sustainability

MDPI

Review

Mainstreaming Ecosystem Services from Indonesia's Remaining Forests

Hunggul Yudono Setio Hadi Nugroho [1,*], Fitri Nurfatriani [2], Yonky Indrajaya [1], Tri Wira Yuwati [1], Sulistya Ekawati [3], Mimi Salminah [2], Hendra Gunawan [1], Subarudi Subarudi [4], Markus Kudeng Sallata [1], Merryana Kiding Allo [1], Nurhaedah Muin [1], Wahyudi Isnan [1], Indra Ardie Surya Liannawatty Purnamawan Putri [1], Retno Prayudyaningsih [5], Fajri Ansari [1], Mohamad Siarudin [1], Ogi Setiawan [1] and Himlal Baral [6,7]

1. Research Center for Ecology and Ethnobiology, National Research and Innovation Agency (BRIN), Jalan Raya Jakarta-Bogor Km 46, Cibinong 16911, Jawa Barat, Indonesia
2. Directorate of Environment, Maritime, Natural Resources, and Nuclear Policy, Deputy of Development Policy, National Research and Innovation Agency (BRIN), Gedung B.J. Habibie, Jl. M.H. Thamrin No. 8, Jakarta Pusat, Jakarta 10340, Indonesia
3. Research Centre for Society and Culture, National Research and Innovation Agency (BRIN), Jl. Gatot Subroto No. 10, Mampang Prapatan Jakarta Selatan, Jakarta 12710, Indonesia
4. Research Center for Population, National Research and Innovation Agency, JL. Gatot Subroto No. 10, Mampang Prapatan Jakarta Selatan, Jakarta 12710, Indonesia
5. Research Centre for Applied Microbiology, National Research and Innovation Agency (BRIN), Jalan Raya Jakarta-Bogor Km 46, Cibinong 16911, Jawa Barat, Indonesia
6. Center for International Forestry Research (CIFOR), Bogor 16115, West Java, Indonesia
7. School of Ecosystem and Forest Science, University of Melbourne, Parkville, VIC 3010, Australia

* Correspondence: hunggul.yudono.setio.hadinugroho@brin.go.id; Tel.: +62-811-409-3999

Citation: Nugroho, H.Y.S.H.; Nurfatriani, F.; Indrajaya, Y.; Yuwati, T.W.; Ekawati, S.; Salminah, M.; Gunawan, H.; Subarudi, S.; Sallata, M.K.; Allo, M.K.; et al. Mainstreaming Ecosystem Services from Indonesia's Remaining Forests. *Sustainability* **2022**, *14*, 12124. https://doi.org/10.3390/su141912124

Academic Editors: Mohammed Alamgir and Sandra Notaro

Received: 29 June 2022
Accepted: 17 September 2022
Published: 25 September 2022

Abstract: With 120 million hectares of forest area, Indonesia has the third largest area of biodiversity-rich tropical forests in the world, and it is well-known as a mega-biodiversity country. However, in 2020, only 70 percent of this area remained forested. The government has consistently undertaken corrective actions to achieve Sustainable Development Goal targets, with a special focus on Goals #1 (no poverty), #2 (zero hunger), #3 (good health and well-being), #7 (affordable and clean energy), #8 (decent work and economic growth), #13 (climate action), and #15 (life on land). Good environmental governance is a core concept in Indonesia's forest management and includes mainstreaming ecosystem services as a framework for sustainable forest management. This paper analyzes efforts to mainstream Indonesia's remaining forest ecosystem services. We review the state of Indonesia's forests in relation to deforestation dynamics, climate change, and ecosystem service potential and options and provide recommendations for mainstreaming strategies regarding aspects of policy, planning, and implementation, as well as the process of the articulation of ecosystem services and their alternative funding.

Keywords: value articulation; sustainable financing; DSS; spatial assessment

1. Introduction

Forests, which, at just over 4 billion hectares, cover nearly one-third of Earth's land area [1], play an important role in the global carbon cycle [2] and are home to a significant portion of the world's terrestrial biodiversity [3]. Forests also provide a wide range of other ecosystem services, including supporting services, such as nutrient cycling and soil formation [4–7]; provisioning services, such as food [8], timber [9], and medicinal plants [10,11]; and regulating services, such as erosion control [12], flood mitigation [13], water and air purification [14–16], pollination [17], and pest and disease control [18,19].

The Government of Indonesia has implemented new measures to improve the sustainability of the nation's forests. The number of forest-related policies has increased significantly over time. These focus primarily on improving forest protection and monitoring, ecosystem services, and biodiversity conservation; determining financial policies for forest-related activities; and restructuring forest-related organizations [20]. Management can become very challenging when multiple ecosystem services, some of which are contradictory, coexist in one landscape. The management process requires the identification of policies, regulations, market conditions, and objectives for integrated ecosystem services' management [21]. These policies underwent significant changes between 2011 and 2016 when international pressure and financial support were applied to restrict illegal timber, promote climate pledges and agreements to reduce carbon emissions, and provide conditional aid for REDD+ activities [20]. The Government of Indonesia has commenced corrective actions to manage the country's remaining forests and achieve Sustainable Development Goals (SDGs). One such action involves the mainstreaming of ecosystem services as a framework for sustainable forest management.

The linkages between forest ecosystem services and SDGs are presented in Figure 1 below.

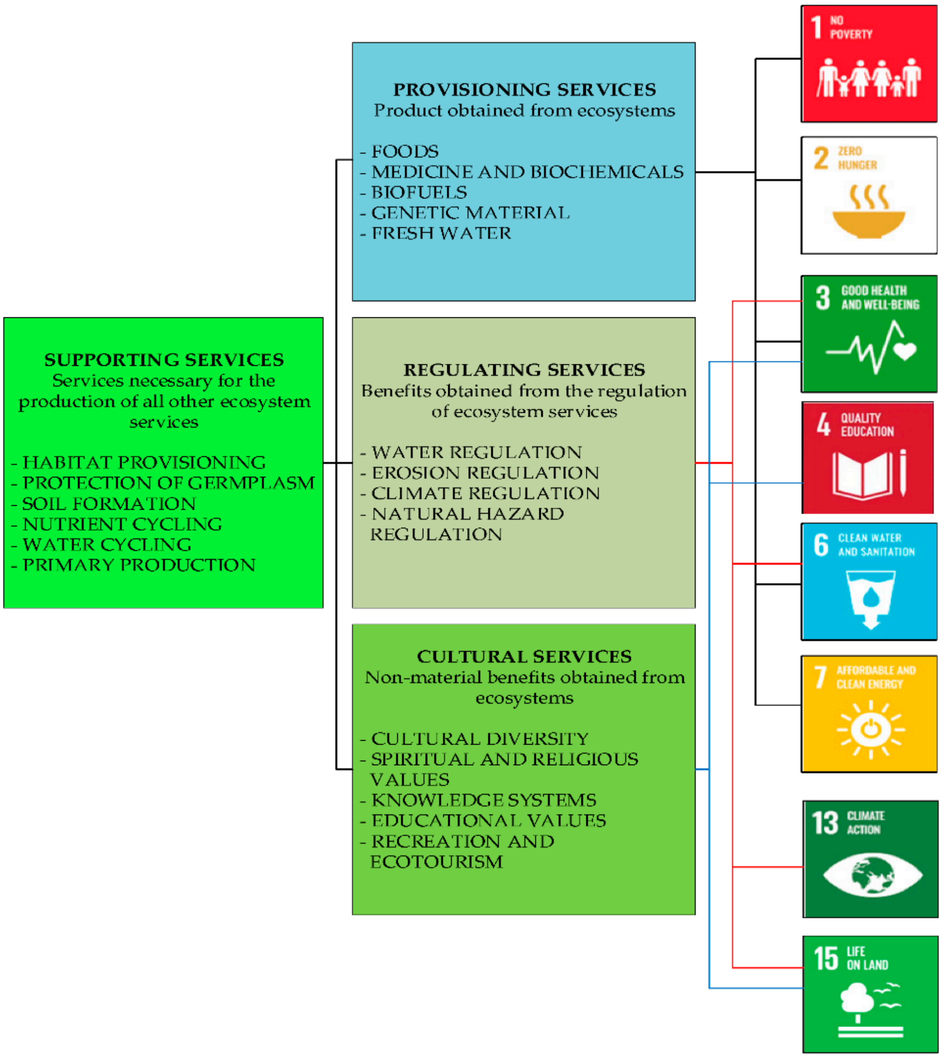

Figure 1. Linkages between ecosystem services and SDGs.

This review paper describes the mainstreaming of ecosystem services (ES) in forest management in Indonesia as a manifestation of the government's policy of changing the forest management paradigm from one of exploitation to a pro-conservation approach. This paper consists of five sections. Sections 2 and 3 of this paper depict the states of Indonesia's forests and their potential services, illustrating the significant value of Indonesia's remaining forests today, as well as the future challenges. Section 4 analyzes the government's efforts in optimizing ecosystem services as an important factor in mitigating and adapting to climate change through policy support instruments, including renewable energy development, carbon trading, green economy, ecotourism, and forest ecosystem management with communities through social forestry. Section 5 highlights four important elements involved in mainstreaming ecosystem services in Indonesia, namely: (1) the development of a payment for ecosystem services (PES) scheme; (2) the utilization of a decision support system (DSS) (3); ES value articulation; and (4) sustainable funding as an incentive.

This paper is based on the results of the authors' research and experiences, as well as a literature review involving finding, reviewing, and evaluating relevant materials and synthesizing all information obtained. The materials reviewed include national and international research papers, research reports, rules and policies, and relevant books and scientific publications concerning ecosystem services.

2. The State of Indonesia's Forests

Located between two continents, Asia and Australia, and between two oceans, the Indian and the Pacific, Indonesia has extremely high levels of biodiversity and endemicity. It is also the largest archipelagic country in the world, with more than 17,000 islands. Sixty-four percent, or 120 million hectares, of the land in Indonesia is designated as state forest area [22].

For more than four decades, forest resources have been important in driving Indonesia's economic development. From 1966 to the late 1980s, Indonesia was the largest exporter of logs in the world and then the world's largest producer of plywood. Timber was the second largest contributor to the Indonesian economy after oil and gas in the years immediately following the fall in oil prices in the 1980s. However, it was not until the 1980s that researchers began to take notice of deforestation in the region. The various activities identified as drivers of deforestation include the increased exploitation of natural forests in concessions; the conversion of forest area to other uses, such as agriculture, mining, and estate crops; migration; illegal encroaching; and forest fires [23]. Indonesia had the highest rate of annual primary natural forest loss in the tropics [24,25], reaching the greatest level of 3.51 million hectares annually between 1996 and 2000 [26], during which time large forest fires occurred.

From 2002 to 2011, the rate of deforestation fell, which was accompanied by a decline in the occurrence of forest and land fires and a reduction in some of the excesses that followed the decentralization of forest management. Between 2011 and 2015, the average annual deforestation rate increased to 0.82 million hectares. Among the main causes of this deforestation were the 2015 wildfires. The annual deforestation rate for 2015 to 2016 was lower at 0.63 million hectares. This fell further to 0.44 million hectares between 2017 and 2018, before rising again to 0.46 million hectares between 2018 and 2019 [26].

To address the causes of deforestation and forest degradation, Indonesia has enacted and implemented various policies, including a moratorium on issuing new concession permits on areas of natural forest and peatlands. Spatially explicit temporal analyses of forest loss from 2001 to 2017 by Chen, et al. [27] show an average annual forest loss rate of 0.091 million hectares for 2001–2011 across the whole of Indonesia, slowing to 0.001 million hectares annually for 2012–2017 following the onset of the moratorium in 2011. Other policies include providing land to communities; resolving land-use conflicts; monitoring environment permits and law enforcement; reducing greenhouse gas emissions; encouraging partnerships between communities, timber concession (IUPHHK) holders, and forest management units (FMUs) to prevent forest and land fires through the establishment of fire brigades; better management of peatland ecosystems; forest landscape restoration involving communities in the management of forests and protected areas through forestry programs; and achieving sustainable forest management (SFM) through the mandatory certification of forests and forest products. In addition, there has been a paradigm change based on a new set of business configurations for the management of production forest resources, with a more diverse set of forest-based businesses, including food, renewable energy, ecotourism, agroforestry, non-timber forest products (NTFPs), and environmental services.

The Government of Indonesia (GoI) has ratified the Paris Agreement (PA) and committed to reducing greenhouse gas emissions by 29% unilaterally and 41% with international cooperation compared to a business-as-usual (BAU) scenario by 2030. The low-carbon scenario compatible with the Paris Agreement target (LCCP) presented by the GoI outlines a long-term vision for creating low-carbon, climate-resilient development. Under the LCCP, emissions from the energy sector will slow down, and the previously net-emitting forestry and other land-use (FoLU) sector will become a net sink by 2030. Under this scenario, greenhouse gas emissions should peak at 1240 million metric tons of carbon dioxide equivalent ($MtCO_2e$) by 2030, before progressively declining to 540 $MtCO_2e$ by 2050, with net zero emissions anticipated by 2060 [28]. Spatial template analysis results show that 10.48 million hectares of natural forest across the various forest functions and outside the forest area are at high risk of deforestation [28]. Under the LCCP scenario, as only 6.8 million hectares of natural forest can be converted before 2050, natural forest conversion needs to be kept as low as possible in order for Indonesia to achieve its net zero emissions target.

3. Ecosystem Services Potential of Indonesia's Forests

Forest ecosystems provide society with a wide range of services. However, many of these ecosystem services are either undervalued or have no financial value at all. Numerous ecosystem structures and functions are being fundamentally undermined as a result of the frequent emphasis on immediate financial returns in day-to-day decisions [29,30]. Understanding the trade-offs between ecosystem services is critical to planning strategic and cost-effective interventions [31]. However, finding the optimum balance between extraction from a forest ecosystem for one ES and the sustainable provision of others remains a major challenge for forest managers and policymakers [32]. Sustainable forest management is aimed at enhancing biodiversity levels and supporting the provision of forest services.

Ecosystem services have been popularized and formalized through the United Nations Millennium Ecosystem Assessment 2004, which defined four categories of ecosystem services that contribute to human well-being, each underpinned by biodiversity. These are provisioning services, regulating services, supporting services, and cultural services [29]:

- Provisioning services are the products obtained from ecosystems for the benefit of humans, including food and fiber; fuel; genetic resources; biochemicals, natural medicines, and pharmaceuticals; ornamental resources; and fresh water [29];
- Regulating services are ES that protect the Earth from disasters, such as floods, landslides, and disease, and ensure the implementation of ecosystem protection services and the provision of other ES [29];
- Supporting services are defined as intermediate services generated through the ecosystem's internal functions, which neither deliver any products nor alter any environmental conditions that people can use instantaneously [33];
- Cultural services are defined as the non-material benefits people obtain from ecosystems through spiritual and religious enrichment, cognitive development, recreation and ecotourism, aesthetics, inspiration, education, a sense of place, and cultural heritage [29].

3.1. Supporting Services

3.1.1. Habitat Provisioning

Indonesia's tropical forests play an essential role in providing habitats for rich biodiversity, from both flora and fauna to low-level life forms such as microbes. Indonesia's forests are habitats for a multitude of rare and protected species, such as the carrion flower (*Amorphophallus titanium* Becc) [34], *Agathis borneensis* [35], *Dipterocarpus* spp. [36], and *Nepenthes* spp. [37]. In addition, the majority of Indonesia's forests are biodiversity hotspots for primates, butterflies, birds, and others [38–42].

Indonesia's tropical forests also constitute habitats for endemic wildlife classified as rare and protected, including the Sumatran elephant [43,44]; the Sumatran tiger [45]; the Sumatran rhino [46]; the Javan rhino [47]; marsupials, such as the bear cuscus [48]; small mammals, such as *Nycticebus javanicus*, *Cynocephalus variegates*, *Petaurista peturista*, and *Petinomys* sp. [49]; and rare and protected endemic primates, such as orangutans and proboscis monkeys [50]. Its forest areas are also habitats for birds, such as the Javan hawk eagle [51]; rare and protected reptiles, such as *Leucocephalon yuwonoi* [52]; and endemic fish, such as *Melanotaenia arfakensis* [53], as well as for a diversity of fungi [54–56] and bacteria [57–59].

History also records several wildlife species that have become extinct due to the loss of functioning habitats in various forest ecosystems in Indonesia. The IUCN Red List lists various extinct species in Indonesia, including: *Panthera tigris* ssp. *sondaica* (Javan tiger), *Panthera tigris* ssp. *balica* (Bali tiger), *Macrobrachium leptodactylus* (freshwater shrimps), and *Coryphomys buehleri* (Buhler's rat) [60].

3.1.2. Protection of Germplasm

Studies on germplasm in Indonesia are limited to the types of plants and animals used by communities; for example, sugar cane [61], Indonesian taro (*Colocasia* sp.) [62], and Aceh cattle [63]. However, Indonesia's tropical forests play essential roles as the source of, and in storing and protecting, germplasm and genetic diversity in various genes between and within species populations. The high diversity of niches found in tropical forests results in the high endemicity of Indonesia's biodiversity. Therefore, Indonesia's forests also act as gene pools for many endemic species not found elsewhere on Earth. This wealth can support the development of various cultivars that can adapt well to the tropical conditions in Indonesia and become gene pools for developing commercial crops and livestock.

The majority of studies on germplasm originating from Indonesian forests focus more on the role of forests as sources of plant germplasm for non-timber forest product plant species [64]; medicinal plant species [65,66]; plant species as food sources [67,68]; and fruit plants, such as mango [69] and durian [70], as well as sources of germplasm for ornamental plant species, such as orchids [71,72].

Though relatively sparse, several studies have looked at the role of forests in animal species germplasm, especially certain bird species [73], as well as *Bos javanicus* [74] and *Dicerorhinus sumatrensis* [75].

3.1.3. Soil Formation

Very few studies have focused specifically on researching supporting services for soil formation. However, some have provided information on forests' essential role in soil formation. One study, for example, compared the soil quality of natural forest, pine forest, and grassland land-cover types in the Curug Cilember sub-watershed [76]. In addition, several studies have examined changes in soil physical properties due to changes in forest land cover or forest degradation. Examples include changes in soil physical properties due to land cover changes in candlenut forest, agroforestry land, and secondary forest [77]; in forests converted to monoculture coffee plantations [78,79] or mixed gardens [80,81]; and in physical properties and soil fertility due to fires in forested areas [82–84].

Although these studies do not explicitly mention the role of forest ecosystems in soil formation in regard to ecosystem services, they have contributed to knowledge about the roles and functions of forest ecosystems in protecting soils and provided scientific evidence of reductions in soil quality when there are changes to or a decline in the quality of a forest ecosystem.

Soil is the foundation of terrestrial ecosystems. Soil and its functions are essential for the provision of ecosystem goods and services [85], including food and biomass production; habitats for living things and gene pools (biodiversity); air and climate regulation; energy supply; and carbon pools [86–90]. Consequently, soil formation as an ecosystem service is vital for the sustainability of an ecosystem's functions.

Soil formation is the result of a complex network of biological, chemical, and physical processes. It is influenced by relief (terrain), parent material, climate, geography, and organisms [86,91]. Biological activity in soil formation mainly involves the roles of organisms, especially microbes [92]. The presence of decomposer microbes (bacteria and fungi) affects the rate of decomposition [93,94] and has an impact on the formation of topsoil.

A study in Sumatra showed that microbial biomass (bacteria and fungi) and amoeba densities were higher in tropical rain forests than in rubber and oil palm plantations and affected rates of litter decomposition [95]. In Central Kalimantan, natural peat swamp forests showed higher species richness for microbial, decomposers such as Acidobacteria, Actinobacteria, and Proteobacteria, than disturbed peat forests [96]. Abundant microbial decomposers, including Bacillus, Plesiomonas, Corynebacterium, Enterobacteria, Aeromonas, Micrococcus, and Clostridium, were also found in mangrove forest sediments in North Kalimantan [97]. The major kinds of soil microbial decomposers (Bacillus, Aspergillus, Pseudomonas, and Streptomycetes) were also more abundant in the secondary forest than in other land-cover types on the western slope of Mount Bromo [98]. As the presence of these decomposer microbes in various forest types certainly plays a crucial role in carbon and nitrogen cycles in soil formation, microbial communities can be considered architects of soil and many ecosystem services linked to forest ecosystems.

3.1.4. Soil Fertility and Nutrient Cycling

Soil fertility plays a vital role in forest ecosystems. Forest soil fertility affects the growth and development of trees, which in turn impacts forest functions, including food provision, carbon sinks, regulating water systems, etc. [99,100]. As soil fertility always relates to the availability of nutrients that can guarantee plant growth, nutrient cycling can maintain soil fertility [101]. Nutrient cycling is a key ecosystem service that contributes to supporting life on Earth [102]. Thus, soil fertility and nutrient cycling affect the provision of other ES that support human existence. A valuation of soil fertility and nutrient cycles in tropical forests in East Kalimantan showed a benefit value of USD 214,000 per year [103].

Microorganisms (bacteria, fungi, actinomycetes, etc.) play a key role in soil fertility, including its maintenance, and they are also critical mediators of this ecosystem service. Some prominent nutrient cycling processes include nitrogen fixation by rhizobacteria [104,105]; phosphorus acquisition by mycorrhizal fungi and phosphate-solubilizing bacteria [106,107]; and litter decomposition and mineralization by decomposer bacteria [108]. The existence and diversity of these soil microbes in forest soils directly affects plant diversity, ecosystem variability, and productivity.

When evaluated, the availability of nitrogen and phosphate in the soil due to the nutrient-cycling process involving microbes provides considerable economic value. One study showed the beneficial value of nitrogen and phosphate availability in the soil in Ethiopian grasslands to be USD 102 per hectare annually [109]. The nutrient cycle, as a major function of mangrove ecosystems, is very important for the production of nutrition, which also contributes to the stability of the food web. One study showed the economic value of a mangrove ecosystem in Sungai Apit Sub-district, Siak District, Riau Province, Indonesia, as a nutrient feeder to be IDR 767,350,075 annually [110]. Likewise, soil organic carbon from the decomposition of litter on the forest floor also has significant value. One study showed the soil organic carbon value in the *Pinus densiflora* forest on Mount Namsam, Seoul, to be KRW 19,467,000 per hectare [111].

3.2. Provisioning Services

3.2.1. Foods

Food and diet are rooted in the context of geographical, cultural, and socio-economic diversity [112]. Indonesian forests provide sources of nutrition, including essential carbohydrates, vitamins, minerals, and fiber [113]. In addition, forest foods are often involved in cultural ceremonies or traditional rituals [114].

