruistic value (where individuals attach a value to the availability of some resources for others members of the same generation) and the value of existence (when individuals attach a value to a natural resource, even if they do not use or plan to use the resource).

According to Open NESS, "the value is the importance of something. Evaluation is the act measurement of value. The biophysical assessment and indicators reflect ecological values when focusing on ecosystem structures and processes of importance to policy objectives. Methods of socio-cultural assessment explore ways of representing cognitive, emotional and ethical responses to nature. These are often shared values, especially appropriate to explain the specifics of the context of values. Monetary assessment methods quantify people's preferences, needs and desires for ecosystem services in economic terms. They are particularly suitable for describing values for larger populations for ecosystem services that are traded directly or indirectly on markets. Natural capital accounting describes how ecosystem asset stocks and ecosystem service and benefit flows change from year to year, both in physical and monetary terms."

The conceptual framework of the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) operates with three dimensions of values: intrinsic values (non-anthropocentric values), instrumental values that include all values of use within VET and relational values that include inter-human and human relations with nature [14]((DEFRA, 2007); (Diaz et al., 2015).

Assigning value to environmental components is a specific area of economics, with its own debates of a philosophical and ethical nature. A basic principle in economics is that of choice, whereby the actors involved compare alternatives based on values, and then make a decision. The translation of ecosystem services into monetary terms allows for comparative analysis and monetary quantification of these services, and ensures an integrated analysis of the alternatives that may influence their provision.

The monetary valuation methods used in the valuation of ecosystem services can be classified into four categories: benefit-based methods, cost-based methods, shadow price method or value transfer ((DEFRA, 2007); (Diaz et al., 2015); (FAO, 2019).

Benefit-based methods are a set of economic tools and models, among which we mention: the travel cost method (TC-Travel Cost, in which the value of cultural ecosystem services is often assessed through the willingness of the beneficiaries to pay the costs related to transport or the time allocated to travel); hedonic price method (HPM-Hedonic Price Model, in which the value of a product is determined by a number of characteristics, which interact with external factors and affect the final value), with the classic example of real estate values depending on the structural characteristics of the building and contextual characteristics, such as access, air quality, proximity to recreation areas; the productivity method (where ecosystem values are found in the market value of a product, based on the

[14] The IPBES is an independent and intergovernmental body of the United Nations created with the aim of strengthening the interface between politics and science in terms of preserving and promoting the sustainability of biodiversity and ecosystem services.

input-output relationship in the production chain), an example being the value of medicinal plants placed on the market that restore the value of ecosystem service in relation to the unit of area of an ecosystem. (Zaman and Gherasim, 2007).

Cost-based methods involve the use of alternative costs with which to create an artificial market for ecosystem service. A classic example in this case is that of the costs of artificial water filtration that can establish the value of ecosystem processes that naturally improve water quality. The costs that natural disasters attach to a socio-economic system can also be used to harness the ecosystem service of protection against that natural disaster, just as the costs generated to an alpine locality by an avalanche reflects the value of the forest that protects it against it.

The shadow price method is based on the assessment of the marginal cost of achieving an ecosystem service unit by implementing an objective. The shadow price is that price that beneficiaries pay to ensure the provision of ecosystem services. For example, the shadow price method can be applied to the benefit derived from the ecosystem-based drinking water service by accepting costs as reductions in the productivity of other sectors due to restrictions imposed.

Value Transfer (VT-Value Transfer) can be used to transfer the values of the benefits and costs of certain services from one area to another, which can be directly or adjusted, meta analytically or through transferring the value function.

All economic models of monetary assessment and quantification of ecosystem services have contextual limitations and challenges. Changes in ecosystem processes and flows can have short- or long-lasting effects (Pascual&Muradian, 2010), with forms of manifestation that vary from snapshot to generational level and with a high degree of uncertainty, which makes the attribution of a value to be made in most cases by subjective, anthropocentric, preference-based methods (FAO, 2019).

Paletto et al. shows through a case study in Italy that stakeholders do not participate according to the theory of rational choice, acting rather according to a system of values, attitudes and preferences regarding the relationship with the environment. At the same time, the systems of values, attitudes and preferences are related to a local context, which makes the correct assessment of an ecosystem service to become a process adapted to all stakeholders (2014; Paletto et al., 2014).

The process of their objective assessment should thus be guided to identify responsible supply and beneficiary systems, take into account the spatial-time scale, include scenario analysis and actively involve the local population. The fact that we are obliged to recognize the conceptual