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Feasibility Assessment of Converting Forest Into Palm Oil Plantation and Its Implication for Forest Policy and Palm Oil Sustainability Challenges: A Case Study in Melawi Regency of West Kalimantan Province, Indonesia

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The massive development of oil palm plantations puts significant pressure on forest converting in Melawi Regency, West Kalimantan Province. This is supported by the target of opening 200,000 ha of new oil palm plantations in West Kalimantan Province until 2034. Meanwhile, deforestation is the most critical climate change issue in tropical countries including Indonesia. This research examines the feasibility of clearing forest areas to be converted to palm oil plantations. This research employs the insurance approach to assess the benefits of forest ecosystems. Based on the calculation of the cost-benefits of financial and environmental feasibility, it is found that the protection of forest ecosystems is more feasible than opening palm oil plantations. However, based on the socio-economic cost-benefit calculation results, it is found that opening palm oil plantations is more feasible to implement than ecosystem protection activities. Finally, from the calculation of the total benefits-cost financial, environmental, and socio-economic feasibility, it is found that forest ecosystem protection activities are more feasible to implement than opening palm oil plantations. Another finding stated that an opening of 10,000 ha forest area for palm oil plantations would cause 6.4401 times more damage than the benefits that might be obtained if 10,000 ha of forest area ecosystem is not converted into a palm oil plantation area.

Keywords: feasibility assessment, forest converted, palm oil plantation, insurance-based values, Ky index

INTRODUCTION

Deforestation is a major source of critical climate change in tropical countries, including Indonesia. Since 1970 deforestation in the tropics is one of the largest contributors to CO_2 emissions, up to 20-25% of global CO_2 (Penman et al., 2003), and cumulative CO_2 emissions from forestry and other land converting have increased by about 40 percent (IPCC, 2014). Deforestation has also led to lowering in the volume of water sources such as lakes and rivers (Wilson, 2018) as well as causing biodiversity (Hansen et al., 2013).

Even Alroy (2017) predicts global biodiversity will be equivalent to a mass extinction event if tropical deforestation continues. The forest conversion permit system in Indonesia is the largest contributor to losing forest cover in Indonesia (Indarto et al., 2015). The environmental impact of this system is forest degradation and deforestation (FAO (Food Agriculture Organization of the United Nations), 2001) and this is a fundamental criticism for the forest conversion system (Barber and Schweithelm, 2000, Gautam et al., 2000, Amacher et al., 2012, Barr and Sayer, 2012, Molnar et al., 2011). However, according to Meijaard and Sheil (2007), forest plant conversion permits have actually increased forest cover.

In Indonesia, the development of oil palm plantations places significant pressure on forests (Indarto et al., 2015). The massive conversion of forests to oil palm plantations (see Muthee et al., 2018) is driven by the fact that palm oil is a leading tropical agricultural commodity and is traded internationally, and has many derivative products and can be used as a suitable raw material for biofuels (Pirard et al., 2015). These often do not take into account the value of forest ecosystem services for which there are many key benefits of forests, such as fresh air and water, wildlife habitat, and carbon sequestration, and these are consistently underappreciated in economic analysis (Raven, 1988; Wunder, 2007). So there are some tropical countries, especially developing countries with low—middle income levels, prioritize economic growth more than conservation strategies (Giam, 2017). The understanding that forests are an economic resource to improve people's welfare is basically based on the anthropocentric approach, which is frequently referenced by developmentalists (Nurrochmat, 2005). Developmentalists tend to view successful development using conventional economic indicators that are based on anthropocentric rationality, and tend to be inherently top-down and ignore other rationales like local wisdom. Munang (2013) estimates that 60 per cent of global ecosystem services are either being unsustainably used or severely degraded by anthropogenic factors.

Melawi Regency is one of the newly-created districts in West Kalimantan Province, which was inaugurated on January 7, 2004. When established, Melawi Regency had a forest area of 1,064,400 ha. As a new district, Melawi District continues has sought to promote development on the par with older district. To find sources of development financing, Melawi Regency utilizes its potential forests to be converted into palm oil plantations. Moreover, its land typologies are suitable for palm oil plantations. The regency's goal is to establish 200,000 ha for palm oil plantation area by 2034 in West Kalimantan Province (Plantation Office of West Kalimantan Province Indonesia, 2015). Glasbergen (1995) suggested that development and environmental policies often produce gaps between the expected conditions and the outcomes. This condition shows that environmental problems not only revolve around physical issues, but also include the interests of the subjects. Contrary to anthropocentric understanding, ecocentricism, with its deep ecological understanding, has become the reference of ecological groups in understanding and applying development programs, as well as for managing natural resources like forest resources.