Studies on food ethnobotany in various regions throughout Indonesia (Table 1) only describe a portion of the food potential provided by forests in Indonesia, considering that the use of forest products as food is still largely underreported. Species used by communities for food can come in the form of trees, shrubs, herbs, vines, and fungi. People use such species for staple foods, secondary foods, spices and seasoning, fruits, vegetables, and beverage ingredients.

The plant parts used for foods are diverse and include fruits, leaves, flowers, stems, seeds, tubers, roots, and rhizomes. Fresh fruits seem to be the major parts used for direct consumption. Several well-known species commonly reported in almost all Indonesian regions include *Lansium parasitum*, *Durio zibethinus*, *Nephelium lappaceum*, *Lansium domesticum*, and *Artocarpus heterophyllus* [115–117]. Other species also reported in specific regions include *Averrhoa carambola* in Central Sulawesi [115]; *Garcinia atroviridis*, *Molineria latifolia*, *Baccaurea motleyana*, and *Baccaurea motleyana* in Kampar Kiri Hulu, Riau [116]; and *Streblus asper*, *Protium javanicum*, and *Phyllanthus acidus* in West Nusa Tenggara [118]. Species consumed both as fresh fruits and seeds include *Artocarpus* spp. (*A. altilis*, *A. elasticus*, *A. integer*) and *Durio zibethinus* [113].

Tuber species are among the carbohydrate-rich plants consumed in many Indonesian regions. In Central Sulawesi, people are familiar with consuming *Manihot esculenta*, *Ipomea batatas*, and *Calocasia monlalon* [115]. People on Moyo island, West Nusa Tenggara even consume *Dioscorea hispida*, *Xanthosoma sagittifolium*, and *Manihot esculenta* as their staple foods, in addition to other non-tuber plants, such as *Cycas rumphii* and *Inocarpus fagifer* [118]. People in Papua also consume the tubers of *Ipomoea batatas*, *Xanthosoma viollaceum* and *Canna edulis* as their staple and alternative foods [119].

The leaves of herbs commonly consumed as vegetables include *Calamus* sp. and *Diplazium esculentum* among Malay communities in Riau [116] and *Brassica oleracea*, *Ocimum basilicum*, and *Sauropus androgynus* in Lombok [120]. Vegetables from some plant species are also common in Sundanese and Javanese communities, where they are usually consumed in the form of fresh leaves called "*lalab*" or "*lalab atah*". Among such species are *Helicia robusta*, *Schefflera aromatica*, and *Symplocos fasciculata* [121].

Various parts of plants are traditionally utilized for spices, seasoning, and condiments. People have been familiar for generations with using well-known herbs, such as the bulbs of *Allium sativum* and *Allium cepa*; rhizomes of zingiberaceae (e.g., *Zingiber officinale*, *Curcuma longa*, and *Alpinia galanga*); and fruits of *Amomum uliinosum* [116,122]. In addition, tree parts also used in the cuisine of Indonesian communities include the fruits of *Tamarindus indica* [118], *Myristica fragrans*, *Sindora sumatrana* [120], *Litsea cubeba* [113], *Aleurites moluccanus*, and *Garcinia atroviridis* [122]; the leaves of *Syzygium polyanthum* [120] and *Premna serratifolia* [122]; the stems of *Sesamum indicum* [118] and *Alyxia stellata* [120]; the bark of *Cinnamomum verum* [120]; the seeds of *Sesamum indicum* [118]; and the flowers of *Syzygium aromaticum* [120]. Some of these tree species have been domesticated, with their products becoming widely commercialized in markets.

Table 1. Examples of traditional uses of forest foods based on ethnobotanical studies in various regions in Indonesia.

No.	No. of Species/Families	Location	Users	Habitus	Parts Used	Uses	Plant Category	Source
1	56 species, 19 families	South Aceh District, Aceh Province	Local communities	Trees	Fruits, young shoots, seeds	Secondary food, fruits, vegetables, spices, beverages	Wild and cultivated	Suwardi, Zidni Ilman, Tisna, Syamsuardi, and Erizal [113]
2	85 species, 37 families	Pasaman District, West Sumatra Province	Minangkabau and Mandailing communities	Trees, shrubs	Fruits, leaves, seeds, stems/shoots tubers, flowers	Starchy staples, fresh fruits, vegetables	Wild	Pawera, et al. [123]
3	76 species, 35 families	Kampar Kiri Hulu, Riau Province	Malay communities	Trees, shrubs, herbs	Fruits, stems, rhizomes, leaves, bulbs	Secondary food ingredients, vegetables, fruits, spices	Wild and cultivated	Susandarini, Khasanah, and Rosalia [116]
4	39 species	Lowland forest of Sukabumi, West Java Province	Local communities	Trees, shrubs, herbs	Fruits, leaves, tubers	Secondary food, fresh fruits, vegetables	Wild and cultivated	Rahayu, Susiarti, and Sihotang [121]
5	19 species	Pulau Panjang Protection Forest, Jepara, Central Java Province	Local communities	Trees, shrubs	Fruits, tubers, leaves, shoots	Fresh fruits, vegetables, seasoning	Wild	Utami [124]
6	21 species	Kampung Birang and Kampung Merabu of Berau District, East Kalimantan Province	Local communities	Trees	Fruits, leaves, young leaves	Secondary food, fresh fruits, vegetables	Wild and cultivated	Hartoyo, Supriyanto, Siregar, Theilade, and Prasetyo [117]
7	111 species, 43 families	Lombok island, West Nusa Tenggara Province	Ethnic Sasak communities	Trees, shrubs, herbs, vines, fungi	Fruits, stems, tubers, leaves, flowers, seeds, bulbs	Secondary food, fruits, vegetables, spices, beverages	Wild, semi-cultivated, cultivated	Sukenti, Hakim, Indriyani, Purwanto, and Matthews [120]
8	20 species	Moyo Island, West Nusa Tenggara Province	Ethnic Brangkuah communities	Trees, shrubs, herbs	Fruits, leaves, tubers, seeds	Staple foods, fresh fruits, vegetables, food seasoning	Wild and cultivated	Trimanto, Danarto, and Ashrafuzzaman [118]
9	32 species, 20 families	Mbeliling Forest Area, East Nusa Tenggara Province	Local communities	Trees, shrubs, herbs	Fruits, stems, tubers, leaves, bulbs	Food and drink	Wild and cultivated	Mulu, et al. [125]
10	39 species	Mantikole village, Sigi District, Central Sulawesi Province	Ethnic Kaili Inde communities	Trees, shrubs	Fruits, bulbs, leaves, roots, rhizomes	Staple food, secondary food, fresh fruits, vegetables	Wild and cultivated	Fathurahman, Nursanto, Madjid, and Ramadanil [115]
11	53 species, 31 families	Menawi village, Yapen District, Papua Province	Ethnic Ampari communities	Trees, shrubs, fungi	Fruits, seeds, flowers, bulbs, leaves, tubers, stems	Staple food, secondary food, seasonings, fresh fruits, vegetables, spices, beverage ingredients	Wild and cultivated	Waroy, Utami, and Jumari [119]

However, Indonesia will face food security challenges in the coming decades [112] and, despite its vast land area, Indonesia imports two million tons of rice from other countries annually [126]. Therefore, it is important for Indonesia, a country of 271 million people, to integrate ecosystem services into food security plans and poverty reduction strategies [127–129].

The issue of national food security is also included in the global agenda through the Sustainable Development Goals (SDGs). Indonesia's Ministry of Environment and Forestry (MoEF) is mandated to support national priority program number four, which relates to food, water, energy, and environmental security [130]. In addition, in 2020, MoEF and the Ministry of National Development Planning (Bappenas) incorporated a 10 year Sustainable Consumption and Production (SCP) framework through SCP Indonesia 2020–2030, which includes climate change, water efficiency, and food resources [26].

To implement its mandate to support food security, MoEF has established major programs, including the Food Estate (FE), Agrarian Land Reform (TORA), and Social Forestry (SF) programs (Table 2).

Table 2. Government programs in the forestry sector to support food security.

Program	Target	Realization
Food Estate	Establishing food estates in four provinces: Central Kalimantan, Papua, North Sumatra, and South Sumatra	The program was underway in 115 villages, 50 sub-districts and two districts/municipalities in the four provinces in 2020
Agrarian Land Reform (TORA)	4.1 million ha	2.6 million ha in 2020
Social Forestry	12.7 million ha	1.7 million ha in 2020

Source: Tabulation of data taken from Ministry of Environment and Forestry [26].

The government has established the FE program as a leading agenda in its efforts towards post-COVID-19 national economic recovery. FE preparation activities aim to meet four targets, including providing forest area land for food production. By 2020, the FE program was reportedly already underway in 4 provinces (Central Kalimantan, Papua, North Sumatra, and South Sumatra), covering 115 villages, 50 sub-districts, and 2 districts/municipalities [130].

Although government programs, such as the FE SF programs and agroforestry, are aimed, among other things, at optimizing forests' capacity to provide food, they need to pay attention to potential associated risks. For example, legalizing the use of protection forests for FE programs has the potential to increase greenhouse gas emissions from deforestation [131] and wildfires [132] and threaten native biodiversity through the use of exotic plants [133]. Therefore, the FE program needs to consider utilizing unproductive lands, maintaining tree-based land cover through agroforestry, and using low-risk local species.

3.2.2. Medicines and Biochemicals

Many medicines; biocides; food additives, such as alginates; and biological materials are derived from ecosystems [29]. The use of natural products in the pharmaceutical industry has fluctuated widely. Medicinal plants continue to play an important role in healthcare systems in many parts of the world. Approximately 50% of prescription medicines were originally discovered in plants [29]. Approximately 80% of the world's human population relies on traditional medicine, which involves the use of plant extracts [134]. Rural communities in Indonesia continue to rely on locally prepared indigenous traditional medicines or *jamu* made from plant materials [135].

As a country rich in biodiversity, Indonesia has many plant species with potential uses as raw materials for the pharmaceutical industry [136,137]. Around 80% of the world's medicinal plants grow in Indonesia [138]. Approximately 30% of the 25,000 plant species in Indonesia's ecosystems are known to have medicinal properties, while only 4% are cultivated. Indonesia's 7500 medicinal plant species account for around 10% of the world's total. The potential value of pharmacochemical medicinal plants in Indonesia is around USD 14.6 billion or more than IDR 150 trillion [139].

Indonesia's Medicine and Food Supervisory Agency, or *Badan Pengawas Obat dan Makanan* (BPOM), classifies traditional medicines as *jamu*, standardized herbal medicines, and scientifically proven phytopharmaca products [137]. *Jamu* covers a variety of Indonesian traditional remedies made from natural materials, such as roots, flowers, leaves, and fruits. Around 350 factories produce packaged *jamu* and export their products to more than a dozen countries in Asia and Europe [135].

3.2.3. Biofuels

Biofuels refer to fuels in which energy is derived from photosynthesis, including woody materials, plant carbohydrates, vegetable oils, and crop seeds [140]. Forest biofuel harvesting is an example of a provisioning ecosystem service, and biofuel production from forest biomass will directly or indirectly affect ecosystem services [141].

The factors affecting biofuel production are biophysical conditions (climate, soil), biofuel choice (species), management (harvested wild or cultivated), and societal factors (biofuel policies, demand, market price). Benefits from biofuels include avoiding the use of fossil fuels, avoiding GHG emissions, and increasing incomes and employment from biofuel production and the consumption of energy generated from biofuels [140].

Biofuels can contribute to solving global energy and economic crises, both as a sustainable energy source and by promoting economic development, especially in rural areas of developing countries. Bioenergy production is also promoted as an energy security and climate change mitigation strategy [142]. However, enhancing ecosystem services via biofuel crops may result in environmental impacts (e.g., changes in habitat or biodiversity quality, changes in soil and air quality, changes in water quality and quantity, changes in productivity, and the local introduction or elimination of species) [143]. Consequently, trade-offs between biofuels and environmental resources are inevitable [144], though enhancing ecosystem services via biofuels can be achieved through location-specific designs of bioenergy systems [143].

Tropical forests produce abundant biomass that can be used in the production of biofuels as another potential ecosystem service. This biomass has not been utilized optimally and becomes unprocessed waste. To help reduce dependence on fossil fuels—an ever-depleting resource—using forest biomass for biofuel has the potential to reduce global emissions from forest decomposition processes and from forest fires.

In the Indonesian context, forest biomass can potentially support the country's fossil-based and renewable energy mix. The government has set targets for renewables to make up 23% of the energy mix by 2025 and 31% by 2050. The mandatory targets for biofuel use in various sectors are presented in Table 3.

Forestry residues from forest operations in seven large islands in 2014 were predicted to be able to produce almost 300 MW of bioenergy [145]. Logging waste in native forests creates biomass ranging from 20% to 40% of the intact wood stands [146]. This biomass comes from tree stumps, broken logs, and remaining tree branches up to 10 cm in diameter. If the average annual log production from Indonesia's native forests is 28 million m^3 [147], those native forests also have the potential to produce approximately 11.2 million m^3 of biomass per year, which could be used in biofuel production.

Meanwhile, based on FAO and Global Forest Resources Assessment datasets, Suntana, et al. [148] estimated annual forest biomass potential to be 5000 to 11,000 million megagrams (Mg) and then calculated potential bio-methanol production from that forest biomass using three estimations, as presented in Table 3. Moreover, total biomass potential, including from agriculture, is presented in Figure 2.

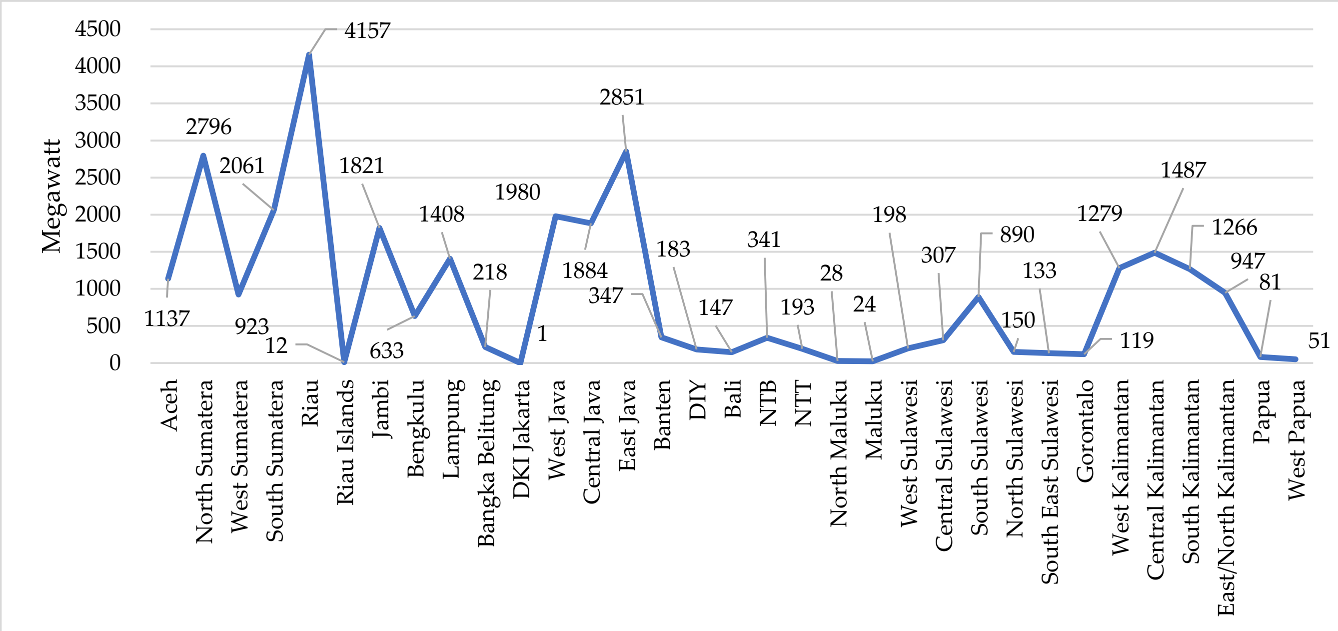

Figure 2. Distribution of biomass-based energy potential (MW) by province in Indonesia based on data from [149,150].

Table 3. The potential of forest biomass and bioethanol production from production forests and other land-use areas with tree cover in Indonesia.

Aboveground Biomass (Wet) * (Mg × 1,000,000)	Aboveground Biomass (Dry) (Mg × 1,000,000)	Amount of Forest Biomass Collected Annually (Dry) (Mg × 1,000,000)	Biomass to Bio-Methanol Conversion Efficiency (%)	Total Bio-Methanol Produced from Forest Biomass Collected Annually (L × 1,000,000)	Total Electrical Energy Produced from Biomass Harvested (Total Gigawatts)
5083	2542	127	25 50	40,029 80,057	41,697 83,393
540	2705	135	25 50	42,604 85,208	44,379 88,758
10,726	5363	268	25 50	84,467 168,935	87,978 175,973

* Aboveground biomass that can be harvested from production forest (natural and plantation forest) and from other land-use areas with tree cover in Mg (Megagrams). Source: Modified from Suntana, Vogt, Turnblom, and Upadhye [148].

3.2.4. Genetic Material

Genetic diversity is one form of biodiversity and encompasses plant, animal, and microbial genetic materials. Genetic diversity in plants, animals, and microbes is important in enhancing ecosystem services. Genetic diversity contributes to agricultural productivity as a source of disease or pest resistance and of higher-yielding varieties/breeds. Genetic diversity helps with climate change impact adaptation through the provision of early-maturing and drought and moisture stress-resistant genotypes. Microbial genetic diversity is vast and widely used in agriculture, industry, food processing, and medicine [151].

Microbial diversity, which represents collections of genes [152], is closely related to ecosystem function. Therefore, microbial genetic diversity is an important environmental service provision of forests in Indonesia. A total of 22 selected isolates of lipolytic bacteria from natural forests in Bukit Duabelas National Park were isolated and identified using a 16 rRNA gene analysis [153]. Enzymes produced by lipolytic bacteria are important in the food, biodiesel, pharmaceutical, and agro-aquaculture industries. As many as 1000 types of actinomyces, which are important for global medicine as they are sources of anti-tumor, anti-viral, anti-bacterial, anti-fungal, and anti-protozoa metabolites, have been isolated from various ecosystems in Indonesia [154]. Bacterial isolation and identification by analysis of the 16 rRNA genes in the rhizosphere of 10 nickel-hyperaccumulator tree species in the nickel-mining area of Halmahera island resulted in 40 bacterial phyla, which indicates that these bacteria play an important role in nickel uptake by hyperaccumulator nickel tree species [155].

Plant genetic resources for food and agriculture, and crop and crop-associated biodiversity (PGRFA-CCAB), are affected by many factors, including globalization, climate change, desertification, loss of biodiversity, food security, food prices, movement of pests and diseases across borders, use of energy and biofuels, land-use change, poverty, and economic imbalances between developing and industrialized countries [156]. There are four types of value that can be delivered by ecosystem services: utilitarian, functional, intrinsic, and serependic [157]. Utilitarian value refers to the benefits derived directly by society from the use of species or their genes as inputs into consumption and production processes. Functional value refers to the contribution made by diversity to supporting ecosystem functions and preserving ecological structure and integrity. Intrinsic value refers to the value that biodiversity has in its own right, and comprises the cultural, social, aesthetic, and ethical benefits of biodiversity. Finally, serependic value refers to the possible future—but unknown—value of biodiversity [156].

3.2.5. Fresh Water

Water is essential for producing food and energy, and human well-being depends on the products and services provided by water [158]. Water is fundamental to all ecosystem benefits, including agricultural production. Forests and trees play a critical role in providing adequate water supply for human consumption, agriculture irrigation, and the alimentation of lakes and rivers on which inland fisheries depend, all of which are essential for food security and nutrition [159,160]. Generally, the value of water-flow regulation by forest ecosystems is not realized in situ, but it may be spatially transferred through rivers to other places outside watersheds, such as electricity generated from hydroelectric power plants [161].

Aquatic ecosystems (rivers, lakes, groundwater, coastal waters, oceans) provide important, directly measurable, valued ecosystem services, such as fish production, water supply, and recreation. Ecosystems also provide regulatory services in the hydrological cycle in watersheds, such as water purification, water retention, and climate regulation. Although these regulatory services are less visible, they must be considered in the sustainable use and management of water resources [162].

Indonesia has a large and abundant water resource potential [163,164]. Total water availability in Indonesia is 690×10^9 m^3 per year, exceeding the country's demand of 175×10^9 m^3 per year [165]. Indonesia's water resources cover almost 6% of all water resources on Earth and almost 21% of all water resources in the Asia–Pacific region. However, water availability is not distributed evenly across all regions of Indonesia. The island of Java has 60% of Indonesia's total population, but only 10% of its water reserves. In contrast, Kalimantan, which has 30% of Indonesia's water reserves, has only 6% of its population, while Papua has 70% of its water reserves and only 1.3% of its population [166,167]. Java is likely to experience a water crisis due to the imbalance between its water availability and population size [167,168].

3.3. Regulating Services

3.3.1. Water Regulation

Forest ecosystems play a very real role in regulating the hydrological cycle [169]. The hydrological cycle is the continuous circulation of water from the atmosphere to the Earth's surface and back to the atmosphere through the processes of condensation, precipitation, evaporation, and transpiration.

The roles of forest ecosystems in regulating the hydrological cycle are as follows [170]:

- Reducing or partially returning water reserves that already exist on Earth through the processes of evapotranspiration and the storing/consumption of water for the formation and growth of vegetation body tissue;
- Adding water droplets to the atmosphere;
- As a controller for the fall of rain directly to the Earth's surface through the processes of interception, through flow, and stem flow;
- As a reducer of the kinetic energy of water flow on the forest floor through surface resistance from stems at the ground level and due to litter on the ground surface;
- As an impetus towards improving the ability of the physical characteristics of soil by absorbing water through root systems, adding organic matter, or increasing biological activity in the soil.

Community expectations for the role of forest ecosystems in controlling the water cycle remain high. These expectations are based on the large numbers of water sources in and around forest areas, which continue to drain water during the dry season. Suryatmojo [171] reported that a pine forest area in the Mount Rahtawu watershed in Wonogiri District, Central Java, with a catchment area of 101.79 ha and rainfall ranging from 2900 to 3500 mm/year, is able to produce potential surface water resources of 2,232,000 cubic meters/year. This area is also capable of producing a fixed discharge of 2–67 L/second that is always available for use. From this potential alone, it can be predicted that the pine forest in the area is able to support 900–2000 people around it who, on average, need 122 L of clean water/person/year.