Global demand for food, biofuels and natural resources drives the capitalization of agricultural development, particularly tropical plantations (Fargione et al., 2008; Rudel et al., 2009; Ziegler et al., 2009; Lambin and Meyfroidt, 2011). The conversion of forests and peatlands to agricultural plantations is a substantial source of greenhouse gas (GHG) emissions as a result of changes in land cover (DeFries and Rosenzweig, 2010; Foley et al., 2011) which increases 10–20% of global GHG emissions (Werf et al., 2009). Environmental degradation due to tropical agribusiness may eliminate the benefits from plantations that generate high returns for world food security (Foley et al., 2011; Tilman et al., 2011). The massive opening of plantations in Indonesia, particularly in Sumatra and Kalimantan, from 1990 to 2005 has made Indonesia be the 10 countries with the largest GHG emissions in the world (Hansen et al., 2009; Indonesian Ministry of Environment, 2010). While FAO data show that the average deforestation rate was approximately 1.9 million ha/year for 1990-2000 and nearly 0.7 million ha/year for 2005-2 (FAO, 2010).

The massive opening of palm oil plantations has prioritized land clearing. While high profit are the norm for investors in palm oil plantation, such development seldom consider the elevated environmental cost associated with associated forest conversion, however, it does not consider the environmental damage that might occur due to the destruction of the forest ecosystem. If forests are seen as natural capital, the owner should have an incentive to limit the amount of logging by sustainably protecting and maintaining the forest in the long-term. This incentive is expected to increase if the forest is regarded as an asset that provides more value than just wood, such as in terms of a climate regulator, flood controller, or place of recreation (Corzine and Jackson, 2007). Natural capital provides a highly fundamental function to support life, which is not provided by other forms of capital (Ehrlich and Ehrlich, 1992). Moreover, some forms of natural capital are extremely unique, so that they cannot be reformed once they are destroyed.

Currently, one of the instruments to determine the feasibility of converting forest areas into palm oil plantations is the Cost-Benefit Analysis. However, this evaluation instrument focuses on the aspect of economic benefit in the short-term perspective, regardless of the impact of the environmental damage occurring due to forest conversion into palm oil plantations as a part of the cost. In addition, the application of this analysis does not often distinguish between the beneficial characteristics of the forest ecosystem functions and that of palm oil plantation activities. However, the benefits of the forest ecosystem functions and palm oil plantation activities have different characteristics, especially as the benefits of the forest ecosystem are related to sustainability. The valuation instrument using a cost-benefit analysis that puts too much emphasis on financial or economic aspects is one of the reasons for forest conversions to palm oil plantation. Previous research calculated the forest benefits using the financial cost-benefit analysis (Dixon and Sherman, 1990; Lal, 1990; Ruitenbeek, 1992; Bennett and Reynold, 1999; and Shuirong et al., 2009).

It is undeniable that forest clearing for palm oil plantation has opened jobs for the community, but it has also caused long-term environmental damage (see Crowley, 1999), and it is one of the causes of global climate change and floods (Bruijnzeel, 1990; Hamilton and Anderson, 1991, Calder, 1992). The value of ecosystem services that benefit the surrounding people and world society is called output value. The value of the system's ability to maintain system conditions should be assessed as insurance value (Gren et al., 1994; Turner et al., 2003; Balmford et al., 2008). In some instances, the impact of environmental crimes on health is uncertain; thus, it is a driving force for some preventive measures (Ramlogan, 1997). Environmental protection and ecosystems are basic resistance to disease (Cortese, 1993, p. 1-3), particularly through reducing deforestation and forest degradation. Overall, a number of studies have indicated that pollution-related regulations are very weak in less developed countries (India, Indonesia, China) (Dasgupta et al., 1995; Wang and Wheeler, 1996), including those pertaining to environmental protection.

Palm oil plantations should actually receive special attention, because they have been the main driver of the deforestation of tropical forests for more than two decades (Fitzherbert et al., 2008; Koh and Ghazoul, 2008; Koh and Wilcove, 2008a,b). The area of palm oil plantations in Indonesia reached 14,326 million in 2018 (Central Bureau of Statistics of Indonesia, 2019). At the conceptual level, there is a conflict of interest in the management of forest resources, which stems from the different theoretical understanding and empirical meaning about society's change and transition. The conflict has a complex dimension and involves the interests of various sectors and development stakeholders. The negative impact on the environment grows more serious because the industrial development's practices of palm oil plantations not only occur within conservation forests, but also penetrates the production in forest areas. It is especially more serious in conservation areas because they have unique ecosystems and high biodiversity value (Potter and Lee, 1998; Manurung, 2000).