The role of forest ecosystems in regulating river flow, both flow discharge and sediment discharge, has also been reported by Junaidi and Tarigan [172], who examined the role of forest ecosystem cover on river flow and sedimentation processes in a watershed. The study's simulations from several scenarios show that a decrease in forest area can increase discharge and surface runoff, whereas an increase in forest area would increase soil infiltration and evapotranspiration.

3.3.2. Climate Regulation

Forests play a key role in the global carbon cycle, absorbing carbon dioxide (CO_2) from the atmosphere, storing it in wood as they grow, and releasing it back into the atmosphere when trees are burned or decomposed. Thus, the forest and land-use sector is unique because it can act as a carbon source or carbon sink. Around 30% of global carbon emissions are caused by deforestation and agricultural practices [173], which greatly affect the maintenance of climate regulation ecosystem services (CRESs), which are important measures to combat climate change [174]. Climate regulation is an ecosystem service that regulates the atmosphere's chemical composition, the ozone layer, rainfall, air quality, temperature patterns, and weather [175].

Reforestation and afforestation to restore forest cover inside and outside the forest area, respectively, are real examples of combatting climate change [174,176,177]. Under its Nationally Determined Contribution (NDC) following the Paris Agreement in 2016, the Government of Indonesia has pledged to reduce GHG emissions by 29% unconditionally and by up to 41% with international assistance during the 2020–2030 period [26]. During the COP 26 forum in Glasgow, Indonesia committed to achieving its 2030 NDC target by implementing a low-carbon climate resilience (LCCP) scenario compatible with the Paris Agreement and to becoming a forest and other land-use (FoLU) net sink by 2060, with its main commitments involving reducing deforestation rates, reducing GHG emissions from the forestry sector, and undertaking other concrete climate actions.

3.3.3. Erosion Regulation

Soil erosion is a natural process that occurs over geologic time, and the majority of erosion-related concerns pertain to accelerated erosion, the natural rate of which has been significantly increased by human activity [178]. Vegetative cover plays an important role in soil retention and in preventing landslides. In addition, deep-rooted trees and shrubs can reduce the occurrence of shallow erosion by strengthening the shallow soil layer and improving drainage [179].

Trees in forest ecosystems play an important role in reducing the risk of landslides. Rows of trees and roots above the soil surface help reduce soil erosion by functioning as an effective barrier to surface runoff, which causes reduced soil-carrying capacity. Conversely, in areas with high rainfall, trees and forests can also increase the risk of landslides by increasing the soil mass load due to subsurface water saturation, especially on very steep slopes.

3.4. Cultural Services

3.4.1. Cultural Diversity

Indonesia has very diverse forest ecosystems, where each type has given rise to cultures with characteristics that reflect the ecosystems inhabited by their people. For example, ethnic Dayak communities living in swamp forests and peat swamp forest ecosystems in Kalimantan have unique ways of life, habits, beliefs, local wisdom, arts, and customs [180]. Further examples are the ethnic Marind and Kanuum tribes living around the peat swamp forests and savanna in Wasur National Park, Papua, who have their own distinctive local cultures and a hereditary tradition of burning the savanna during the dry season to stimulate grass regrowth and attract deer to the area [181].

3.4.2. Spiritual and Religious Values

Forests in Indonesia occupy essential spiritual and religious positions for communities, and especially for indigenous peoples, some of whom still hold the traditional beliefs that certain areas of forest, where entry is forbidden, are sacred and must be protected. One such example is the indigenous Ammatoa community in Kajang *adat* village, Bulukumba, South Sulawesi, whose distinctive culture and beliefs have kept their customary forest area in pristine condition until today [182]. In Papua, the Malind-Anim tribe also has sacred ground in the swamp forest area of Wasur National Park. They believe they are forest people created in the forest birthplace of their ancestors [183].

Ethnic Dayak Ngaju communities in Kalimantan also have spiritual beliefs that involve maintaining forests, which contain sacred places known as *Pukung Pahewan*, the abode of supernatural spirits [184].

3.4.3. Knowledge Systems (Traditional and Formal)

The diversity of forest ecosystems in Indonesia gives Indonesian peoples different local knowledge about forest management. Their various customary rules are based on traditional knowledge and local wisdom related to using and conserving forests. Examples include the Dayak Ngaju people, with their *Tana' Ulen* system [185]; the Baduy people, with their *Leuweung Kolot* forbidden forest [186]; the Kajang people, with their *Rabbang Seppang* system [182,187]; and six Bengkulu customary communities, each with their own customary forestry laws called *rejang*, *serawai*, *pekal*, *lembak*, *mukomuko*, and *kaur* [188], which divide forest landscapes into different use zones.

Indigenous communities living around Indonesia's forests also have traditional wisdom in regulating the use of natural resources and hunting. Such arrangements, known as *Sasi*, regulate hunting times, utilization periods, and catches. Such arrangements are commonly found in peoples inhabiting eastern Indonesia, such as communities in Merauke [189], the Napan tribe in Papua [190], and the Kei tribe in southeast Maluku [191]. *Sasi* systems are full of conservation value because they prevent overhunting and ensure animals can reproduce.

3.4.4. Educational Value

Indonesia's forest area provides a variety of educational values for people living in or around forests and for people living far from forests. For example, knowledge about medicinal plants from various indigenous peoples has been used to enrich traditional and modern Indonesian medicine. Indigenous peoples, including Dayaks [192], the Naga tribe in West Java [193], and the Kajang tribe [194], have diverse knowledge of medicinal plants.

3.4.5. Recreation and Ecotourism

Ecosystem services in recreation and ecotourism can contribute both directly and indirectly to human well-being. Nahuelhual, et al. [195] explored experiences that have both physical and psychological effects for tourists. Indonesian forests provide various ecotourism services that accommodate a multitude of activities and experiences within their diverse ecosystems. The Pattunuang Asue ecotourism area in Bantimurung Bulusaraung National Park in South Sulawesi, for instance, accommodates adventure tourism, including camping, hiking, and rock climbing [196]. Savannas, such as those in Baluran National Park and the sand sea in Bromo Tengger Semeru National Park, provide off-road tours for exploration.

4. Ecosystem Services for Climate Change Mitigation and Adaptation

No matter how much we reduce fossil fuel use, changes in climate conditions will continue to affect humans and ecosystems. One proven means for tackling climate change is to invest in nature-based solutions through the development of ecosystem services that not only reduce its impacts but also help with climate change adaptation [197].

In forest management, Indonesia has taken the initiative to shift from conventional forestry practices to introducing innovative approaches to producing goods and services [26]. The Government of Indonesia has taken serious steps to facilitate the emergence of a new environmental services sector. Regulations have been issued on tourism services in forest areas (2013), micro-hydropower (2014), the utilization of conservation areas (2014 and 2015), geothermal power (2015), the utilization of ecotourism environmental services in production forest areas, social forestry enterprises (2016), and non-timber forest products (2017) [26].

This section presents ecosystem service-based activities aimed at climate change mitigation and adaptation that have received government attention through policy support instruments, including renewable energy development, carbon trading, green economy, ecotourism, and forest ecosystem management with communities through social forestry.

4.1. Renewable Energy Promotion

Official energy statistics from the U.S. Government's Energy Information Administration (EIA) project a nearly 50% increase in global energy consumption by 2050 due to strong economic growth [198]. Our dependence on and increasing demand for energy are causing significant changes to the ecosystems we rely on to meet our well-being needs. The challenge is how to meet this demand in a way that does not damage ecosystems.

Public authorities worldwide are focusing on promoting policies and instruments for using low-carbon renewable energy, which is intrinsically linked to ecosystem services [199]. The shift to a low-carbon energy era requires sustainable ecosystems that provide renewable energy while maintaining the availability of other ecosystem services [200].

Indonesia has set a target for new and renewable energy to make up 23% of its primary energy mix by 2025 in order to support the achievement of its Nationally Determined Contribution (NDC) target of reducing emissions by 29–41% by 2030 and achieving net-zero emissions (NZE) by 2060, or faster with international support [201]. Based on Law No. 30/2007 on Energy, renewable energy is defined as the energy that comes from renewable energy sources, including geothermal, wind, bioenergy, solar, hydropower, tidal, and ocean thermal energy conversion [202].

To support renewable energy development and decision making, interdisciplinary research is needed to gain a more comprehensive understanding of the impacts of renewable energy sources and their dependence on ecosystem services [203,204]. This includes using GIS-based modeling to determine potential sites, assess potential ecosystem services, and determine which parts of ecosystems can be exploited to develop renewable energy in a socially acceptable manner with maximum benefit and minimum risk [204].

4.2. Carbon Incentives for Forest Conservation

Tropical deforestation contributes significantly to global warming and atmospheric change [205–207]. Reducing emissions from deforestation as a potential global contribution to controlling climate change was first considered at the United Nations Framework Convention on Climate Change's (UNFCCC) Montreal Conference of the Parties (COP) in 2005. Reducing Emissions from Deforestation and Forest Degradation, including the sustainable management of forests and the conservation and enhancement of forest carbon stocks (REDD+), was then included in UNFCCC climate agreement negotiations in Bali, Indonesia, in 2007, and its implementation was eventually included in the 2015 Paris Agreement on Climate Change [208].

The UNFCCC is considering financing systems for REDD+ in developing nations [209]. Funding possibilities for potential REDD+-participating countries are divided into two categories: market and non-market financing [210]. Like any traded commodity, carbon credits are priced primarily by supply and demand. However, some countries party to the UNFCCC want the problem to be solved with traditional grant funding [209]. Most developing countries need a lot of money and help from institutions to build their capacity to design, implement, and keep track of their national REDD+ programs [210]. This capacity building and funding should help build and strengthen the institutions that will run the different parts of national REDD+ programs. This is an important non-market step that must come before any REDD+ program can be successful. Grants are the most common kind of financial assistance, followed by loans provided through multilateral, bilateral, and regional cooperation structures.

The Government of Indonesia has conservatively calculated that it will need roughly USD 247 billion to implement climate change mitigation efforts under its conditional NDC target for 2030 [211]. In 2020, Indonesia's Ministry of Environment and Forestry and the World Bank's Forest Carbon Partnership Facility signed a landmark agreement, releasing up to USD 110 million for Indonesia's efforts to reduce carbon emissions from deforestation and forest degradation between 2020 and 2025 [212].

Venter, et al. [213] estimated that, at carbon prices of USD 10–33 per ton of CO_2, or USD 2–16 per ton if only cost-effective areas are saved, payments for REDD+ could cover the costs of halting deforestation for oil palm plantations planned for Kalimantan. In addition, payments could conserve the habitats of the Bornean orangutan (*Pongo pygmaeus*) and Borneo pygmy elephant (*Elephas maximus borneensis*)—2 of the 40 endangered mammal species living in these planned plantation areas [213].

4.3. Green Economy

One way to overcome basic problems related to food, water, and energy shortages due to environmental and economic pressures is to internalize ecosystems into decision-making tools; for example, integrating the value of economic services into existing economic models and indicators, such as gross national product (GDP) [197]. The green economy is a development paradigm whose main targets are a low-carbon economy and a shift away from the extractive and short-term development patterns that cause such a variety of problems.

The implementation of green products in the green industry in Indonesia includes efficiency and effectiveness in the sustainable use of resources, the sustainable use of energy, the use of renewable energy, and reducing greenhouse gas emissions [214,215]. Strategies include campaigning for sustainable forestry development policies in Indonesia (sustainable development) and adherence to international standards, such as sustainable forest management certification from the International Tropical Timber Organization (ITTO) and from the Food and Agriculture Organization (FAO).

Indonesia is one of a number of countries with a strong commitment to eradicating illegal logging and timber trading. This commitment has been realized through its establishment of a Timber Legality Verification System (SVLK) [216] and the application of Forest Stewardship Council (FSC) green product labeling [217]. The FSC is pro-environment, while the SVLK is pro-government and private sector [218]. FSC certification, an effort to protect natural resources, is given to various timber and non-timber products, including furniture, paper (copy paper, tissue, etc.), food and beverage packaging, bamboo, and environmental services.

Despite a strong commitment to FSC certification, its implementation is not without challenges [219,220], including a lack of education for communities about forest protection and sustainability, limited regulatory support from the government, incompatibility with current forest conditions, the lack of information on green products, the unavailability of global standards, and the Ministry of Environment and Forestry policy combining SVLK and FSC certification to prevent illegal timber, despite SVLK being mandatory and FSC being voluntary [221–223]. Other obstacles include the fact that FSC-labeled consumer goods from Indonesia generally have relatively little appeal in European countries [221], and certified products' prices make them less competitive than non-certified products [224]. The above constitute significant obstacles to effective, sustainable forest management implementation and suggest the necessity of total commitment from many stakeholders [225].

4.4. Ecotourism

Ecotourism has become one of the fastest-growing and most dynamic tourism sectors [226], raising concerns over the ecological and social disruption it can cause, contrary to sustainability. Ecotourism has proven to be an effective concept in the sustainable use of natural resources [227]; however, more effort should be made to understand the relationships between ecotourism, resource protection, and economic benefits in order to provide input for decision-makers [228].

Ecotourism activities can increase public awareness, prompting the public to carry out conservation, conserve and protect biodiversity, and improve natural resource management [229]. The existence of ecotourism in an area can positively impact the economy of the surrounding community [230,231]. The rapid growth of tourism can create opportunities for financing the conservation of tourism areas [232,233].

As community-based ecotourism can achieve desired social outcomes, increase household income and welfare, and have positive impacts on the local ecology, it is in a position to reduce conflicts between conservation and development interests [234,235]. However, ecotourism activities can also have negative impacts on the environment [236]. In Indonesia, the commercialization of conservation forests for ecotourism has sometimes resulted in environmental degradation and had adverse social impacts with monopolies over management [237]. Globally, between 2009 and 2013, tourism also contributed to an 8% increase in greenhouse gas emissions from transportation, shopping, and food [238].

4.5. Social Forestry

The sustainability of forest ecosystem services has a strong relationship with local communities' dependence on forests. Anthropogenic factors are often the leading causes of forest degradation and can threaten the ecosystem services forests provide [239]. Sustaining forest ecosystem services is about managing forests in sustainable ways [240]; determining how to improve the livelihoods of local communities that rely on forest resources; and enhancing the socio-economic benefits of forests for human well-being. Forest ecosystem services can help improve people's well-being by providing ecological and socio-economic benefits [241,242], such as timber, fodder, fuel, and medicine, as well as water regulation, natural disaster prevention, and ecosystem health.

The challenge is to manage the livelihood-related activities carried out by local communities to ensure they do not damage forests. Indonesia's Social Forestry (SF) program is a government policy aimed at seeking economic equity for local communities and indigenous peoples by making land available for them to manage. One form of SF program implementation involves the establishment of social forestry business enterprise groups (KUPS). In 2020, food commodities produced by KUPS included 276,300 tons of fruit, 32,200 tons of coffee, 1500 tons of honey, 2800 tons of palm sugar, and 9700 tons of various other food crops [130].

SF has been promoted to broaden communities' legal access to forest resources to improve their well-being while protecting remaining intact forests and restoring degraded forests. The government has committed to allocating around 12.7 million hectares of state forest area for social forestry through community forest (*hutan kemasyarakatan*), village forest (*hutan desa*), community plantation forest (*hutan tanaman rakyat*), customary forest (*hutan adat*), and forest partnership (*kemitraan kehutanan*) schemes, as laid out in its Indicative Social Forestry Allocation Map (PIAPS). By May 2020, the SF program had already covered approximately 4,147,875 hectares and involved 857,819 households [26].

In protecting ecosystem services, these SF schemes provide significant support to other climate change-related programs in Indonesia, such as low-carbon development and FoLU Net Sink 2030. However, SF implementation still faces social and environmental constraints, including a lack of cooperation between communities, weak organizational management capacity, and various technical issues relating to forest management [243].

5. Mainstreaming Strategies

In the natural resources management and conservation context, the goal of mainstreaming is to internalize the aim of conserving natural resources into economic sector policies, programs, and development models for the benefit of humanity [244]. Mainstreaming aims to ensure that conservation and the sustainable use of ecosystems is not only the responsibility of conservation actors but of all stakeholders, from policymakers to business actors and local communities [245]. There are four elements to a framework for achieving mainstreaming: prerequisites—mandatory elements without which mainstreaming cannot occur; stimuli—external and internal elements that trigger awareness of the need for mainstreaming; mechanisms—real activities aimed at influencing mainstreaming; and measurable outcomes as indicators of mainstreaming effectiveness [246].

This paper highlights important elements in mainstreaming ecosystem services in Indonesia. The first element is the development of a payment for ecosystem services (PES) scheme as a mandatory element related to socio-economic and institutional prerequisites; the second is sustainable funding as an incentive element; the third is the utilization of a decision support system (DSS); and the fourth is ES value articulation, so that ecosystem services management can be executed and produce measurable outcomes.

5.1. PES Mechanisms

One of the reasons for the decline in ecosystem services is that people can consume them for free, which removes the incentive to invest in providing more ecosystem services. In addition, ecosystem services such as clear water, clean air, pollination, and climate stabilization are public goods that cannot be restricted to certain groups but are provided to all simultaneously. This inability to limit certain consumables makes it impossible to charge fees to enjoy them. The result is the depletion of ecosystem services. Part of the solution lies in finding ways to make these ecosystem services available at a price commensurate with the value they provide.

Payments for ecosystem services (PES) are financial incentives given directly to land owners as compensation for better land management, including conservation activities, in providing services from ecosystems that other parties need on a continuous basis [247]. The main idea of PES is that ecosystem service providers should be compensated by those who benefit from the services produced [248]. By assigning a value to ecosystem services, it is possible to identify which social and environmental gains and losses from resource exploitation or ecological imbalances result from land-use change [249]. PES is perceived as a tool for conservation financing [250]. It has become an economic instrument, as indicated by the payment value of each PES program. The concept of PES is inseparable from the basic idea of building incentives for individuals and communities to protect ecosystem services by rewarding them for any costs incurred in managing and providing those services [251].

PES schemes have two common forms; namely, voluntary and compulsory. Compulsory schemes involve contracts between conservation agents and landowners. The landowner agrees to manage an ecosystem according to agreed-upon rules and will receive an in-kind or cash payment upon complying with the contract [252]. This is the definition of PES outlined in Government Regulation No. 46/2017 on Environmental Economic Instruments.

The PES concept is highly promising, but its implementation is very slow, especially in low-income countries. PES can only work if there is the right culture of giving and taking, wherein service users are encouraged to pay and service providers feel motivated by receiving payments to deliver more services [253].

Some examples of PES established through agreements between providers and buyers in different regions in Indonesia are presented in Table 4.

Table 4. Some PES programs in Indonesia and their results.

No.	Program	The Parties	Agreement	Result	Source
1.	River Care Program in the Way Besai watershed, Lampung	Farmers as providers of ecosystem services, and PT PLN Lampung's Besai Hydroelectric Power Plant as user	The project goal is to reduce sedimentation by 30% within one year; in return, PT PLN will award micro hydro equipment worth IDR 20 million	The community carried out the content of the agreement effectively, with 86% of activities being successful; sediment concentrations fell by 20%	Pasha, et al. [254]
2.	PES Mechanism Initiative in the Cidanau watershed	Krakatau Titra Industry Inc., upstream farmers in the Cidanau watershed, and Cidanau Watershed Communication Forum as a mediator	Industries in downstream areas that utilize Cidanau watershed ecosystem services provide compensation of IDR 1.2–1.75 million per ha per year to several groups of upstream farmers to manage their land in a sustainable manner	Improved awareness among farmer groups about planting more trees (more than 12,500 trees on 25 ha)	Laila, et al. [255]
3.	Program for water source protection for PDAM Menang, Mataram, West Nusa Tenggara	Farmer Water Users Association (P3A) and an association of PDAM customers, accompanied by Samdhana	PDAM users pay conservation fees for the protection of catchments that provide water sources for Mataram in Lombok	90% of customers are willing to pay conservation fees of IDR 1000–5000/month	Fauzi and Anna [256]
4.	Building a mechanism for upstream–downstream relations in water resource conservation in the Citarum watershed (Cikapundung sub-watershed)	Giri Putri and Surga Air farmer groups with PT Aetra, BPLHD as a facilitator, and LP3ES as a companion	PT Aetra pays compensation of IDR 40,504,500 in stages for seed procurement and planting activities to two groups of upstream farmers for soil and water conservation activities through planting, maintenance, and other activities related to efforts to preserve watershed functions	The program has yet to fully meet the criteria for a sustainable PES mechanism (realistic, voluntary, conditional, and pro-poor)	Napitupulu, et al. [257]

Pagiola, et al. [258] identified four factors that are critical to the success of incentive-based programs: ensuring effective demand, flexibility in program design, ensuring the poor can participate, and covering transaction costs.

The full economic impacts of PES mechanisms for farmers remain unclear. A PES scheme in Cidanau involves PT KTI as the ES buyer, paying IDR 1,200,000 per hectare to farmers as ES providers, with FKDC facilitating its implementation [259,260]. A similar situation applies to a PES scheme in Lake Toba, where five districts surrounding the lake are ES providers, while PT Inalum is the buyer [261]. A PES scheme in West Lombok involves local water company PDAM's customers as ES buyers, with each household paying IDR 12,000 per year and each industry paying IDR 36,000 per year to the West Lombok District Government and IMP as providers [262]. Meanwhile, a PES scheme in Kuningan involving the Kuningan District Government as ES provider and Cirebon City Government as ES user has transactions of IDR 2.65 billion per year [263].

An analysis of PES implementation in Indonesia shows a number of problems to resolve: unavailability of main and supporting data; methods for PES analysis and economic value calculations; and an institutional system for PES. Suich, et al. [264] have identified constraining or challenging factors in PES implementation in Indonesia, such as a lack of recognition of potential buyers for ecosystem services, rights and tenure issues for local communities, limited operational programs, and ownership over a relatively small land area.

Small-scale PES implementation, such as the programs in the Cidanau watershed and West Lombok, provide good examples of increasing community awareness and participation in conservation efforts. Although their payments are low, they do have social, economic, and environmental multiplier effects. The PES program in West Lombok has successfully increased local community awareness to participate in conservation by planting trees in upstream areas [262].

One technical problem faced by the PES programs in the Cidanau watershed and Lake Toba is determining the water catchment areas that affect the water sources. This technical problem can be resolved for these programs and for all ecosystem services by using spatial analysis. Suich, et al. [264] identified the main supporting factors for a successful PES scheme in Indonesia as: easily identifiable ecosystem services and service users; long-term support from individuals or institutions to facilitate the scheme; and maintaining and building on relationships between communities and these facilitating institutions.

Following more than fifteen years of research and development, a research team from the Makassar Environment and Forestry Research and Development Center (BP2LHK Makassar) has come up with a watershed-based PES approach through what is known as downscaled PES (Figure 3). BP2LHK Makassar has designed an incentive scheme for community-based forest management (CBFM) involving micro hydropower (MHP) plants. The government, NGOs, and the private sector act as investors paying in-kind contributions in the form of MHP plants to service-providing local communities in forested upstream areas of watersheds. On a watershed scale, villagers are ES providers, while on a smaller scale, they are buyers.

Based on their comparative study of 40 PES cases from the 1990s, Grima, Singh, Smetschka, and Ringhofer [248] stated that a successful PES scheme is one that ensures resource sustainability while at the same time making a positive contribution to people's livelihoods. In their opinion, the common characteristics of successful PES schemes include:

- Ensuring the continuity of supply and quality of resources while making a positive contribution to local livelihoods;
- Operating at local and regional scales with time periods of 10–30 years;
- Using in-kind contributions in preference to cash payments;
- Involving the private sector without intermediaries between buyers and sellers.

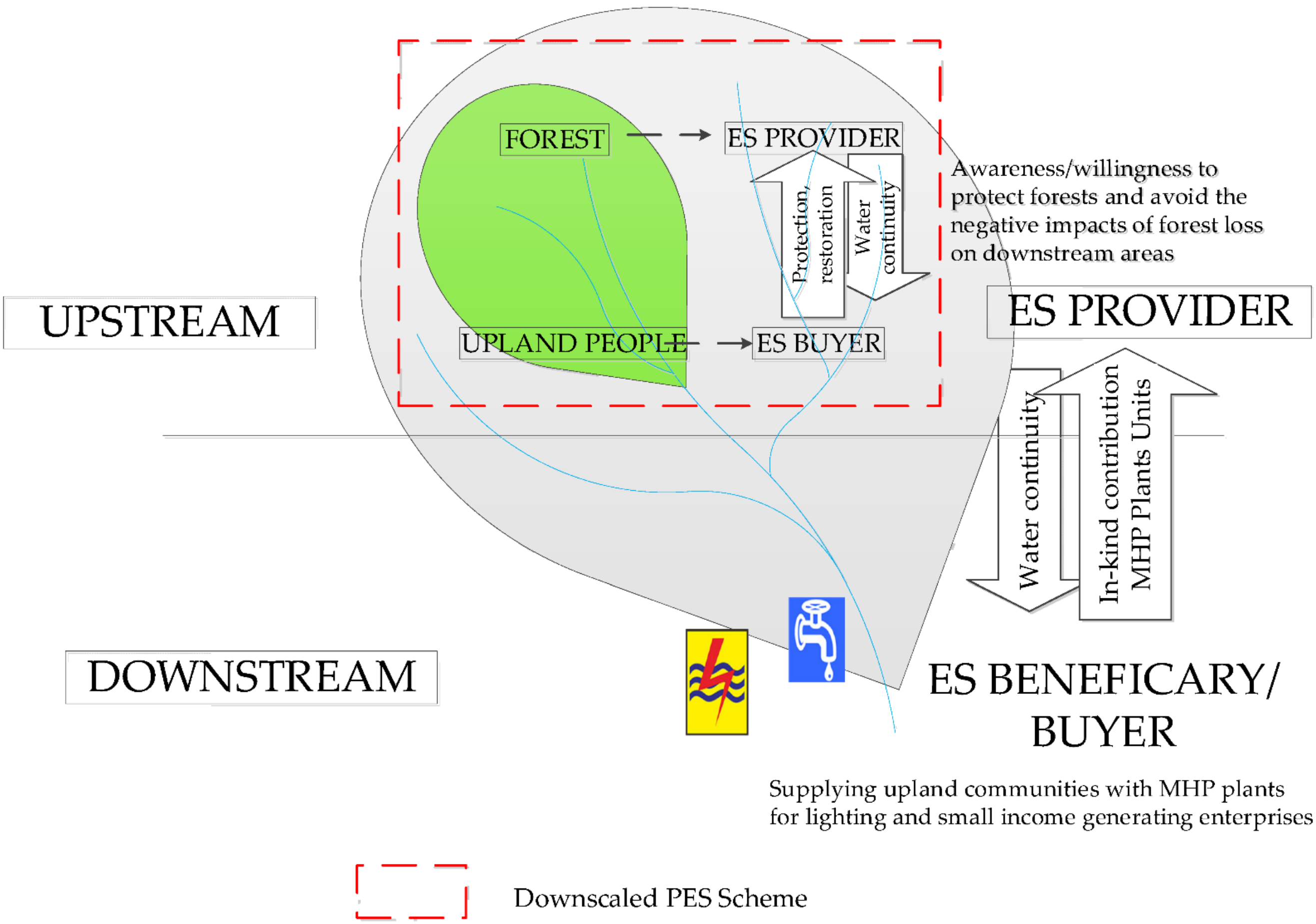

Figure 3. Downscaled PES scheme (formulated based on the authors' thoughts for this article).

Conversely, factors causing PES schemes to fail include inaccuracies in target selection due to different perspectives between stakeholders, and unanticipated trade-offs between social and conservation goals [265]. Unsuccessful PES schemes are characterized, among other things, by the following: their implementation failing to reduce pressures on ecosystems; an absence of added value from payments; no improvements in local livelihoods; and inequitable sharing of benefits [248]. To harmonize social and ecological goals, it is necessary to build agreement on objectives and have flexible mechanisms for achieving those objectives. Government, non-government, and local community stakeholders need to agree in order for a PES scheme's poverty alleviation and conservation goals to be achievable [265]. Interestingly, in general, farmers join PES schemes out of awareness and not because of economic incentives [266].

The effective management of PES programs requires detailed data on the spatial distribution of environmental quality indicators and the potential benefits of activities carried out, especially in agriculture [267]. The main challenge at the landscape level is determining the optimal allocation and management of the numerous land-use options [268]. Targeting environmentally sensitive or critical areas within the ecosystem will increase the effectiveness of PES mechanisms [269].

5.2. Decision Support System and Spatial Assessment-Based Planning

Due to a wide range of ecological characteristics and socio-economic restrictions, forest management needs to deal with multifaceted planning challenges. A robust decision support system (DSS) and spatial assessment are required to identify management options that take into account the wide variety of goals, criteria, and stakeholder interests [270]. The DSS must also be measurable, reproducible, trustworthy, adaptable, and inexpensive for extensive usage.

A DSS is a computer-based system that integrates a database, scientific analysis, modeling, and expert knowledge to implement established concepts and principles to solve decision obstacles. A DSS is concentrated on one of three sub-systems: a database sub-system (e.g., forest landscape characteristics, ecosystem services types); a modeling-based sub-system (e.g., growth and yield modeling, ecosystem services valuation); and a method-based sub-system (e.g., optimizing forest management options) [271].

Multi-criteria decision-making (MCDM) is the most implemented technique used in a DSS. An MDCM problem can be solved by first determining the weights of variables, then normalizing those variables and ranking the index based on aggregating the normalized values of variables for different management options and objectives [272].

Integrating a DSS and spatial assessment through geographic information system (GIS) approaches can help optimize possible trade-offs between different ecosystem services. It can also improve decision-making regarding optimizing ES provision for short-term and long-term ES-based forest management [273]. GIS uses a wide range of cutting-edge geospatial technologies and data sources from the field of Earth observation. These include remote sensing, terrestrial measurement, unmanned aerial vehicle (UAV) tools, a laser scanning system, a multispectral satellite system, new sensors on mobile devices, and the integration of digital cameras and global navigation satellite systems (GNSSs) [274,275]. Moreover, GIS approaches allow a DSS to simultaneously analyze diverse management options on various spatial and temporal scales [276,277].

According to several studies, a multitude of ecosystem-based DSSs exists, with 183 tools listed in the Ecosystem-Based Management (EBM) database [278]. DSSs that focus on ecosystem services as the basis for management include Artificial Intelligence for Ecosystem Services (ARIES), EcoAIM, EcoMetrix, Ecosystem Services Review (ESR), ES Value, Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), and the Benefit Transfer and Use Estimating Model Toolkit. Integrating MCDM and GIS approaches has been the most frequently used approach in DSSs for ES-based ecosystem management scenarios, such as ecotourism [279]; the location of biomass energy facilities [280]; trade-offs between ES and management goals [281]; biodiversity, carbon sequestration, and water [282]; and climate change impacts on multiple forest ecosystem services [283]. An analytical hierarchy process (AHP) has been the most commonly used technique for calculation, since it provides a rapid and rational workflow under imperfect conditions [270].

Based on various studies and the roles of existing DSS tools, it can be concluded that DSSs and spatial assessments need to be mainstreamed in ES-based forest management in Indonesia. Generalization, simplification, clearness, abstraction, difficulty, and spatial scale considerations have been recognized as significant factors for the success of a DSS in optimizing ES in a forest management framework. A DSS also needs to provide frameworks that make it possible to consider uncertainties during decision-making processes and offer opportunities for risk assessment [284].

5.3. Value Articulation

Ecosystem service valuation could help policymakers decide what to do by showing the benefits of managing ecosystems in a sustainable way. However, the valuation techniques used have serious limitations, and many ecosystem services are simply not amenable to valuation using the techniques currently available. Participatory approaches to addressing ES value articulation promote the more comprehensive integration of stakeholder perceptions and values [285,286]. A participatory approach can help by allowing for the more thorough integration of perceptions and values. As the first step in a participatory ES framework, Lopes and Videira [285] suggested a collaborative scoping process to broaden the scope of ES identification by eliciting the multiple values of ES from the ground up.

5.3.1. Economic Value

From the economic perspective, direct use-value is traditionally focused on quantifying and analyzing goods and services that produce tangible benefits. However, economists have broadened the scope from the meaning of "economic value" to the use, non-use, existence, inheritance, and indirect option values of ecosystems, including developing techniques for valuing the economic value of ecosystem services [287].

The purposes of economic valuation are to manage ecosystem services sustainably; to price products of ecosystem services [288]; to make valuable inputs to decision-makers [289]; and to provide the right policy options [290,291]. There are many methods available for valuing ecosystem services: contingent valuation [292]; total economic valuation [110]; output-based classification [293]; willingness to pay [294]; market prices; opportunity costs; and consumer surplus [295].

The economic valuation of ecosystem services is a growing field of research. There are a wide variety of reasons for, and methods associated with, the economic valuation of ecosystem services. Traditionally, many ecosystem services have been viewed as free gifts from nature to society, or "public goods", including landscape amenities, watershed services, and carbon storage. For this reason, little attention has been paid to measuring and valuing such ecosystem services in monetary terms. In addition, due to the lack of a monetary value and a formal market, these ES are often overlooked in public and private resource management planning and decision-making. Recent developments in approaches and tools for valuing ES provide a basis for estimating the economic benefits of a wide range of ecosystem services [296,297]. Many ES can be given a monetary value by using economic methods and tools [298]. Bullock, et al. [299] suggested that the discount rates used to assess the present value of future benefits and/or the future value of current benefits are a crucial aspect of monetary analysis. Key ecological and economic reasons for valuing ES include: economic incentives for keeping natural resources and also for conservation; providing justification for the allocation of public funding for conservation; and providing a useful step towards institutional innovation, such as payment for ecosystem services (PES) [298,300–303]. To this end, the economic valuation of ecosystem services provides a useful tool for justifying set priorities and programs, policies, or actions that protect or restore an ecosystem and its associated services. Common methods for estimating the economic value of ecosystem services are summarized as the market price method, non-market valuation methods, and value transfer.

(a) Market price method: This method calculates the economic value of ecosystem goods and services that are bought and sold in commercial markets. It can be used to assess changes in the quantity or quality of a good or service.
(b) Non-market valuation methods: Values for many ecosystem goods and services are not readily captured in market transactions and, thus, require non-market valuation methods, such as travel cost, the hedonic approach, and contingent valuation.
(c) Value transfer: This is an accepted economic methodology that estimates the economic value of non-market goods or services through work conducted at another site or group of sites [304]. The "transfer" refers to applying economic values and other information from the original "study site" to a "policy site". The study used this technique to estimate the economic value of biodiversity and associated services.

5.3.2. Social Value

Ecosystem services depend on the interrelationships between humans and the environment [305,306] or, more specifically, a set of support, supply, regulatory, and cultural services that provide direct and indirect benefits to everyone [29]. This has made people more aware of the social value of ecosystem services [307].

The GIS tool Social Values for Ecosystem Services (SolVES) is used to determine the non-material benefits a community obtains from an ecosystem through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience [29], as well as the ecosystem's various intrinsic, cultural, religious, and historical values [308]. Such assessments tend to be more difficult than determining ecological and economic values. Social value is strongly influenced by human preferences for nature, so accessibility, actors, and time can affect the effectiveness of the assessment.

SolVES uses different approaches in different landscapes depending on the objectives to be achieved [309–311] and can also be used to evaluate other ecosystem services [312]. According to Chintantya [313], ecosystems play a role in maintaining and enhancing social relations, especially culture. Therefore, ES social criteria need to be integrated with biophysical and economic criteria into systematic regional planning for sustainable ecosystem management [314].

5.4. Sustainable Financing

The environmental services produced by forest ecosystems have been widely identified. Studies show important ecosystem services, including watershed protection, biodiversity protection, carbon sequestration, wood-based biomass and energy, wild foods, animal-based energy, coastal protection, maintenance of nursery populations and habitats, pollination and seed dispersal, and nature-based recreation and tourism [315]. As pressures on forests and the environment, coupled with increasing financial limitations [316–318], are making efforts to maintain the provision of these ecosystem services increasingly difficult [319,320], new funding concepts for sustainable ecosystems are needed [321,322]. Sustainable financing concepts require adequate and available sources of funding for long-term management to ensure the prompt allocation to programs with ecosystem protection objectives [316].

There are several sustainable financing scheme options available for environmental and forest conservation. Funding for environmental protection and management that supports the provision of ecosystem services can come from both domestic and international sources. It can take the form of public funds from government budgets, grants, and foreign loans or non-public funds in the form of private funds, blended finance, state-owned company funds, and funds from philanthropic institutions or NGOs [323–326]. Funding from domestic sources originating from public funds—namely, national APBN and/or regional APBD budgets—can be channeled through a fiscal transfer mechanism from relevant ministry/agency spending, trusteeship institutions, equity participation for state-owned enterprises (BUMN), and/or investment (revolving funds). Environmental funding originating from overseas can take the form of bilateral or multilateral grants, grants from philanthropic institutions, loans and investment funds from the state or the private sector, and performance-based payment funds. This overseas funding can be channeled through intermediary institutions in charge of activities (executing agencies) consisting of ministries and government agencies, international development institutions/partners, regional governments, and trust institutions [324].

Private sector funding for the environment, both domestic and international, can be derived from investments in other companies; for example, green bonds/*Sukuk*. In addition, there is also a blended finance model, where private investment mobilization is supported by subsidies or government capital participation to create projects that are not only business-friendly but also generate social and environmental benefits. Another model is funding from philanthropic institutions, such as family foundations, corporate foundations, civil society organizations, and non-governmental organizations within and outside the country. All of these financial options are outlined in Figure 4.

Gutman and Davidson [318] discuss funding mechanisms available for biodiversity conservation in providing ecosystem services. These mechanisms are divided into traditional and innovative categories for the local, national, and international levels (Table 5).

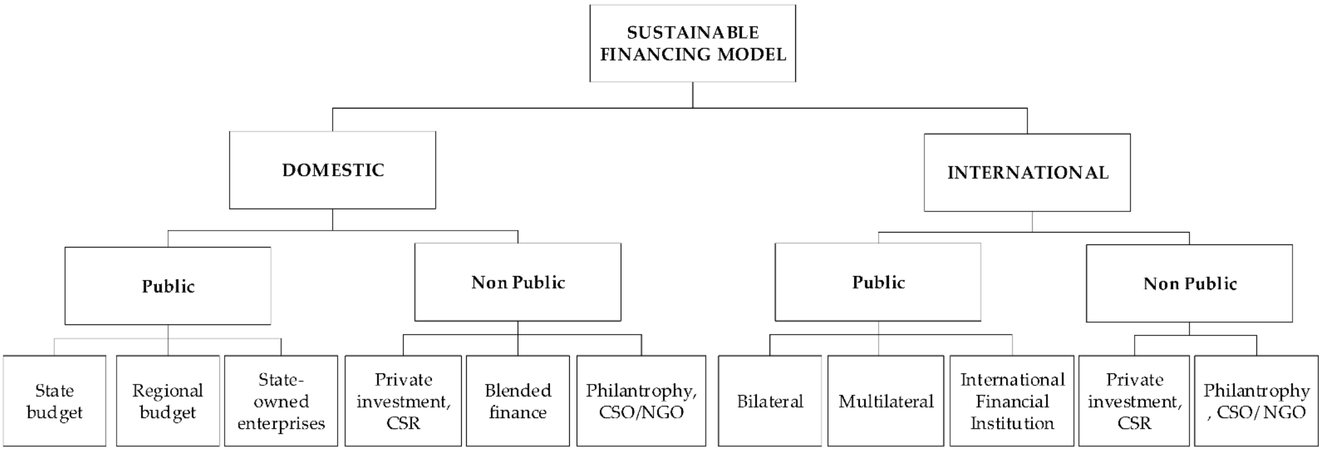

Figure 4. Possible sources of funding to support the provision of sustainable ecosystem services.

Table 5. Traditional and innovative finance mechanisms for biodiversity conservation and ecosystem services.

No.	Level	Traditional Finance Mechanisms	Innovative Finance Mechanisms
1	Local	○ Protected area entrance fees ○ Tourism-related incomes ○ Local markets for sustainable rural products ○ Local NGOs and charities ○ Local businesses' goodwill investments	○ Local markets for all types of ecosystem services (PES)
2	National	○ Government budgetary allocations ○ National tourism ○ National NGO fundraising and fund granting ○ National businesses' goodwill investments	○ Earmarking public revenues ○ Environmental tax reform ○ Reforming rural production subsidies ○ National-level PES ○ Green lotteries ○ New goodwill fundraising instruments (internet-based, rounding up, etc.) ○ Business/public/NGO partnerships ○ Businesses' voluntary standards ○ National green markets ○ National markets for all types of ecosystem services (PES)
3	International	○ Bilateral aid ○ Multilateral aid ○ Debt-for-Nature swaps ○ Development banks and agencies ○ GEF ○ International NGO fundraising and fund granting ○ International foundations ○ International tourism ○ International businesses' goodwill investments	○ Long-term ODA commitments ○ Environment-related taxes ○ Other international taxes ○ Reforms in the international monetary system ○ Green lotteries ○ New goodwill fundraising instruments (internet-based, rounding up, etc.) ○ Business/public/NGO partnerships ○ Businesses' voluntary standards ○ International green markets ○ International markets for all types of ecosystem services (PES)

Source: This table was created by extracting information from Gutman and Davidson [318].

Enabling conditions are needed to support the implementation of any sustainable financing concept. In determining enabling conditions, we use the policy instrument framework from Krott [327], which looks at the regulatory, fiscal, and administrative instruments that support policy implementation.

5.4.1. Regulatory Instruments

A legal basis for funding ecosystem services must be prepared in the form of regulatory instruments. The Government of Indonesia has issued various pieces of legislation that could be used as the basis for environmental funding. Law No. 32/2009 on Environmental Management and Protection and Government Regulation No. 46/2017 on Environmental Economic Instruments constitute the formal juridical bases for environmental funding, incentives, and disincentives presented to parties in the provision of environmental services. Government Regulation No. 46/2017 stipulates compensation/reward mechanisms for environmental services between regions and PES between different stakeholders. In addition, as a derivative of Job Creation Law No. 11/2020, Government Regulation No. 23/2021 provides a mandate to the central and regional governments, and other parties, to provide incentives to stakeholders who can restore, maintain, and preserve forests both inside and outside the forest area. As stated by Fauzi and Anna [256], such regulatory arrangements are necessary for reducing the complexity of the process of paying for environmental services.

5.4.2. Administrative Instruments

Funding mechanisms for ecosystem services must be flexible and site-specific, and administrative instruments and criteria for ecosystem services that can be funded should accord with a site's characteristics and needs. In addition, institutional arrangements for agreements between providers and users of ecosystem services either need to be set out in agreements/MoUs or formally institutionalized in local, national, and international regulations [328]. Finally, it is essential to record every stage in the funding of ecosystem services, from planning, implementation, assessment, and payment to monitoring and evaluation.

5.4.3. Fiscal Instruments

Finally, it is necessary to have fiscal instruments available to ensure the certainty of funding sources. One solution for doing so could be to integrate sustainable funding for the environment into a government budgeting mechanism. In addition, there need to be complementary sources of sustainable funding for ecosystem services from private sector operators as users and from public funding through government budgets [256,329]. This combination would further strengthen funding certainty for the provision of ecosystem services.

6. Conclusions

Forest resources have played a significant role in facilitating Indonesia's economic development for more than five decades. To ensure their sustainability, the Government of Indonesia has implemented new measures to improve the sustainability of the nation's forests. The number of forest-related policies has increased significantly over time. Mainstreaming ecosystem services is a manifestation of the government's policy of changing the forest management paradigm from one of exploitation to a pro-conservation approach.

In the natural resources management and conservation context, the goal of mainstreaming is to internalize the aim of conserving natural resources in economic sector policies, programs, and development models for the benefit of humanity. Mainstreaming aims to ensure that the conservation and sustainable use of ecosystems is not only the responsibility of conservation actors but of all stakeholders, from policymakers to business actors and local communities.

The required mainstreaming strategy for ecosystem services in Indonesia is divided into four important elements; namely, supporting regulations and policies regarding payments for ecosystem services (PES) as a mandatory element related to socio-economic and institutional prerequisites; an accurate planning system that can be accepted through the use of a decision support system (DSS); the articulation of ES values so that the management of ecosystem services can be carried out and produce measurable results; and sustainable funding as an element of incentives to ensure that implementation is continuous and on-target.

A key challenge of PES implementation at the landscape level is determining the optimal allocation and management of different land-use options. In this case, the use of DSSs combined with spatial analysis and remote sensing is important and strategic.

DSSs can be used to support a more comprehensive understanding of the problem and the development of alternative management options and to project the consequences of different actions.

The assessment of ecosystem services can help policymakers decide what to do by demonstrating the benefits of managing ecosystems sustainably. A participatory approach to articulating the value of ecosystem services can help promote a more comprehensive integration of stakeholder perceptions and values, starting with bringing out the economic, as well as the social, value of ecosystem services from the ground up.

At the implementation level, a combination of the private sector and public funding would strengthen funding certainty for the provision of environmental services. The PES concept is highly promising, but its implementation remains rare in Indonesia. Notes taken from several cases of PES implementation in Indonesia have shown weak community capacity, a need for intermediary agents, no discernible increase in farmers' income, and the need for incentives to encourage participation. To ensure the continuity of ecosystem services through environmental and forest conservation efforts, there are several options for sustainable financing schemes that can be optimized. The sustainable sources of funding come from domestic and international sources in the form of public funds from the government budget, grants, and foreign loans or non-public funds in the form of private funds, blended finance, BUMN funds, and funds from philanthropic institutions or NGOs.

Author Contributions: Conceptualization: H.Y.S.H.N., F.N., Y.I., T.W.Y., S.E., H.G. and S.S.; Literature review and data analysis: H.Y.S.H.N., F.N., Y.I., T.W.Y., S.E., M.S. (Mimi Salminah), H.G., S.S., M.K.S., M.K.A., N.M., W.I., I.A.S.L.P.P., R.P., F.A., M.S. (Mohamad Siarudin), O.S. and H.B.; Writing original draft: F.N., T.W.Y., S.E., M.S. (Mimi Salminah), M.K.S., M.K.A., N.M., W.I., I.A.S.L.P.P., R.P., F.A., M.S. (Mohamad Siarudin) and O.S.; Review and editing: H.Y.S.H.N., Y.I., T.W.Y., M.K.A., M.K.S., N.M., W.I., I.A.S.L.P.P., R.P., F.A., M.S. (Mohamad Siarudin), M.S. (Mimi Salminah), O.S., S.S. and H.B.; Supervision: H.Y.S.H.N., Y.I., F.N., H.G., S.S. and H.B. All authors have shared roles according to their respective disciplines and experiences as major contributors who equally discussed the conceptual ideas and the outline, provided critical feedback on each section, and helped shape and write the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: The English editing cost and article processing charges were supported by the Center for International Forestry Research (CIFOR).

Acknowledgments: The authors thank the anonymous reviewers for their useful comments. We are thankful for the financial support provided by the Center for International Forestry Research (CIFOR) to cover English editing costs and article processing charges. Disclaimer: the opinions and arguments in this paper are solely those of the authors' and do not reflect the views of CIFOR or the National Research and Innovation Agency (BRIN).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. FAO. *Global Forest Resources Assessment 2020*; FAO: Rome, Italy, 2020. [CrossRef]
2. Canadell, J.G.; Raupach, M.R. Managing forests for climate change mitigation. *Science* **2008**, *320*, 1456–1457. [CrossRef] [PubMed]
3. Betts, M.G.; Wolf, C.; Ripple, W.J.; Phalan, B.; Millers, K.A.; Duarte, A.; Butchart, S.H.M.; Levi, T. Global forest loss disproportionately erodes biodiversity in intact landscapes. *Nature* **2017**, *547*, 441–444. [CrossRef] [PubMed]
4. Attiwill, P.M.; Adams, M.A. Nutrient cycling in forests. *New Phytol.* **1993**, *124*, 561–582. [CrossRef] [PubMed]
5. Vitousek, P.M.; Sanford, R.L. Nutrient cycling in moist tropical forest. *Annu. Rev. Ecol. Syst.* **1986**, *17*, 137–167. [CrossRef]
6. Foster, N.W.; Bhatti, J.S. Forest ecosystems: Nutrient cycling. *Encycl. Soil Sci.* **2006**, *718721*. [CrossRef]
7. Šamonil, P.; Král, K.; Hort, L. The role of tree uprooting in soil formation: A critical literature review. *Geoderma* **2010**, *157*, 65–79. [CrossRef]
8. Dlamini, C.S. Contribution of Forest Ecosystem Services Toward Food Security and Nutrition. In *Zero Hunger*; Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T., Eds.; Encyclopedia of the UN Sustainable Development Goals; Springer International Publishing: Cham, Switzerland, 2020; pp. 179–196.
9. Burgess, J.C. Timber Production, Timber Trade and Tropical Deforestation. *Ambio* **1993**, *22*, 136–143.
10. Begossi, A.; Hanazaki, N.; Tamashiro, J.Y. Medicinal Plants in the Atlantic Forest (Brazil): Knowledge, Use, and Conservation. *Hum. Ecol.* **2002**, *30*, 281–299. [CrossRef]

11. Caniago, I.; Stephen, F.S. Medicinal plant ecology, knowledge and conservation in Kalimantan, Indonesia. *Econ. Bot.* **1998**, *52*, 229–250. [CrossRef]
12. Vatandaşlar, C.; Yavuz, M.; Leuchner, M. Erosion Control Service of Forest Ecosystems: A Case Study from Northeastern Turkey. In *Smart Geography: 100 Years of the Bulgarian Geographical Society*; Nedkov, S., Zhelezov, G., Ilieva, N., Nikolova, M., Koulov, B., Naydenov, K., Dimitrov, S., Eds.; Key Challenges in Geography; Springer International Publishing: Cham, Switzerland, 2020; pp. 443–455.
13. Calder, I.R.; Aylward, B. Forest and Floods. *Water Int.* **2006**, *31*, 87–99. [CrossRef]
14. Lee, H.-H. Estimations on the Water Purification of Forest by Analyzing Water Quality Variations in Forest Hydrological Processes. *J. Korean Soc. For. Sci.* **1997**, *86*, 56–68.
15. Vilhar, U. Water Regulation and Purification. In *The Urban Forest: Cultivating Green Infrastructure for People and the Environment*; Pearlmutter, D., Calfapietra, C., Samson, R., O'Brien, L., Krajter Ostoić, S., Sanesi, G., Alonso del Amo, R., Eds.; Future City; Springer International Publishing: Cham, Switzerland, 2017; pp. 41–47.
16. Song, C.; Lee, W.-K.; Choi, H.-A.; Kim, J.; Jeon, S.W.; Kim, J.S. Spatial assessment of ecosystem functions and services for air purification of forests in South Korea. *Environ. Sci. Policy* **2016**, *63*, 27–34. [CrossRef]
17. Taki, H.; Kevan, P.G.; Ascher, J.S. Landscape effects of forest loss in a pollination system. *Landsc. Ecol.* **2007**, *22*, 1575–1587. [CrossRef]
18. Reid, W.V.; Mooney, H.A.; Cropper, A.; Capistrano, D.; Carpenter, S.R.; Chopra, K.; Dasgupta, P.; Dietz, T.; Duraiappah, A.K.; Hassan, R.; et al. *Millenium Ecosystem Assessment: Ecosystems and Human Well-Being*; Island Press: Washington, DC, USA, 2005; p. 155.
19. Ji, L.; Wang, Z.; Wang, X.; An, L. Forest Insect Pest Management and Forest Management in China: An Overview. *Environ. Manag.* **2011**, *48*, 1107–1121. [CrossRef] [PubMed]
20. Erbaugh, J.T.; Nurrochmat, D.R. Paradigm shift and business as usual through policy layering: Forest-related policy change in Indonesia (1999–2016). *Land Use Policy* **2019**, *86*, 136–146. [CrossRef]
21. Baskent, E.Z. A Framework for Characterizing and Regulating Ecosystem Services in a Management Planning Context. *Forests* **2020**, *11*, 102. [CrossRef]
22. KKP. Laut Masa Depan Bangsa, Mari Jaga Bersama. Available online: https://kkp.go.id/artikel/12981-laut-masa-depan-bangsa-mari-jaga-bersama (accessed on 12 August 2022).
23. Sunderlin, W.D.; Pradnja Resosudarmo, I.A. *Rates and Causes of Deforestation in Indonesia: Towards a Resolution of the Ambiguities*; CIFOR: Bogor, Indonesia, 1996.
24. Margono, B.A.; Potapov, P.V.; Turubanova, S.; Stolle, F.; Hansen, M.C. Primary forest cover loss in Indonesia over 2000–2012. *Nat. Clim. Chang.* **2014**, *4*, 730–735. [CrossRef]
25. Austin, K.G.; Schwantes, A.; Gu, Y.; Kasibhatla, P.S. What causes deforestation in Indonesia? *Environ. Res. Lett.* **2019**, *14*, 024007. [CrossRef]
26. Ministry of Environment and Forestry. *The State of Indonesia's Forests 2020*; Ministry of Environment and Forestry: Jakarta, Indonesia, 2021; p. 118.
27. Chen, B.; Kennedy, C.M.; Xu, B. Effective moratoria on land acquisitions reduce tropical deforestation: Evidence from Indonesia. *Environ. Res. Lett.* **2019**, *14*, 044009. [CrossRef]
28. KLHK. *Operational Plan Indonesia's FOLU Net Sink 2030*; Kemeterian Lingkungan Hidup dan Kehutanan: Jakarta, Indonesia, 2022.
29. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being*; Island Press United States of America: Washington, DC, USA, 2005; Volume 5.
30. Luck, G.W.; Daily, G.C.; Ehrlich, P.R. Population diversity and ecosystem services. *Trends Ecol. Evol.* **2003**, *18*, 331–336. [CrossRef]
31. Wood, S.L.R.; Jones, S.K.; Johnson, J.A.; Brauman, K.A.; Chaplin-Kramer, R.; Fremier, A.; Girvetz, E.; Gordon, L.J.; Kappel, C.V.; Mandle, L.; et al. Distilling the role of ecosystem services in the Sustainable Development Goals. *Ecosyst. Serv.* **2018**, *29*, 70–82. [CrossRef]
32. Piponiot, C.; Rutishauser, E.; Derroire, G.; Putz, F.E.; Sist, P.; West, T.A.P.; Descroix, L.; Guedes, M.C.; Coronado, E.N.H.; Kanashiro, M.; et al. Optimal strategies for ecosystem services provision in Amazonian production forests. *Environ. Res. Lett.* **2019**, *14*, 124090. [CrossRef]
33. Price, C. Regulating and supporting services and disservices: Customary approaches to valuation, and a few surprising case-study results. *N. Z. J. For. Sci.* **2014**, *44*, S5. [CrossRef]
34. Achyani, A. Struktur dan komposisi tumbuhan pada habitat bunga bangkai (*Amorphophallus titanium* Becc.) di cagar alam pagar gunung kepahiang Bengkulu. *Biolova* **2021**, *2*, 26–33.
35. Usmadi, D. Potensi distribusi Agathis borneensis di Provinsi Kalimantan Tengah. *Proc. Pros Sem Masy Biodiv Indon* **2019**. [CrossRef]
36. Robiansyah, I.; Davy, A.J. Population status and habitat preferences of critically endangered Dipterocarpus littoralis in West Nusakambangan, Indonesia. *Makara J. Sci.* **2015**, *19*, 4. [CrossRef]
37. Mansur, M.; Brearley, F.Q.; Esseen, P.J.; Rode-Margono, E.J.; Tarigan, M.R.M. Ecology of Nepenthes clipeata on Gunung Kelam, Indonesian Borneo. *Plant Ecol. Divers.* **2021**, *14*, 195–204. [CrossRef]
38. Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; da Fonseca, G.A.; Kent, J. Biodiversity hotspots for conservation priorities. *Nature* **2000**, *403*, 853–858. [CrossRef]

39. Meijaard, E.; Nijman, V. Primae hotspots on Borneo: Predictive value for general biodiversity and the effects of taxonomy. *Conserv. Biol.* **2003**, *17*, 725–732. [CrossRef]
40. Putri, I.A. Submontane Forest at Bantimurung Bulusaraung National Park: Hotspot of Bird Diversity and Its Management Conservation. *J. Penelit. Kehutan. Wallacea* **2015**, *4*, 115–128. [CrossRef]
41. Persulessy, Y.E.; Putuhena, J. Keragaman dan Populasi Burung Endemik pada Hotspot Kesatuan Pengelolaan Hutan Produksi Wae Sapalewa Seram Utara. *MAKILA J. Penelit. Kehutan.* **2020**, *14*, 99–113. [CrossRef]
42. Verma, M.; Symes, W.S.; Watson, J.E.; Jones, K.R.; Allan, J.R.; Venter, O.; Rheindt, F.E.; Edwards, D.P.; Carrasco, L.R. Severe human pressures in the Sundaland biodiversity hotspot. *Conserv. Sci. Pract.* **2020**, *2*, e169. [CrossRef]
43. Setiasih, G.; Rianti, A.; Takandjandji, M. Potensi vegetasi dan daya dukung untuk habitat gajah Sumatera (*Elephas maximus sumatranus*) di areal perkebunan sawit dan hutan produksi Kecamatan Sungai Menang, Kabupaten Ogan Komering Ilir. *Ber. Biol.* **2018**, *17*, 49–64. [CrossRef]
44. Abdullah, A.; Japisa, T. Karakteristik habitat gajah Sumatera *(Elephas maximus sumatranus* Temminck) pada habitat terganggu di ekosistem hutan Seulawah. *J. Edubio Trop.* **2013**, *1*, 57–60.
45. Hadadi, O.H.; Hartono, H.; Haryono, E. Analisis Potensi Habitat dan Koridor Harimau Sumatera di Kawasan Hutan Lindung Bukit Batabuh, Kabupaten Kuantan Singingi, Provinsi Riau. *Maj. Geogr. Indones.* **2015**, *29*, 40–50. [CrossRef]
46. Muslim, A.; Nurdjali, B.; Dewantara, I. Studi habitat dan jenis pakan badak Sumatera (*Dicerorhinus sumatrensis*) di Kutai Barat Dan Mahakam Ulu Kalimantan Timur. *J. Hutan Lestari* **2015**, *3*, 6. [CrossRef]
47. Putro, H.R. Heterogenitas habitat badak Jawa (*Rhinoceros sondaicus* Desm. 1822) di Taman Nasional Ujung Kulon. *Media Konserv. Ed. Khusus* **1997**, *1997*, 17–40.
48. Sucipto, N. *Struktur Dan Komposisi Vegetasi Habitat Kuskus Beruang (Ailurop Ursinus) di Kawasan Hutan Desa Peana Kecamatan Pipikoro Kabupaten Sigi*; Universitas Tadulako: Palu, Indonesia, 2020.
49. Pranowo, S. *Kepadatan Mamalia Kecil Nokturnal Arboreal di Kantong Habitat Hutan Kemuning Kabupaten Temanggung*; Universitas Gadjah Mada: Yogyakarta, Indonesia, 2018.
50. Kartono, A.P.; Ginting, A.; Santoso, N. Karakteristik Habitat dan Wilayah Jelajah Bekantan di Hutan Mangrove Desa Nipah Panjang Kecamatan Batu Ampar Kabupaten Kubu Raya Provinsi Kalimantan Barat. *Media Konserv.* **2008**, *13*. [CrossRef]
51. Harisin, Y.A. *Sebaran dan Penggunaan Habitat Elang Jawa dan Elang Brontok di SPTN I Kuningan, Taman Nasional Gunung Ciremai*; Institut Pertanian Bogor: Bogor, Indonesia, 2021.
52. Riyanto, A.; Soemarno, S.; Wawangningrum, H.; Partomihardjo, T. Karakteristik habitat kura-kura hutan Sulawesi berstatus kritis *Leucocephalon yuwonoi* di Kawasan Sungai Ganonggol Dan Bangkir, Sulawesi Tengah. *Indones. J. Biol.* **2006**, *4*, 78354. [CrossRef]
53. Perikanan, K.K.d. *Ikan Air Tawar Langka di Indonesia*; Direktorat Konservasi Kawasan dan Jenis Ikan: Jakarta, Indonesia, 2012.
54. Nasution, F.; Prastyaningsih, S.R.; Ikhwan, M. Identifikasi jenis dan habitat jamur makroskopis di Hutan Larangan Adat Rumbio Kabupaten Kampar Provinsi Riau. *Wahana For. J. Kehutan.* **2018**, *13*, 64–76. [CrossRef]
55. Wati, R.; Noverita, N.; Setia, T.M. Keanekaragaman jamur makroskopis di beberapa habitat Kawasan Taman Nasional Baluran. *Al-Kauniyah J. Biol.* **2019**, *12*, 171–180. [CrossRef]
56. Kasongat, H.; Gafur, M.A.; Ponisri, P. Identifikasi dan keanekaragaman jenis jamur ektomikoriza pada hutan jati di Seram Bagian Timur. *Median: J. Ilmu Ilmu Eksakta* **2019**, *11*, 39–46. [CrossRef]
57. Kiding, A.; Khotimah, S.; Linda, R. Karakterisasi dan kepadatan bakteri nitrifikasi pada tingkat kematangan tanah gambut yang berbeda di kawasan hutan lindung Gunung Ambawang Kabupaten Kubu Raya. *J. Protobiont* **2015**, *4*, 5. [CrossRef]
58. Nurrochman, F. *Eksplorasi Bakteri Selulolitik Dari Tanah Hutan Mangrove Baros, Kretek, Bantul, Yogyakarta*; Universitas Muhammadiyah Surakarta: Surakarta, Indonesia, 2015.
59. Yusnia, E.D.; Gunam, I.B.W.; Antara, N.S. Isolasi dan skrining bakteri selulolitik dari beberapa tanah hutan di Bali. *J. Rekayasa Dan Manaj. Agroindustri* **2019**, *2503*, 488X. [CrossRef]
60. Mongabay. List of Extinct Species in Indonesia. Available online: https://rainforests.mongabay.com/biodiversity/en/indonesia/EX.html (accessed on 16 June 2022).
61. Widyasari, W.B.; Putra, L.K.; Ranomahera, M.R.R.; Puspitasari, A.R. Historical notes, germplasm development, and molecular approaches to support sugarcane breeding program in Indonesia. *Sugar Tech* **2022**, *24*, 30–47. [CrossRef]
62. Prana, M.; Hartati, S.; Prana, T. A study on isozyme variation in the Indonesian taro (*Colocasia* spp.) germplasm collection. *Glob. Divers. Taro* **2010**, 56–59. Available online: https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=g7lPA80AAAAJ&citation_for_view=g7lPA80AAAAJ:2osOgNQ5qMEC (accessed on 16 June 2022).
63. Mirza, I.; Yusriani, Y.; Azis, A. Plasma nutfah dan pelestarian sapi Aceh. In Proceedings of the Prosiding Seminar dan Kongres Nasional Sumber Daya Genetik, Medan, Indonesia, 12–14 December 2012.
64. Febrialdi, A. Kondisi Beberapa Plasma Nutfah Non Kayu Disekitar Hutan Kecamatan Rantau Pandan Muara Bungo. *J. Sains Agro* **2017**, *2*, 11.
65. Galingging, R.Y. Potensi plasma nutfah tanaman obat sebagai sumber biofarmaka di Kalimantan Tengah. *J. Pengkaj. Dan Pengemb. Teknol. Pertan.* **2007**, *10*, 76–83.
66. Fatimah, F.; Rahayu, R.; Wiwoho, J.; Firdaus, S.U.; Pujiyono, P.; Marimin, M.; Ariyanto, D.P.; Pramono, A. Genetic diversity of eucalypts for germplasm conservation in Forest Area with the Special Purpose of Mount Bromo, Karanganyar, Indonesia. *Biodivers. J. Biol. Divers.* **2021**, *22*, 13. [CrossRef]

67. Berding, N.; Koike, H. Germplasm conservation of the Saccharum complex: A collection from the Indonesian archipelago. *Hawaii. Plant. Rec.* **1980**, *59*, 87–176.
68. Sumarlin, D.; Dirhamsyah, M.; Ardian, H. Identifikasi tumbuhan sumber pangan di Hutan Tembawang Desa Aur Sampuk Kecamatan Sengah Temila Kabupaten Landak. *J. Hutan Lestari* **2015**, *4*, 8.
69. Fitmawati, F.; Suwita, A.; Sofiyanti, N.; Herman, H. Eksplorasi dan Karakterisasi Keanekaragaman Plasma Nutfah Mangga (Mangifera) di Sumatera Tengah. In Proceedings of the Prosiding SEMIRATA 2013, Lampung, Indonesia, 10–12 May 2013.
70. Uji, T. Keanekaragaman jenis dan sumber plasma nutfah Durio (*Durio* spp.) di Indonesia. *Bul. Plasma Nutfah* **2005**, *11*, 28–33.
71. Widowati, D.A.H. Inventarisasi Keanekaragaman Anggrek (*Orchidaceae*) di Hutan Resort Way Kanan Balai Aman Nasional Way Kambas Sebagai Sumber Informasi dalam Melestarikan Plasma Nutfah. *Bioedukasi (J. Pendidik. Biol.)* **2015**, *6*. [CrossRef]
72. Siregar, C. Exploration and inventory of native orchid germplasm in West Borneo, Indonesia. *HortScience* **2008**, *43*, 554–557. [CrossRef]
73. Sjafani, N. *Studi Habitat dan Pengembangbiakan Burung Mamoa (Eulipoa wallacei) Sebagai Upaya Konservasi Plasma Nutfah Kabupaten Halmahera Utara*; Universitas Brawijaya: Malang, Indonesia, 2015.
74. Tyapradana, D.O. *Evaluasi Implementasi Program Kawin Semi Alami Sebagai Upaya Peningkatan Jumlah Populasi Dan Kelestarian Plasma Nutfah Banteng Jawa (Bos javanicus) di Taman Nasional Baluran*; Universitas Brawijaya: Malang, Indonesia, 2017.
75. Kurniawanto, A. Studi Perilaku Badak Sumatera (*Dicerorhinus sumatrensis* Fischer, 1814) di Suako Rhino Sumatera Taman Nasional Way Kambas Lampung. Undergraduate Thesis, Faculty of Forestry, IPB University, Bogor, Indonesia, 2007.
76. Ramdaniah, Y. *Studi Kualitas Tanah Pada Tipe Penutupan Lahan Hutan Alam, Hutan Pinus Dan Padang Rumput di Sub das Curug Cilember, Cisarua, Bogor*; IPB University: Bogor, Indonesia, 2001.
77. Lapadjati, K.K.; Wardah, W.; Rahmawati, R. Sifat fisik tanah pada hutan tanaman kemiri, lahan agroforestri dan lahan hutan sekunder di Desa Labuan Kungguma Kabupaten Donggala Sulawesi Tengah. *J. War. Rimba* **2016**, *4*, 6.
78. Aini, Z.Z.; Khasanah, N.m.; Kusuma, Z. Degradasi sifat fisik tanah sebagai akibat alih guna lahan hutan menjadi sistem kopi monokultur: Kajian perubahan makroporositas tanah. *Agrivita* **2004**, *26*, 60–68.
79. Diana, A. Kajian Sifat Fisika Tanah Akibat Alih Fungsi Lahan dari Hutan Primer dan Kebun Karet (*Havea brasiliensis*) Menjadi Kebun Kopi Robusta (*Coffea canephora*) di Nagari Sibakur Kabupaten Sijunjung. Undergraduate Thesis, Soil Science Department, Faculty of Agriculture, Andalas University, Padang, Indonesia, 2021.
80. Anggara, S.A. Kajian Sifat Fisika Tanah Pada Beberapa Penggunaan Lahan di Hulu DAS Batang Kandis. Undergraduate Thesis, Department of Soil Science, Faculty of Agriculture, Andalas University, Padang, Indonesia, 2021.
81. Alfiani, B.P. Analisis Sifat Fisika Tanah dan Laju Infiltrasi pada Berbagai Penggunaan Lahan. Undergraduate Thesis, IPB University, Bogor, Indonesia, 2019.
82. Wasis, B. Dampak Kebakaran Hutan dan Lahan terhadap Kerusakan Tanah. *J. Manaj. Hutan Trop.* **2003**, *9*, 79–86.
83. Murtinah, V.; Edwin, M.; Bane, O. Dampak kebakaran hutan terhadap sifat fisik dan kimia tanah di Taman Nasional Kutai, Kalimantan Timur. *J. Pertan. Terpadu* **2017**, *5*, 128–139. [CrossRef]
84. Wasis, B.; Saharjo, B.H.; Waldi, R.D. Dampak kebakaran hutan terhadap flora dan sifat tanah mineral di kawasan hutan Kabupaten Pelalawan Provinsi Riau. *J. Silvikultur Trop.* **2019**, *10*, 40–44. [CrossRef]
85. Greiner, L.; Keller, A.; Grêt-Regamey, A.; Papritz, A. Soil function assessment: Review of methods for quantifying the contributions of soils to ecosystem services. *Land Use Policy* **2017**, *69*, 224–237. [CrossRef]
86. Gerzabek, M.H. Global soil use in biomass production: Opportunities and challenges of ecological and sustainable intensification in agriculture. *Bodenkultur* **2014**, *65*, 5–15.
87. Silver, W.L.; Perez, T.; Mayer, A.; Jones, A.R. The role of soil in the contribution of food and feed. *Philos. Trans. R. Soc. B Biol. Sci.* **2021**, *376*, 20200181. [CrossRef] [PubMed]
88. De Deyn, G.B.; Kooistra, L. The role of soils in habitat creation, maintenance and restoration. *Philos. Trans. R. Soc. B Biol. Sci.* **2021**, *376*, 20200170. [CrossRef] [PubMed]
89. Lal, R.; Monger, C.; Nave, L.; Smith, P. The role of soil in regulation of climate. *Philos. Trans. R. Soc. B Biol. Sci.* **2021**, *376*, 20210084. [CrossRef]
90. Smith, J.; Farmer, J.; Smith, P.; Nayak, D. The role of soils in provision of energy. *Philos. Trans. R. Soc. B Biol. Sci.* **2021**, *376*, 20200180. [CrossRef]
91. Jónsson, J.Ö.G.; Davídsdóttir, B. Classification and valuation of soil ecosystem services. *Agric. Syst.* **2016**, *145*, 24–38. [CrossRef]
92. Widyati, E.; Siarudin, M.; Indrajaya, Y. The Dynamic of Functional Microbes Community Under Auri (*Acacia auriculiformis* Cunn. Ex Benth) Agroforestry System. *J. Manaj. Hutan Trop.* **2022**, *28*, 119–127. [CrossRef]
93. Dixon, G.R.; Tilston, E.L. *Soil Microbiology and Sustainable Crop Production*; Springer Science & Business Media: Berlin, Germany, 2010; pp. 1–436.
94. Hobara, S.; Osono, T.; Hirose, D.; Noro, K.; Hirota, M.; Benner, R. The roles of microorganisms in litter decomposition and soil formation. *Biogeochemistry* **2014**, *118*, 471–486. [CrossRef]
95. Krashevska, V.; Malysheva, E.; Klarner, B.; Mazei, Y.; Maraun, M.; Widyastuti, R.; Scheu, S. Micro-decomposer communities and decomposition processes in tropical lowlands as affected by land use and litter type. *Oecologia* **2018**, *187*, 255–266. [CrossRef]
96. Talukder, M.J.H.; Sun, H. The microbial diversity and structure in peat land forest in Indonesia. *J. Biodivers. Conserv. Bioresour. Manag.* **2019**, *5*, 133–144. [CrossRef]

97. Yulma; Ihsan, B.; Awaludin; Zainuddin; Bija, S.; Rani, M.; Andira, A.; Ramadani, F.; Sunarti. Identification of bacteria from mangrove forest in Mamburungan, Tarakan City. *IOP Conf. Ser. Earth Environ. Sci.* **2020**, *564*, 012020. [CrossRef]
98. Sasongko, P.E. Land Use Change and Soil Quality in the West Slope of Bromo Mountain, East Java, Indonesia. *Nusant. Sci. Technol. Proc.* **2018**, *2017*, 160–165. [CrossRef]
99. Jamnadass, R.H.; McMullin, S.; Iiyama, M.; Dawson, I.K.; Powell, B.; Termote, C.; Ickowitz, A.; Kehlenbeck, K.; Vinceti, B.; Vliet, N.v.; et al. Understanding the roles of forests and tree-based systems in food provision. *For. Trees Landsc. Food Secur. Nutr. A Glob. Assess. Rep.* **2015**, *2*, 24.
100. Farooqi, T.J.A.; Li, X.; Yu, Z.; Liu, S.; Sun, O.J. Reconciliation of research on forest carbon sequestration and water conservation. *J. For. Res.* **2021**, *32*, 7–14. [CrossRef]
101. Zhang, W.; Ricketts, T.H.; Kremen, C.; Carney, K.; Swinton, S.M. Ecosystem services and dis-services to agriculture. *Ecol. Econ.* **2007**, *64*, 253–260. [CrossRef]
102. Ghaley, B.B.; Porter, J.R.; Sandhu, H.S. Soil-based ecosystem services: A synthesis of nutrient cycling and carbon sequestration assessment methods. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* **2014**, *10*, 177–186. [CrossRef]
103. Rahma, N.E.; Rositah, E.; Pramono, D.A.; Widyasasi, D.; Fariyanti, F. Valuasi jasa lingkungan hutan tropis: Studi kasus beberapa kampung di Kalimantan Timur. *J. Ris. Pembang.* **2020**, *2*, 67–78. [CrossRef]
104. Wang, D.; Xu, A.; Elmerich, C.; Ma, L.Z. Biofilm formation enables free-living nitrogen-fixing rhizobacteria to fix nitrogen under aerobic conditions. *ISME J.* **2017**, *11*, 1602–1613. [CrossRef]
105. Baset Mia, M.A.; Shamsuddin, Z.H. Nitrogen fixation and transportation by rhizobacteria: A scenario of rice and banana. *Int. J. Bot.* **2010**, *6*, 235–242. [CrossRef]
106. Ezawa, T.; Saito, K. How do arbuscular mycorrhizal fungi handle phosphate? New insight into fine-tuning of phosphate metabolism. *New Phytol.* **2018**, *220*, 1116–1121. [CrossRef]
107. Zhang, Y.; Li, Y.; Wang, S.; Umbreen, S.; Zhou, C. Soil phosphorus fractionation and its association with soil phosphate-solubilizing bacteria in a chronosequence of vegetation restoration. *Ecol. Eng.* **2021**, *164*, 106208. [CrossRef]
108. Chakravarty, S.; Rai, P.; Vineeta; Pala, N.A.; Shukla, G. Litter Production and Decomposition in Tropical Forest. In *Handbook of Research on the Conservation and Restoration of Tropical Dry Forests*; IGI Global: Hershey, PA, USA, 2019; pp. 193–212. [CrossRef]
109. Mekuria, W.; Veldkamp, E.; Tilahun, M.; Olschewski, R. Economic valuation of land restoration: The case of exclosures established on communal grazing lands in Tigray, Ethiopia. *Land Degrad. Dev.* **2011**, *22*, 334–344. [CrossRef]
110. Warningsih, T.; Kusai, K.; Bathara, L.; Zulkarnain, Z.; Deviasari, D. Economic Valuation of Mangrove Ecosystem Services in Sungai Apit District, Siak Regency, Riau Province, Indonesia. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *695*, 012036. [CrossRef]
111. Lee, E.P.; Lee, S.I.; Jeong, H.M.; Han, Y.S.; Lee, S.Y.; Park, J.H.; Jang, R.H.; Hong, Y.S.; Jung, Y.H.; Kim, E.J.; et al. Valuation of ecosystem services in the organic carbon of the Pinus densiflora forest at Mt. Namsan, Seoul Metropolitan City. *J. Ecol. Environ.* **2019**, *43*, 1–11. [CrossRef]
112. Vermeulen, S.; Wellesley, L.; Airey, S.; Singh, S.; Agustina, R.; Izwardy, D.; Saminarsih, D. *Healthy Diets from Sustainable Production: Indonesia*; Chatham House and Hoffman Centre for Sustainable Resource Economy: Jakarta, Indonesia, 2019.
113. Suwardi, A.B.; Zidni Ilman, N.; Tisna, H.; Syamsuardi; Erizal, M. Ethnobotany and conservation of indigenous edible fruit plants in South Aceh, Indonesia. *Biodivers. J. Biol. Divers.* **2020**, *21*, 1850–1860. [CrossRef]
114. Andesmora, E.; Muhadiono, M.; Hilwan, I. Ethnobotanical Study of Plants Used by People in Hiang Indigenous Forest Kerinci, Jambi. *J. Trop. Life Sci.* **2017**, *7*, 95–101. [CrossRef]
115. Fathurahman, F.; Nursanto, J.; Madjid, A.; Ramadanil, R. Ethnobotanical Study of "Kaili Inde Tribe" in Central Sulawesi Indonesia. *Emir. J. Food Agric.* **2016**, *28*, 337–347. [CrossRef]
116. Susandarini, R.; Khasanah, U.; Rosalia, N. Ethnobotanical study of plants used as food and for maternal health care by the Malays communities in Kampar Kiri Hulu, Riau, Indonesia. *Biodivers. J. Biol. Divers.* **2021**, *22*, 3111–3120. [CrossRef]
117. Hartoyo, A.P.P.; Supriyanto, S.; Siregar, I.Z.; Theilade, I.D.A.; Prasetyo, L.B. Agroforest diversity and ethnobotanical aspects in two villages of Berau, East Kalimantan, Indonesia. *Biodivers. J. Biol. Divers.* **2018**, *19*, 387–398. [CrossRef]
118. Trimanto; Danarto, S.A.; Ashrafuzzaman, M. Ethnobotanical uses of plants by Brangkuah Community of Moyo Island, West Nusa Tenggara, Indonesia: Ethnobotanical use of plants in Indonesia. *J. Bangladesh Agric. Univ.* **2019**, *17*, 325–337. [CrossRef]
119. Waroy, H.F.; Utami, S.; Jumari. The food plant ethnobotany of Ampari tribe community in Papua, Indonesia. *J. Phys. Conf. Ser.* **2020**, *1524*, 012074. [CrossRef]
120. Sukenti, K.; Hakim, L.; Indriyani, S.; Purwanto, Y.; Matthews, P.J. Ethnobotanical study on local cuisine of the Sasak tribe in Lombok Island, Indonesia. *J. Ethn. Foods* **2016**, *3*, 189–200. [CrossRef]
121. Rahayu, M.; Susiarti, S.; Sihotang, V.B.L. A preliminary ethnobotanical study on useful plants by local communities in Bodogol Lowland Forest, Sukabumi, West Java. *J. Trop. Biol. Conserv. (JTBC)* **2012**, *9*, 115–125.
122. Navia, Z.I.; Audira, D.; Afifah, N.; Turnip, K.; Nuraini, N.; Suwardi, A.B. Ethnobotanical investigation of spice and condiment plants used by the Taming tribe in Aceh, Indonesia. *Biodivers. J. Biol. Divers.* **2020**, *21*, 4467–4473. [CrossRef]
123. Pawera, L.; Khomsan, A.; Zuhud, E.A.M.; Hunter, D.; Ickowitz, A.; Polesny, Z. Wild Food Plants and Trends in Their Use: From Knowledge and Perceptions to Drivers of Change in West Sumatra, Indonesia. *Foods* **2020**, *9*, 1240. [CrossRef]
124. Utami, S. Keanekaragaman Tumbuhan yang Berpotensi sebagai Bahan Pangan di Hutan Lindung Pulau Panjang Jepara Jawa Tengah. *Bioma Berk. Ilm. Biol.* **2018**, *19*, 136–140. [CrossRef]

125. Mulu, M.; Zephisius, R.E.N.; Petrus, S.I.I.; Hildegardis, M. Ethnobotanical knowledge and conservation practices of indigenous people of Mbeliling Forest Area, Indonesia. *Biodivers. J. Biol. Divers.* **2020**, *21*, 1861–1873. [CrossRef]
126. Piesse, M. Food security in Indonesia: A continued reliance on foreign markets. *Indep. Strateg. Anal. Aust. Glob. Interests* **2016**. Available online: http://inford.org/food-security-in-indonesia-a-continued-reliance-on-foreign-markets/ (accessed on 16 June 2022).
127. Richardson, R.B. Ecosystem Services and Food Security: Economic Perspectives on Environmental Sustainability. *Sustainability* **2010**, *2*, 3520–3548. [CrossRef]
128. Boseren, M.; Weterings, R. *Sago Palm: A Sustainable Solution for Food Security and Peat Conservation in Indonesia*; FORCLIME Forests and Climate Change Programme: Jakarta, Indonesia, 2021. Available online: https://forclime.org/documents/Briefing%20Note/English/Policy%20Brief%20-%20Sago%20Palm.pdf (accessed on 16 June 2022).
129. Sudomo, A.; Hani, A.; Agus, C.; Nugroho, A.W.; Utomo, M.M.B.; Indrajaya, Y. Intensification of Agroforestry Systems in Community Forests to Increase Land Productivity and Sustainable Food Sovereignty. In *Sustainable Agriculture and Food Security*; Leal Filho, W., Kovaleva, M., Popkova, E., Eds.; Springer International Publishing: Cham, Switzerland, 2022; pp. 183–199.
130. Ministry of Environment and Forestry. *Performance Report 2020 of Ministry of Environment and Forestry*; Ministry of Environment and Forestry: Jakarta, Indonesia, 2021; p. 315.
131. Maskun; Napang, M.; Nur, S.; Bachril, S.; Al Mukarramah, N. Detrimental impact of Indonesian food estate policy: Conflict of norms, destruction of protected forest, and its implication to the climate change. In *Proceedings of the IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bogor, Indonesia, 2021; p. 012097. [CrossRef]
132. Marwanto, S.; Pangestu, F. Food estate program in Central Kalimantan Province as an integrated and sustainable solution for food security in Indonesia. In *Proceedings of the IOP Conference Series: Earth and Environmental Scienc*; IOP Publishing: Bogor, Indonesia, 2021; p. 012068. [CrossRef]
133. Yeny, I.; Garsetiasih, R.; Suharti, S.; Gunawan, H.; Sawitri, R.; Karlina, E.; Narendra, B.H.; Ekawati, S.; Djaenudin, D.; Rachmanadi, D. Examining the socio-economic and natural resource risks of food estate development on peatlands: A strategy for economic recovery and natural resource sustainability. *Sustainability* **2022**, *14*, 3961. [CrossRef]
134. Farnsworth, N.R.; Akerele, O.; Bingel, A.S.; Soejarto, D.D.; Guo, Z. *Medicinal Plants in Therapy*; World Health Organization: Geneva, Switzerland, 1985; p. 965.
135. Afdhal, A.F.; Welsch, R.L. The Rise of the Modern Jamu Industry in Indonesia: A Preliminary Overview. In *The Context of Medicines in Developing Countries: Studies in Pharmaceutical Anthropology*; van der Geest, S., Whyte, S.R., Eds.; Springer: Dordrecht, The Netherlands, 1988; pp. 149–172.
136. User, M.; Kusumaputri, V.S.; Hendrix, T. Bioprospection of traditional medicinal plants in increasing potential of traditional wisdom-based local drugs. *J. Kelitbangan Inov. Pembang.* **2016**, *4*, 133–146.
137. Sholikhah, E.N. Indonesian medicinal plants as sources of secondary metabolites for pharmaceutical industry. *J. Med. Sci.* **2016**, *48*, 226–239. [CrossRef]
138. Herika Jennifer, E.S. Preferensi Individu Terhadap Pengobatan Tradisional di Indonesia. *J. Ekon. Dan Studi Pembang.* **2015**, *16*, 1.
139. Dwiartama, A.; Purnamahati, R.R.; Pramudya, A.A. *Policy Brief Arah Pengembangan Bioprospecting di Indonesia*; KEHATI: Jakarta Selatan, Indonesia, 2020. Available online: https://kehati.or.id/wp-content/uploads/2021/02/Policy-Brief-Arah-Pengembangan-Bioprospecting-di-Indonesia.pdf (accessed on 16 June 2022).
140. Balvanera, P.; Quijas, S.; Karp, D.S.; Ash, N.; Bennett, E.M.; Boumans, R.; Brown, C.; Chan, K.M.A.; Chaplin-Kramer, R.; Halpern, B.S.; et al. Ecosystem Services. In *The GEO Handbook on Biodiversity Observation Networks*; Walters, M., Scholes, R.J., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 39–78.
141. Rad, M.F.; Fröling, M.; Grönlund, E. Including ecosystem services in sustainability assessment of forest biofuels. In Proceedings of the World Bioenergy, Jönköping, Sweden, 29–31 May 2012; pp. 75–78.
142. Gasparatos, A.; Stromberg, P.; Takeuchi, K. Biofuels, ecosystem services and human wellbeing: Putting biofuels in the ecosystem services narrative. *Agric. Ecosyst. Environ.* **2011**, *142*, 111–128. [CrossRef]
143. McBride, A.C.; Dale, V.H.; Baskaran, L.M.; Downing, M.E.; Eaton, L.M.; Efroymson, R.A.; Garten, C.T.; Kline, K.L.; Jager, H.I.; Mulholland, P.J.; et al. Indicators to support environmental sustainability of bioenergy systems. *Ecol. Indic.* **2011**, *11*, 1277–1289. [CrossRef]
144. Joly, C.; Verdade, L.; Huntley, B.; Dale, V.; Mace, G.; Muok, B.; Ravindranath, N.H. Biofuel impacts on biodiversity and ecosystem services. In *Bioenergy & Sustainability: Bridging the Gaps*; Souza, G.M., Victoria, R.L., Joly, C.A., Verdade, L.M., Eds.; SCOPE: Sao Paulo, Brazil, 2015; Volume 72, pp. 548–574.
145. Putrasari, Y.; Praptijanto, A.; Santoso, W.B.; Lim, O. Resources, policy, and research activities of biofuel in Indonesia: A review. *Energy Rep.* **2016**, *2*, 237–245. [CrossRef]
146. Effendi, R.; Roffandi, N.; Puspitodjati, T.; Bangsawan, I. Menggagas Energi Biomassa Hutan Sebagai Sumber Energi Terbarukan. *Penelit. Dan Pengemb. Sos. Ekon. Kebijak. Dan Perubahan Iklim* **2018**, *11*, 1–5.
147. Central Bureau of Statistics. *Statistik Produksi Kehutanan*; Central Bureau of Statistics: Jakarta, Indonesia, 2020.
148. Suntana, A.S.; Vogt, K.A.; Turnblom, E.C.; Upadhye, R. Bio-methanol potential in Indonesia: Forest biomass as a source of bio-energy that reduces carbon emissions. *Appl. Energy* **2009**, *86*, S215–S221. [CrossRef]
149. Sarana Multi Infrastruktur. *PT SMI Insight—Q3 Reaching the Energy Mix Target through Bioenergy*; PT Sarana Multi Infrastruktur (Persero): Jakarta, Indonesia, 2017; pp. 1–13.

150. Yana, S.; Nizar, M.; Irhamni; Mulyati, D. Biomass waste as a renewable energy in developing bio-based economies in Indonesia: A review. *Renew. Sustain. Energy Rev.* **2022**, *160*, 112268. [CrossRef]
151. Mohammed, J. The Role of Genetic Diversity to Enhance Ecosystem Service. *Am. J. Biol. Environ. Stat.* **2019**, *5*, 46–51. [CrossRef]
152. Sembiring, L. Microbial diversity and its importance in microbial genetic resources preservation and its role in natural. *J. Biol. Res.* **2015**, *21*, 13–17. [CrossRef]
153. Wijayanti, M.; Meryandini, A.; Wahyudi, A.T.; Yuhana, M. Diversity and the Composition of Fatty Acids of Lipolytic Bacteria Isolated from Soil and Aquatic Sediment in a Forest and on an Oil Palm Plantation. *Makara J. Sci.* **2014**, *18*, 71–78. [CrossRef]
154. Sukara, E. Tropical Forest Biodiversity to Provide Food, Health and Energy Solution of the Rapid Growth of Modern Society. *Procedia Environ. Sci.* **2014**, *20*, 803–808. [CrossRef]
155. Lopez, S.; Goux, X.; van der Ent, A.; Erskine, P.D.; Echevarria, G.; Calusinska, M.; Morel, J.L.; Benizri, E. Bacterial community diversity in the rhizosphere of nickel hyperaccumulator species of Halmahera Island (Indonesia). *Appl. Soil Ecol.* **2019**, *133*, 70–80. [CrossRef]
156. Martínez, A.; Amri, A. *Managing Plant Genetic Resources in the Agro-Ecosystem: Global Change, Crop-Associated Biodiversity and Ecosystem Services*; FAO-ICARDA: Rome, Italy, 2008.
157. Swift, M.J.; Izac, A.M.N.; van Noordwijk, M. Biodiversity and ecosystem services in agricultural landscapes—Are we asking the right questions? *Agric. Ecosyst. Environ.* **2004**, *104*, 113–134. [CrossRef]
158. Priscoli, J.D. Linking ecosystem services and water security-SDGs offer a new opportunity for integration. *Glob. Water Partnersh. Perspect. Pap.* **2016**. Available online: https://www.gwp.org/globalassets/global/toolbox/publications/perspective-papers/gwp_pp_-ecosystemservices.pdf (accessed on 20 June 2022).
159. Carignan, R.; Steedman, R.J. Impacts of major watershed perturbations on aquatic ecosystems. *Can. J. Fish. Aquat. Sci.* **2000**, *57*, 1–4. [CrossRef]
160. Ceci, P. *Forest and Water: International Momentum and Action*; FAO: Rome, Italy, 2013.
161. Guo, Z.; Xiao, X.; Li, D. An assessment of ecosystem services: Water flow regulation and hydroelectric power production. *Ecol. Appl.* **2000**, *10*, 925–936. [CrossRef]
162. Grizzetti, B.; Lanzanova, D.; Liquete, C.; Reynaud, A.; Cardoso, A.C. Assessing water ecosystem services for water resource management. *Environ. Sci. Policy* **2016**, *61*, 194–203. [CrossRef]
163. Fakhriyah, F.; Yeyendra, Y.; Marianti, A. Integrasi Smart Water Management Berbasis Kearifan Lokal Sebagai Upaya Konservasi Sumber Daya Air di Indonesia. *Indones. J. Conserv.* **2021**, *10*, 34–41.
164. Fulazzaky, M.A. Challenges of integrated water resources management in Indonesia. *Water* **2014**, *6*, 2000–2020. [CrossRef]
165. ADB. *Indonesia Country Water Assessment*; Asian Development Bank: Manila, Philippines, 2016.
166. Piesse, M. Indonesian Water Security: Improving but Still Subject to Shocks. *Future Dir. Int.* **2016**. Available online: http://inford.org/indonesian-water-security-improving-but-still-subject-to-shocks/ (accessed on 20 June 2022).
167. Ardhianie, N. Coping with Water Scarcity in Indonesia. Available online: https://www.thejakartapost.com/news/2015/03/25/coping-with-water-scarcity-indonesia.html (accessed on 20 June 2022).
168. Nugroho, H.Y.; Indrawati, D.R.; Wahyuningrum, N.; Adi, R.N.; Supangat, A.B.; Indrajaya, Y.; Putra, P.B.; Cahyono, S.A.; Nugroho, A.W.; Basuki, T.M.; et al. Toward Water, Energy, and Food Security in Rural Indonesia: A Review. *Water* **2022**, *14*, 1645. [CrossRef]
169. Asdak, C. *Hidrologi dan Pengelolaan Daerah Aliran Sungai*; Gadjah Mada University Press: Yogyakarta, Indonesia, 2018.
170. Suryatmojo, H. *Peran Hutan Sebagai Penyedia Jasa Lingkungan*; Fakultas Kehutanan Universitas Gadjah Mada: Yogyakarta, Indonesia, 2006.
171. Suryatmojo, H. *Peran Hutan Pinus Sebagai Penyedia Jasa Lingkungan Melalui Penyimpanan Karbon dan Penyediaan Sumberdaya Air*; Hasil Penelitian: Yogyak, Indonesia, 2004.
172. Junaidi, E.; Tarigan, S.D. Pengaruh hutan dalam pengaturan tata air dan proses sedimentasi Daerah Aliran Sungai (DAS): Studi Kasus di DAS Cisadane. *J. Penelit. Hutan Dan Konserv. Alam* **2011**, *8*, 155–176. [CrossRef]
173. Scherr, S.J.; Shames, S.; Friedman, R. From climate-smart agriculture to climate-smart landscapes. *Agric. Food Secur.* **2012**, *1*, 12. [CrossRef]
174. Campos, J.C.; Rodrigues, S.; Sil, Â.; Hermoso, V.; Freitas, T.R.; Santos, J.A.; Fernandes, P.M.; Azevedo, J.C.; Honrado, J.P.; Regos, A. Climate regulation ecosystem services and biodiversity conservation are enhanced differently by climate- and fire-smart landscape management. *Environ. Res. Lett.* **2022**, *17*, 054014. [CrossRef]
175. Zari, M.P. Utilizing relationships between ecosystem services, built environments, and building materials. *Mater. A Healthy Ecol. Sustain. Built Environ.* **2017**, 3–27. [CrossRef]
176. Indrajaya, Y.; Yuwati, T.W.; Lestari, S.; Winarno, B.; Narendra, B.H.; Nugroho, H.Y.; Rachmanadi, D.; Pratiwi; Turjaman, M.; Adi, R.N.; et al. Tropical Forest Landscape Restoration in Indonesia: A Review. *Land* **2022**, *11*, 328. [CrossRef]
177. Basuki, T.M.; Nugroho, H.Y.; Indrajaya, Y.; Pramono, I.B.; Nugroho, N.P.; Supangat, A.B.; Indrawati, D.R.; Savitri, E.; Wahyuningrum, N.; Purwanto; et al. Improvement of Integrated Watershed Management in Indonesia for Mitigation and Adaptation to Climate Change: A Review. *Sustainability* **2022**, *14*, 9997. [CrossRef]
178. Markov, B.; Nedkov, S. Mapping of Erosion Regulation Ecosystem Services. In Proceedings of the 6th International Conference on Cartography and GIS, Albena, Bulgaria, 13–17 June 2016.
179. Sidle, R.C.; Ziegler, A.D.; Negishi, J.N.; Nik, A.R.; Siew, R.; Turkelboom, F. Erosion processes in steep terrain—Truths, myths, and uncertainties related to forest management in Southeast Asia. *For. Ecol. Manag.* **2006**, *224*, 199–225. [CrossRef]

180. Sihombing, R.S.M. The role of the indigenous knowledge system of the community Dayak in water management Kahayan River: Review of local wisdom perspective. In Proceedings of the Iapa Proceedings Conference, Bali, Indonesia, 11–12 November 2019; pp. 341–350. [CrossRef]
181. Sundari, S.; Ibo, L.; Rahajoe, J.; Alhamd, L.; Gunawan, H.; Priyono, N. Biodiversity study of several peatland types in Papua. In Proceedings of the IOP Conference Series: Earth and Environmental Science; IOP Publishing: Bogor, Indonesia, 2020; p. 012002.
182. Hijjang, P. Pasang dan Kepemimpinan Ammatoa: Memahami Kembali Sistem Kepemimpinan Tradisional Masyarakat Adat dalam Pengelolaan Sumberdaya Hutan di Kajang Sulawesi Selatan. *Antropol. Indones.* **2015**, *29*, 255–256. [CrossRef]
183. Muntaza, M. Satu Abad Perubahan Sakralitas Alam Malind-anim. *J. Sosiol. Reflektif* **2016**, *8*, 179–208.
184. Satia, R.; Gumiri, S.; Utsman, S.; Asmawati, Y.; Abubakar, H.M.; Bulkani, B.; Yusuf, M.; Ardianor, A.; Yusuf, N.S.; Nasir, M. *Pukung Pahewan*; Diva Press: Yogyakarta, Indonesia, 2019; p. 358.
185. Wiati, C.B. Kajian aturan adat pemanfaatan Tana' Olen oleh masyarakat local di Desa Setulang Kabupaten Malinau, Kalimantan Timur. *J. Penelit. Ekosist. Dipterokarpa* **2013**, *7*, 123–130. [CrossRef]
186. Suparmini, S.; Setyawati, S.; Sumunar, D.R.S. Pelestarian lingkungan masyarakat Baduy berbasis kearifan lokal. *J. Penelit. Hum.* **2013**, *18*, 8–22. [CrossRef]
187. Syarif, E.; Fatchan, A.; Astina, K. Tradition of "Pasang Ri-Kajang" in the forests managing in system mores of "Ammatoa" at District Bulukumba South Sulawesi, Indonesia. *Mediterr. J. Soc. Sci.* **2016**, *7*, 325. [CrossRef]
188. Yamani, M. Strategi perlindungan hutan berbasis hukum lokal di enam komunitas adat daerah bengkulu. *J. Huk. Ius Quia Iustum* **2011**, *18*, 175–192. [CrossRef]
189. Sumarsono, A.; Wasa, C. Traditional Sasi wisdom in Papua-based nature conservation. In *Proceedings of the IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bogor, Indonesia, 2019; p. 012092. [CrossRef]
190. Pattiselanno, F. The wildlife hunting in Papua. *Biota* **2006**, *XI*, 59–61.
191. Renjaan, M.J.; Purnaweni, H.; Anggoro, D.D. Studi kearifan lokal sasi kelapa pada masyarakat adat di Desa Ngilngof Kabupaten Maluku Tenggara. *J. Ilmu Lingkung.* **2013**, *11*, 23–29. [CrossRef]
192. Efremila; Wardenaar, E.; Sisillia, L. Studi etnobotani tumbuhan obat oleh etnis suku Dayak di desa Kayu Tanam kecamatan Mandor kabupaten Landak. *J. Hutan Lestari* **2015**, *3*. [CrossRef]
193. Pristi, N.A. Etnobotani Dalam Upacara Adat Masyarakat Suku Naga, Desa Neglasari, Kecamatan Salawu, Kabupaten Tasikmalaya, Jawa Barat. Bachelor's Thesis, Fakultas Sains dan Teknologi Universitas Islam Negeri Syarif Hidayatullah, Jakarta, Indonesia, 2015.
194. Wansa, W.S. *Pemanfaatan Etnobotani Masyarakat Suku Kajang Desa Tanah Toa Kecamatan Kajang Kabupaten Bulukumba*; Universitas Muhammadiyah Makassar: Makassar, Indonesia, 2019.
195. Nahuelhual, L.; Carmona, A.; Lozada, P.; Jaramillo, A.; Aguayo, M. Mapping recreation and ecotourism as a cultural ecosystem service: An application at the local level in Southern Chile. *Appl. Geogr.* **2013**, *40*, 71–82. [CrossRef]
196. Putri, I.A.S.L.P.; Ansari, F.; Susilo, A. Response of Bird Community Toward Tourism Activities in the Karst Area of Bantimurung Bulusaraung National Park. *J. Qual. Assur. Hosp. Tour.* **2019**, *21*, 146–167. [CrossRef]
197. UNEP. *The Role of Ecosystems in Developing a Sustainable 'Green Economy'*; United Nation Environment Programme: Nairobi, Kenya, 2010.
198. EIA. EIA Projects Nearly 50% Increase in world Energy Usage by 2050, Led by Growth in Asia. Available online: https://www.eia.gov/todayinenergy/detail.php?id=41433 (accessed on 18 April 2022).
199. Platform. Finding Synergies between Renewable Energy and Ecosystem Services. Available online: https://www.interregeurope.eu/find-policy-solutions/stories/finding-synergies-between-renewable-energy-and-ecosystem-services (accessed on 16 May 2022).
200. Picchi, P.; Verzandvoort, S.; Geneletti, D.; Hendriks, K.; Stremke, S. Deploying ecosystem services to develop sustainable energy landscapes: A case study from the Netherlands. *Smart Sustain. Built Environ.* **2020**. *ahead-of-print*. [CrossRef]
201. Ministry of National Development Planning. *Pedoman Teknis Penyusunan Rencana Aksi—Tujuan Pembangunan Berkelanjutan/Sustainable Development Goals (TPB/SDGs)*, 2nd ed.; Ministry of National Development Planning: Jakarta, Indonesia, 2020.
202. Republik Indonesia Energi. Undang-undang Republik Indonesia nomor 40 tahun 2007 tentang perseroan terbatas. *Jkt. Sekr. Negara* **2007**. Available online: https://www.ojk.go.id/Files/box/keuangan-berkelanjutan/UU_PT_No_40_tahun_2007.pdf (accessed on 20 June 2022).
203. Espécie, M.d.A.; de Carvalho, P.N.; Pinheiro, M.F.B.; Rosenthal, V.M.; da Silva, L.A.F.; Pinheiro, M.R.d.C.; Espig, S.A.; Mariani, C.F.; de Almeida, E.M.; Sodré, F.N.G.A.d.S. Ecosystem services and renewable power generation: A preliminary literature review. *Renew. Energy* **2019**, *140*, 39–51. [CrossRef]
204. Hastik, R.; Basso, S.; Geitner, C.; Haida, C.; Poljanec, A.; Portaccio, A.; Vrščaj, B.; Walzer, C. Renewable energies and ecosystem service impacts. *Renew. Sustain. Energy Rev.* **2015**, *48*, 608–623. [CrossRef]
205. Fearnside, P.M. Global Warming and Tropical Land-Use Change: Greenhouse Gas Emissions from Biomass Burning, Decomposition and Soils in Forest Conversion, Shifting Cultivation and Secondary Vegetation. *Clim. Chang.* **2000**, *46*, 115–158. [CrossRef]
206. Cramer, W.; Bondeau, A.; Schaphoff, S.; Lucht, W.; Smith, B.; Sitch, S. Twenty-first century atmospheric change and deforestation: Potential impacts on tropical forests. In *Tropical Forests and Global Atmospheric Change*; Malhi, Y., Phillips, O., Eds.; Oxford Scholarship Online: Oxford, UK, 2005; pp. 17–30.
207. Ramankutty, N.; Gibbs, H.K.; Achard, F.; Defries, R.; Foley, J.A.; Houghton, R.A. Challenges to estimating carbon emissions from tropical deforestation. *Glob. Chang. Biol.* **2007**, *13*, 51–66. [CrossRef]

208. Tacconi, L.; Muttaqin, M.Z. Reducing emissions from land use change in Indonesia: An overview. *For. Policy Econ.* **2019**, *108*, 101979. [CrossRef]
209. Miles, L.; Kapos, V. Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation: Global Land-Use Implications. *Science* **2008**, *320*, 1454–1455. [CrossRef]
210. Johns, T.; Merry, F.; Stickler, C.; Nepstad, D.; Laporte, N.; Goetz, S. A three-fund approach to incorporating government, public and private forest stewards into a REDD funding mechanism. *Int. For. Rev.* **2008**, *10*, 458–464. [CrossRef]
211. Cadman, T.; Sarker, T.; Muttaqin, Z.; Nurfatriani, F.; Salminah, M.; Maraseni, T. The role of fiscal instruments in encouraging the private sector and smallholders to reduce emissions from deforestation and forest degradation: Evidence from Indonesia. *For. Policy Econ.* **2019**, *108*, 101913. [CrossRef]
212. Boediono, L. Indonesia and the World Bank Sign Milestone Agreement on Emission Reductions. Available online: https://www.worldbank.org/en/news/press-release/2020/12/08/indonesia-and-the-world-bank-sign-milestone-agreement-on-emission-reductions (accessed on 29 May 2022).
213. Venter, O.; Meijaard, E.; Possingham, H.; Dennis, R.; Sheil, D.; Wich, S.; Hovani, L.; Wilson, K. Carbon payments as a safeguard for threatened tropical mammals. *Conserv. Lett.* **2009**, *2*, 123–129. [CrossRef]
214. Saepudin, A.; Muryantini, A.; Maghfiroh, H.D. Kebijakan Indonesia Dalam Mewujudkan Industri Hijau (Green Industry) Masa Pemerintahan Presiden Joko Widodo. *J. EKSOS* **2020**, *2*, 166–177.
215. Pusat Pengkajian Strategis Kehutanan. Green Product Kehutanan vs. Issue Lingkungan. Available online: http://www.forestforlife.web.id/2012/09/green-product-kehutanan-versus-issue.html (accessed on 2 June 2022).
216. Maryudi, A.; Devkota, R.R.; Schusser, C.; Yufanyi, C.; Salla, M.; Aurenhammer, H.; Rotchanaphatharawit, R.; Krott, M. Back to basics: Considerations in evaluating the outcomes of community forestry. *For. Policy Econ.* **2012**, *14*, 1–5. [CrossRef]
217. Purwanto, A.; Asbari, M.; Prameswari, M.; Pramono, R. Sistem manajemen pengelolaan hutan FSC, PEFC, ISO 38200:2018 dan pengaruhnya terhadap kinerja industri kayu di Indonesia. *Tengkawang* **2020**, *10*, 34–44. [CrossRef]
218. Wibowo, A.; Sahide, M.A.K.; Pratiwi, S.; Dharmawan, B.; Giessen, L. Ragam Skema Sertifikasi Hutan Global Dan Opsi Transformasinya Di Indonesia. *RISALAH KEBIJAKAN PERTANIAN DAN LINGKUNGAN Rumusan Kaji. Strateg. Bid. Pertan. Dan Lingkung.* **2015**, *2*, 1–8. [CrossRef]
219. Gavrilut, I.; Halalisan, A.-F.; Giurca, A.; Sotirov, M. The Interaction between FSC Certification and the Implementation of the EU Timber Regulation in Romania. *Forests* **2016**, *7*, 3. [CrossRef]
220. Kongmanee, C.; Ahmed, F.; Longpichai, O. Cost-Benefit Analysis and Challenges of Implementing FSC Standards in Rubber Plantations in Southern Thailand. *J. Asian Financ. Econ. Bus.* **2020**, *7*, 423–431. [CrossRef]
221. Palupi, R.D. Implementasi Sertifikasi FSC (Forest Stewardship Council) Terhadap Eco-Product di Indonesia. Available online: https://pediailmu.com/kehutanan/implementasi-sertifikasi-fsc-terhadap-eco-product-di-indonesia/ (accessed on 10 June 2022).
222. Tacconi, L.; Rodrigues, R.J.; Maryudi, A. Law enforcement and deforestation: Lessons for Indonesia from Brazil. *For. Policy Econ.* **2019**, *108*, 101943. [CrossRef]
223. Wiyono, W.; Oktalina, S.N. Kendala Implementasi Sistem Verifikasi Legalitas Kayu pada Industri Kayu di Daerah Istimewa Yogyakarta. In Proceedings of the Prosiding Seminar Nasional Teknologi Terapan 2015 "Inovasi Budaya dan Teknologi untuk Kemajuan Bangsa". Sekolah Vokasi Universitas Gajah Mada, Yogjakarta, Indonesia, 14 November 2015.
224. Romero, C.; Sills, E.O.; Guariguata, M.R.; Cerutti, P.O.; Lescuyer, G.; Putz, F.E. Evaluation of the impacts of Forest Stewardship Council (FSC) certification of natural forest management in the tropics: A rigorous approach to assessment of a complex conservation intervention. *Int. For. Rev.* **2017**, *19*, 36–49. [CrossRef]
225. Yahya, A.F.; Damayanti, E.; Zuhud, E.A. Traditional forest-related knowledge for ecosystem services in Sundanese ethnic of Sukabumi District, West Java Province. In Proceedings of the XIV WORLD FORESTRY CONGRESS, Durban, South Africa, 7–11 September 2015.
226. Yeoman, J. Ecotourism and Sustainable Development. In *Who Owns Paradise?* 2nd ed.; Island Press: Washington, DC, USA, 2001; Volume 22, pp. 206–208.
227. Libosada, C.M. Business or leisure? Economic development and resource protection-Concepts and practices in sustainable ecotourism. *Ocean Coast. Manag.* **2009**, *52*, 390–394. [CrossRef]
228. Hsu, P.H. Economic impact of wetland ecotourism: An empirical study of Taiwan's Cigu Lagoon area. *Tour. Manag. Perspect.* **2019**, *29*, 31–40. [CrossRef]
229. Indira Anggraini, R.; Gunawan, B. Ecotourism development in National Parks: A new paradigm of forest management in Indonesia. *E3S Web Conf.* **2021**, *249*, 03010. [CrossRef]
230. Pynanjung, P.A. Dampak pengembangan ekowisata terhadap kesejahteraan masyarakat di Kabupaten Bengkayang: Studi kasus Kawasan Ekowisata Riam Pangar. *J. Nas. Pariwisata* **2018**, *10*, 22–38. [CrossRef]
231. Wiyono, W.; Hidayat, R.; Oktalina, S. The Community Empowerment Strategy in Protected Forest Management through Community-Based Ecotourism Development in Kalibiru Village, Kulon Progo Regency. *Habitat* **2020**, *31*, 11–27. [CrossRef]
232. Atmodjo, E.; Lamers, M.; Mol, A. Financing marine conservation tourism: Governing entrance fees in Raja Ampat, Indonesia. *Mar. Policy* **2017**, *78*, 181–188. [CrossRef]
233. Schuhmann, P.W.; Skeete, R.; Waite, R.; Lorde, T.; Bangwayo-Skeete, P.; Oxenford, H.A.; Gill, D.; Moore, W.; Spencer, F. Visitors' willingness to pay marine conservation fees in Barbados. *Tour. Manag.* **2019**, *71*, 315–326. [CrossRef]

234. Ma, B.; Yin, R.; Zheng, J.; Wen, Y.; Hou, Y. Estimating the social and ecological impact of community-based ecotourism in giant panda habitats. *J. Environ. Manag.* **2019**, *250*, 109506. [CrossRef]
235. Wiratno, W.; Withaningsih, S.; Gunawan, B.; Iskandar, J. Ecotourism as a Resource Sharing Strategy: Case Study of Community-Based Ecotourism at the Tangkahan Buffer Zone of Leuser National Park, Langkat District, North Sumatra, Indonesia. *Sustainability* **2022**, *14*, 3399. [CrossRef]
236. Butarbutar, R.; Soemarno, S. Environmental effects of ecotourism in Indonesia. *J. Indones. Tour. Dev. Stud.* **2013**, *1*, 97–107. [CrossRef]
237. Purnomo, M.; Maryudi, A.; Dedy Andriatmoko, N.; Muhamad Jayadi, E.; Faust, H. The cost of leisure: The political ecology of the commercialization of Indonesia's protected areas. *Environ. Sociol.* **2022**, *8*, 121–133. [CrossRef]
238. Lenzen, M.; Sun, Y.Y.; Faturay, F.; Ting, Y.P.; Geschke, A.; Malik, A. The carbon footprint of global tourism. *Nat. Clim. Chang.* **2018**, *8*, 522–528. [CrossRef]
239. Morris, E.K.; Morris, D.J.P.; Vogt, S.; Gleber, S.C.; Bigalke, M.; Wilcke, W.; Rillig, M.C. Visualizing the dynamics of soil aggregation as affected by arbuscular mycorrhizal fungi. *ISME J.* **2019**, *13*, 1639–1646. [CrossRef] [PubMed]
240. Kholil, K.; Dharoko, T.A.; Widayati, A. Pendekatan multi dimensional scaling untuk evaluasi keberlanjutan waduk Cirata—Propinsi Jawa Barat. *J. Mns. Dan Lingkung.* **2015**, *22*, 22–31. [CrossRef]
241. Nandini, R.; Kusumandari, A.; Gunawan, T.; Sadono, R. Multidimensional Scaling Approach to Evaluate the Level of Community Forestry Sustainability in Babak Watershed, Lombok Island, West Nusa Tenggara. *Forum Geogr.* **2017**, *31*, 28–42. [CrossRef]
242. Suryanto, S.; Onrizal, O.; Susilo, A.; Andriansyah, M.; Muslim, T. Implementation of Multi-System Silviculture (MSS) to improve performance of production forest management: A case study of PT Sarpatim, Central Kalimantan. *Indones. J. For. Res.* **2018**, *5*, 1–19. [CrossRef]
243. Rakatama, A.; Pandit, R. Reviewing social forestry schemes in Indonesia: Opportunities and challenges. *For. Policy Econ.* **2020**, *111*, 102052. [CrossRef]
244. Cowling, R.M.; Egoh, B.; Knight, A.T.; O'Farrell, P.J.; Reyers, B.; Rouget, M.; Roux, D.J.; Welz, A.; Wilhelm-Rechman, A. An operational model for mainstreaming ecosystem services for implementation. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 9483–9488. [CrossRef]
245. Mijatović, D.; Sakalian, M.; Hodgkin, T. *Mainstreaming Biodiversity in Production Landscapes*; United Nations Environment Programme: New Delhi, India, 2018.
246. Cowling, R.M.; Pierce, S.M.; Sandwith, T. Conclusions: The Fundamentals of Mainstreaming Biodiversity. In *Mainstreaming Biodiversity in Development: Case Studies from South Africa*; van Wilgen, B., Marais, C., Magadlela, D., Jezile, N., Stevens, D., Eds.; The International Bank for Reconstructionand Development/The World Bank: Washington, DC, USA, 2002; p. 143.
247. Capodaglio, A.G.; Callegari, A. Can Payment for Ecosystem Services schemes be an alternative solution to achieve sustainable environmental development? A critical comparison of implementation between Europe and China. *Resources* **2018**, *7*, 40. [CrossRef]
248. Grima, N.; Singh, S.J.; Smetschka, B.; Ringhofer, L. Payment for Ecosystem Services (PES) in Latin America: Analysing the performance of 40 case studies. *Ecosyst. Serv.* **2016**, *17*, 24–32. [CrossRef]
249. Folharini, S.d.O.; De Oliveira, R.C. Environmental Services and Ecosystem Services: Conceptual Difference and Application in Brazilian Environmental Legislation. *Geoambiente-Line* **2020**, *38*, 210–229. [CrossRef]
250. Ferraro, P.J. The future of payments for environmental services. *Conserv. Biol.* **2011**, *25*, 1134–1138. [CrossRef] [PubMed]
251. Pham, T.T.; Loft, L.; Bennett, K.; Phuong, V.T.; Dung, L.N.; Brunner, J. Monitoring and evaluation of Payment for Forest Environmental Services in Vietnam: From myth to reality. *Ecosyst. Serv.* **2015**, *16*, 220–229. [CrossRef]
252. Ferraro, P.J. Asymmetric information and contract design for payments for environmental services. *Ecol. Econ.* **2008**, *65*, 810–821. [CrossRef]
253. Wunder, S. When payments for environmental services will work for conservation. *Conserv. Lett.* **2013**, *6*, 230–237. [CrossRef]
254. Pasha, R.; Asmawan, T.; Leimona, B.; Setiawan, E.; Wijaya, C.I. *Komoditisasi Atau Koinvestasi Jasa Lingkungan: Skema Imbal Jasa Lingkungan Program Peduli Sungai di DAS Way Besai, Lampung, Indonesia*; World Agroforestry Centre: Bogor, Indonesia, 2011.
255. Laila, N.; Murtilaksono, K.; Nugroho, B. Kelembagaan kemitraan hulu hilir untuk pasokan air DAS Cidanau, Provinsi Banten. *J. Penelit. Sos. Dan Ekon. Kehutan.* **2014**, *11*, 29177. [CrossRef]
256. Fauzi, A.; Anna, Z. The complexity of the institution of payment for environmental services: A case study of two Indonesian PES schemes. *Ecosyst. Serv.* **2013**, *6*, 54–63. [CrossRef]
257. Napitupulu, D.F.; Asdak, C.; Budiono, B. Mekanisme imbal jasa lingkungan di sub-das Cikapundung (studi kasus pada Desa Cikole dan Desa Suntenjaya Kabupaten Bandung Barat). *J. Ilmu Lingkung. Undip* **2013**, *11*, 73–83. [CrossRef]
258. Pagiola, S.; Landell-Mills, N.; Bishop, J. Market-based mechanisms for forest conservation and development. In *Selling Forest Environmental Services*; Pagiola, S., Bishop, J., Landell-Mills, N., Eds.; Earthscan Publications Ltd.: New York, NY, USA, 2002; pp. 1–13.
259. Aviantara, D.B.; Suciati, F. Penggunaan model matematik gaussian dispersion untuk pendugaan perubahan kualitas udara dalam analisis dampak lingkungan. *J. Rekayasa Lingkung.* **2021**, *14*. [CrossRef]
260. Budhi, G.S.; Kuswanto, S.; Iqbal, M. Concept and implementation of PES program in the Cidanau watershed: A lesson learned for future environmental policy. *Anal. Kebijak. Pertan.* **2008**, *6*, 37–55.
261. Santosa, A.; Sakti, D.K.; Hardiyanto, G.; Berliani, H.; Suwito. *Mendorong Pemanfaatan Air dan Energi Air yang Lebih Baik*; The Partnership for Governance Reform: Jakarta, Indonesia, 2015.

262. Diswandi, D. A hybrid Coasean and Pigouvian approach to Payment for Ecosystem Services Program in West Lombok: Does it contribute to poverty alleviation? *Ecosyst. Serv.* **2017**, *23*, 138–145. [CrossRef]
263. Iqbal, Y.M.; Burhanudin, H. Penentuan Biaya Kompensasi Air dari Kota Cirebon untuk Penghijauan Desa Sekitar Mata Air Cipaniis Kabupaten Kuningan. In Proceedings of the Seminar Penelitian Sivitas Akademika UNISBA, Bandung, Indonesia, 6–11 August 2020; pp. 408–416. [CrossRef]
264. Suich, H.; Lugina, M.; Muttaqin, M.Z.; Alviya, I.; Sari, G.K. Payments for ecosystem services in Indonesia. *Oryx* **2017**, *51*, 489–497. [CrossRef]
265. Romero, H.G. Payments for Environmental Services: Can They Work? The Case of Mexico. *Field Actions Sci. Rep. J. Field Actions* **2012**, *6*, 1–7.
266. Lapeyre, R.; Pirard, R.; Leimona, B. Payments for environmental services in Indonesia: What if economic signals were lost in translation? *Land Use Policy* **2015**, *46*, 283–291. [CrossRef]
267. Bulte, E.H.; Lipper, L.; Stringer, R.; Zilberman, D. Payments for ecosystem services and poverty reduction: Concepts, issues, and empirical perspectives. *Environ. Dev. Econ.* **2008**, *13*, 245–254. [CrossRef]
268. de Groot, R.S.; Alkemade, R.; Braat, L.; Hein, L.; Willemen, L. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecol. Complex.* **2010**, *7*, 260–272. [CrossRef]
269. Bond, I.; Mayers, J. *Fair Deals for Watershed Services Lessons from a Multi-Country Action-Learning Project*; International Institute for Environment and Development: London, UK, 2010.
270. Tahri, M.; Kaspar, J.; Vacik, H.; Marusak, R. Multi-attribute decision making and geographic information systems: Potential tools for evaluating forest ecosystem services. *Ann. For. Sci.* **2021**, *78*, 1–19. [CrossRef]
271. Borges, J.G.; Nordstrom, E.M.; Garcia Gonjalo, J.; Hujala, T.; Trasobares, A. *Computer-Based Tools for Supporting Forest Management. The Experience and the Expertise World-Wide*; Forest Resource Management-SLU: Umeå, Sweden, 2014; p. 507. ISBN 978-91-576-9236-8.
272. Zhang, Z.; Sherman, R.; Yang, Z.; Wu, R.; Wang, W.; Yin, M.; Yang, G.; Ou, X. Integrating a participatory process with a GIS-based multi-criteria decision analysis for protected area zoning in China. *J. Nat. Conserv.* **2013**, *21*, 225–240. [CrossRef]
273. Armatas, C.A.; Campbell, R.M.; Watson, A.E.; Borrie, W.T.; Christensen, N.; Venn, T.J. An integrated approach to valuation and tradeoff analysis of ecosystem services for national forest decision-making. *Ecosyst. Serv.* **2018**, *33*, 1–18. [CrossRef]
274. Hyyppä, E.; Yu, X.; Kaartinen, H.; Hakala, T.; Kukko, A.; Vastaranta, M.; Hyyppä, J. Comparison of backpack, handheld, under-canopy UAV, and above-canopy UAV laser scanning for field reference data collection in boreal forests. *Remote Sens.* **2020**, *12*, 3327. [CrossRef]
275. Liang, X.; Wang, Y.; Pyörälä, J.; Lehtomäki, M.; Yu, X.; Kaartinen, H.; Kukko, A.; Honkavaara, E.; Issaoui, A.E.I.; Nevalainen, O.; et al. Forest in situ observations using unmanned aerial vehicle as an alternative of terrestrial measurements. *For. Ecosyst.* **2019**, *6*, 1–16. [CrossRef]
276. Palomino, J.; Muellerklein, O.C.; Kelly, M. A review of the emergent ecosystem of collaborative geospatial tools for addressing environmental challenges. *Comput. Environ. Urban Syst.* **2017**, *65*, 79–92. [CrossRef]
277. Emery, B.; Camps, A. *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications*; Elsevier: Amsterdam, The Netherlands, 2017.
278. Bagstad, K.J.; Semmens, D.J.; Waage, S.; Winthrop, R. A comparative assessment of decision-support tools for ecosystem services quantification and valuation. *Ecosyst. Serv.* **2013**, *5*, 27–39. [CrossRef]
279. Çetinkaya, C.; Kabak, M.; Erbaş, M.; Özceylan, E. Evaluation of ecotourism sites: A GIS-based multi-criteria decision analysis. *Kybernetes* **2018**, *47*, 1664–1686. [CrossRef]
280. Woo, H.; Acuna, M.; Moroni, M.; Taskhiri, M.S.; Turner, P. Optimizing the location of biomass energy facilities by integrating Multi-Criteria Analysis (MCA) and Geographical Information Systems (GIS). *Forests* **2018**, *9*, 585. [CrossRef]
281. Garcia-Gonzalo, J.; Bushenkov, V.; McDill, M.E.; Borges, J.G. A decision support system for assessing trade-offs between ecosystem management goals: An application in Portugal. *Forests* **2015**, *6*, 65–87. [CrossRef]
282. Nordström, E.M.; Nieuwenhuis, M.; Başkent, E.Z.; Biber, P.; Black, K.; Borges, J.G.; Bugalho, M.N.; Corradini, G.; Corrigan, E.; Eriksson, L.O.; et al. Forest decision support systems for the analysis of ecosystem services provisioning at the landscape scale under global climate and market change scenarios. *Eur. J. For. Res.* **2019**, *138*, 561–581. [CrossRef]
283. Cristal, I.; Ameztegui, A.; González-Olabarria, J.R.; Garcia-Gonzalo, J. A Decision support tool for assessing the impact of climate change on multiple ecosystem services. *Forests* **2019**, *10*, 440. [CrossRef]
284. Pasalodos-Tato, M.; Mäkinen, A.; Garcia-Gonzalo, J.; Borges, J.G.; Lamas, T.; Eriksson, L.O. Review. Assessing uncertainty and risk in forest planning and decision support systems: Review of classical methods. *For. Syst.* **2013**, *22*, 282–303.
285. Lopes, R.; Videira, N. How to articulate the multiple value dimensions of ecosystem services? Insights from implementing the PArticulatES framework in a coastal social-ecological system in Portugal. *Ecosyst. Serv.* **2019**, *38*, 100955. [CrossRef]
286. Lopes, R.; Videira, N. Valuing marine and coastal ecosystem services: An integrated participatory framework. *Ocean Coast. Manag.* **2013**, *84*, 153–162. [CrossRef]
287. Chee, Y.E. An ecological perspective on the valuation of ecosystem services. *Biol. Conserv.* **2004**, *120*, 549–565. [CrossRef]
288. Jamouli, A.; Allali, K. Economic valuation of ecosystem services in Africa. *E3S Web Conf.* **2020**, *183*, 01002. [CrossRef]
289. Christie, M.; Hyde, A.; Cooper, R.; Fazey, I.; Dennis, P.; Warren, J.; Colombo, S.; Hanley, N. *Economic Valuation of the Benefits of Ecosystem Services Delivered by the UK Biodiversity Action Plan (Defra Project SFFSD 0702)*; DEFRA: London, UK, 2011.

290. Pisani, D.; Pazienza, P.; Perrino, E.V.; Caporale, D.; De Lucia, C. The Economic Valuation of Ecosystem Services of Biodiversity Components in Protected Areas: A Review for a Framework of Analysis for the Gargano National Park. *Sustainability* **2021**, *13*, 11726. [CrossRef]
291. Selivanov, E.; Hlaváčková, P. Methods for monetary valuation of ecosystem services: A scoping review. *J. For. Sci.* **2021**, *67*, 499–511. [CrossRef]
292. Eregae, J.E.; Njogu, P.; Karanja, R.; Gichua, M. Economic Valuation for Cultural and Passive Ecosystem Services Using a Stated Preference (Contingent Valuation Method (CVM)) Case of the Elgeyo Watershed Ecosystem, Kenya. *Int. J. For. Res.* **2021**, *2021*, 5867745. [CrossRef]
293. Ojea, E.; Martin-Ortega, J.; Chiabai, A. Economic Valuation of Ecosystem Services: Conflicts in Classification. In Proceedings of the 9th International and National Webinar on Fisheries and Marine Science (ISFM 9), Riau, Indonesia, 10 September 2010.
294. Resendea, F.M.; Fernandesa, G.W.; Andraded, D.C.; Néderd, H.D. Economic valuation of the ecosystem services provided by a protected area in the Brazilian Cerrado: Application of the contingent valuation method. *Braz. J. Biol.* **2017**, *77*, 762–773. [CrossRef] [PubMed]
295. Roslinda, E.; Yuliantini, Y. The economic value of hydrological services in Mendalam Sub Watershed, Kapuas Hulu Regency, West Kalimantan, Indonesia. *Indones. J. For. Res.* **2014**, *1*, 1–8. [CrossRef]
296. Balasubramanian, M. Economic value of regulating ecosystem services: A comprehensive at the global level review. *Environ. Monit. Assess.* **2019**, *191*, 616. [CrossRef]
297. Baral, H.; Jaung, W.; Bhatta, L.D.; Phuntsho, S.; Sharma, S.; Paudyal, K.; Zarandian, A.; Sears, R.R.; Sharma, R.; Dorji, T.; et al. Approaches and tools for assessing mountain forest ecosystem services. *Work. Pap.* **2017**, *235*. [CrossRef]
298. Farber, S.; Costanza, R.; Childers, D.L.; Erickson, J.; Gross, K.; Grove, M.; Hopkinson, C.S.; Kahn, J.; Pincetl, S.; Troy, A.; et al. Linking Ecology and Economics for Ecosystem Management. *BioScience* **2006**, *56*, 121–133. [CrossRef]
299. Bullock, J.M.; Aronson, J.; Newton, A.C.; Pywell, R.F.; Rey-Benayas, J.M. Restoration of ecosystem services and biodiversity: Conflicts and opportunities. *Trends Ecol. Evol.* **2011**, *26*, 541–549. [CrossRef] [PubMed]
300. Baral, H.; Keenan, R.J.; Sharma, S.K.; Stork, N.E.; Kasel, S. Economic evaluation of ecosystem goods and services under different landscape management scenarios. *Land Use Policy* **2014**, *39*, 54–64. [CrossRef]
301. Barbier, E.B.; Heal, G.M. Valuing Ecosystem Services. *Econ. Voice* **2006**, *3*, 6. [CrossRef]
302. Turner, R.K.; Morse-Jones, S.; Fisher, B. Ecosystem valuation. *Ann. N. Y. Acad. Sci.* **2010**, *1185*, 79–101. [CrossRef]
303. Salles, J.-M. Valuing biodiversity and ecosystem services: Why put economic values on Nature? *C. R. Biol.* **2011**, *334*, 469–482. [CrossRef] [PubMed]
304. Troy, A.; Wilson, M.A. Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer. *Ecol. Econ.* **2006**, *60*, 435–449. [CrossRef]
305. Effendi, R.; Salsabila, H.; Malik, A. Pemahaman Tentang Lingkungan Berkelanjutan. *Modul* **2018**, *18*, 75. [CrossRef]
306. Raymond, C.M.; Singh, G.G.; Benessaiah, K.; Bernhardt, J.R.; Levine, J.; Nelson, H.; Turner, N.J.; Norton, B.; Tam, J.; Chan, K.M.A. Ecosystem Services and Beyond: Using Multiple Metaphors to Understand Human–Environment Relationships. *BioScience* **2013**, *63*, 536–546. [CrossRef]
307. Lin, Y.P.; Lin, W.C.; Li, H.Y.; Wang, Y.C.; Hsu, C.C.; Lien, W.Y.; Anthony, J.; Petway, J.R. Integrating social values and ecosystem services in systematic conservation planning: A case study in Datuan Watershed. *Sustainability* **2017**, *9*, 718. [CrossRef]
308. Phelps, J.; Dermawan, A.; Garmendia, E. Institutionalizing environmental valuation into policy: Lessons from 7 Indonesian agencies. *Glob. Environ. Chang.* **2017**, *43*, 15–25. [CrossRef]
309. Johnson, D.N.; van Riper, C.J.; Chu, M.; Winkler-Schor, S. Comparing the social values of ecosystem services in US and Australian marine protected areas. *Ecosyst. Serv.* **2019**, *37*, 100919. [CrossRef]
310. Walz, A.; Schmidt, K.; Ruiz-Frau, A.; Nicholas, K.A.; Bierry, A.; de Vries Lentsch, A.; Dyankov, A.; Joyce, D.; Liski, A.H.; Marbà, N.; et al. Sociocultural valuation of ecosystem services for operational ecosystem management: Mapping applications by decision contexts in Europe. *Reg. Environ. Chang.* **2019**, *19*, 2245–2259. [CrossRef]
311. Marupah; Zubair, H.; Rukmana, D.; Baja, S. Economic valuation of erosion. *IOP Conf. Ser. Earth Environ. Sci.* **2018**, *157*, 012018. [CrossRef]
312. Felipe-Lucia, M.R.; Comín, F.A.; Escalera-Reyes, J. A framework for the social valuation of ecosystem services. *AMBIO* **2015**, *44*, 308–318. [CrossRef] [PubMed]
313. Chintantya, D. Peranan Jasa Ekosistem dalam Perencanaan Kebijakan Publik di Perkotaan. *Proc. Biol. Educ. Conf.* **2017**, *14*, 144–147.
314. Bryan, B.A.; Raymond, C.M.; Crossman, N.D.; Macdonald, D.H. Targeting the management of ecosystem services based on social values: Where, what, and how? *Landsc. Urban Plan.* **2010**, *97*, 111–122. [CrossRef]
315. Emerton, L.; Aung, Y.M. *The Economic Value of Forest Ecosystem Services in Myanmar and Options for Sustainable Financing*; International Management Group: Yangon, Myanmar, 2013.
316. Emerton, L.; Bishop, J.; Thomas, L. *Sustainable Financing of Protected Areas: A Global Review of Challenges and Options*; IUCN: Gland, Switzerland, 2006.
317. Saputra, W.; Halimatussadiah, A.; Haryanto, J.; Nurfatriani, F.; Salminah, M. *Designing Policy of Regional Incentive Funds (DID), Specific Purpose Funds (DAK) for Environment and Forestry Sector and Village Funds (DD) Ecological Fiscal Transfers in Indonesia*; USAID-Kemitraan: Jakarta, Indonesia, 2021.
318. Gutman, P.; Davidson, S. *A Review of Innovative International Financial Mechanisms for Biodiversity Conservation with a Special Focus on the International Financing of Developing Countries' Protected Areas*; WWF: Washington, DC, USA, 2007.

319. Barbier, E.B. Valuing ecosystem services as productive inputs. *Econ. Policy* **2007**, *22*, 178–229. [CrossRef]
320. Freeman, A.M., III; Herriges, J.A.; Kling, C.L. *The Measurement of Environmental and Resource Values: Theory and Methods*; Routledge: London, UK, 2014.
321. Bayon, R.; Lovink, J.S.; Veening, W.J. *Financing Biodiversity Conservation*; Citeseer: Washington, DC, USA, 2000.
322. Panayotou, T. Taking stock of trends in sustainable development finance since Rio. In Proceedings of the Finance for Sustainable Development: The Road Ahead, Santiago, Chile, 8–10 January 1997.
323. Nurfatriani, F.; Satrio, A.E. Urgensi Pendanaan Pembangunan Berbasis Ekologi. Dalam Pendanaan Pembangunan Berbasis Ekologi di Provinsi Kalimantan Timur. In *Tinjauan Atas Skema Result Based Payment Sebagai Insentif REDD+*; Nurfatriani, F., Dharmawan, I.W.S., Eds.; IPB Press: Bogor, Indonesia, 2020.
324. Fiskal, B.K. *Pendanaan Publik Untuk Pengendalian Perubahan Iklim Indonesia 2016–2018*; Badan Kebijakan Fiskal: Jakarta, Indonesia, 2019.
325. Direktorat Mobilisasi Sumberdaya Sektoral dan Regional. *Menuju Operasionalisasi Pendanaan Iklim*; Direktorat Mobilisasi Sumberdaya Sektoral dan Regional (Direktorat MSSR); Kementerian Lingkungan Hidup dan Kehutanan: Jakarta, Indonesia, 2017.
326. Dhewanthi, L. Kebijakan dan strategi pendanaan perlindungan dan pengelolaan lingkungan hidup. In Proceedings of the Perbaikan Tata Kelola dan Dukungan Pendanaan Perubahan Iklim di Daerah, Jakarta, Indonesia, 23 April 2020.
327. Krott, M. *Forest Policy Analysis*; Springer Science & Business Media: Dordrecht, The Netherlands, 2005.
328. Aryal, K.; Bhatta, L.D.; Thapa, P.S.; Ranabhat, S.; Neupane, N.; Joshi, J.; Shrestha, K.; Shrestha, A.B. Payment for ecosystem services: Could it be sustainable financing mechanism for watershed services in Nepal? *Green Financ.* **2019**, *1*, 221–236. [CrossRef]
329. Blackman, A.; Woodward, R.T. User financing in a national payments for environmental services program: Costa Rican hydropower. *Ecol. Econ.* **2010**, *69*, 1626–1638. [CrossRef]