To maintain the benefits of forest ecosystems along with the overall functions, a comprehensive and integrative evaluation are required. More specifically, evaluations are made by comparing similar component values between forest ecosystems and palm oil plantations that take the environmental impacts into account. With a comprehensive and integrated benefit assessment of the forest functions, the value of forest ecosystem benefits can certainly be higher than the economic benefits of palm oil plantations. In addition, the evaluation of the benefits of forest ecosystem functions must adhere to the concept of insurance value. In relation to the evaluation of ecosystem service, Farber et al. (2002) suggested that economic valuations of output-based ecosystem services should be confronted with insurance-based ecological valuations. In addition, Farber argued that ecological evaluation is related to the critical zone or threshold conditions for the ecosystem. This leads to the idea that forests are a premium insurance that people will pay to avoid disturbance to the ecosystem.

Insurance value considers the benefits of the forest ecosystems. It does not merely encompass the present benefits, but also future benefits brought by a sustainable forest ecosystem. Hence, the reasons for maintaining natural capital within the framework of future use produce positive values for environmental sustainability (Beltratti and Heal, 1993; Chichilnisky and Heal, 1993). Armsworth, 2010 stated that the value of the ecosystem services insurance is closely related to the resilience and self-organizing capacity, as well as the regulatory function of the forest ecosystems. This view reinforces that the concept of insurance value from the forest ecosystems is caused by the inherent regulatory characteristics of forest ecosystems. With these characteristics, the correct evaluation to evaluate ecosystem services is using the insurance value. It implicitly emphasize the idea that organisms and ecosystems are important in and of themselves (intrinsic value) or that they might benefit people in the future (future value) (see Chan et al., 2012).

Assessing forest ecosystems retains many constraints, including the lack of information related to forest functions. An attempt to assess forest ecosystems quantitatively faces some difficulties, because forest functions are not merely about the amount of wood production. Progressive assessment should be done through the identification of forest functions and the assessment of every function that is known and perceived as being beneficial to human needs (Meijerink, 2001). However, some difficulties arise due to the limited knowledge and understanding of the functions of tropical forests, which causes uncertainty about the dynamics of forest ecosystems.

To determine the amount of net benefits lost from forest conversion activities, the Total Economic Value approach is employed. Conceptually, the total economic value of forest resources consists of (1) usage value, which consists of direct usage, non-direct usage, and optional values; and (2) non-usage values, which consist of the bequest value and existence value (Garrod Kenneth Garrod and Kenneth, 1999; see Pearce and Turner, 1990; Freeman, 1992; McNeely, 1992). The assessment of forest resources can be done using the market or productivity pricing approach, replacement cost approach, or the survey approach (Duerr, 1960; Hufschmidt, 1992; Lette and de Boo, 2002).

Research on the cost estimates of global biodiversity management have been conducted by several researchers (Ando et al., 1998; Montgomery et al., 1999; Balmford et al., 2003); while studies on the benefit estimation were conducted by Pimentel et al. (1997), Costanza, 1994; and Balmford et al. (2003). The development of palm oil plantations certainly has a major impact on the physical environment and social environment. The growth of palm oil plantations two decades ago in some tropical forest countries resulted in important economic benefits (see Crowley, 1999); however, the growth also increased the threat to the existence of tropical forests.

Besides conducting partial estimation, some researchers estimated the total economic value of the forest resources' benefits. Howard (1995), Kumari, 1995, Ruitenbeek (1989, 1992), and (Bann, 1998) estimated the total economic value of the forest benefits by analyzing selected alternatives to the use of forest areas, which include a more comprehensive evaluation of marketed forest products and non-marketable forest products. Adger et al. (1995) estimated some non-timber forest benefits by excluding timber values in the analysis.

Related to the evaluation of forest ecosystem services under the natural capital concept, Turner and Daily (2008) conducted a study by analyzing the services generated by the ecosystem as capital flows. The method is called CBA. The study found that the value of forest ecosystem services as natural capital contributed significantly to achieving community welfare. The same study was conducted by Brown et al. (2008) who appraised ecosystem services in the perspective of natural assets using personal perceptions, in which everyone was asked to perform evaluations. The study findings suggested that the natural assets' values vary based on the needs and interests of the individuals on the ecosystem services in their socio-economic lives. However, these results are considered biased, because the calculation technique used individual perception, which is highly subjective and influenced by individual characteristics.

Beukering et al. (2003) conducted a research in Nangroe Aceh Darussalam (NAD) by calculating the total economic value of the services and forest ecosystem resources in the province within thirty years of observation. To assess the value of the forest ecosystem services in NAD, two scenarios were assessed. The first scenario was called the conservation scenario, where all the extractive activities were discontinued. The forest ecosystem service was fully maintained, and the economy continued to benefit from the forest ecosystems service in the future. The second was called the deforestation scenario, which assumed business-as-usual with a deforestation rate of 1.3 percent per year. A certain proportion of the forest is converted to agricultural land, which slowly reduced the forest ecosystem services. This research employed the CBA method. The study findings suggested that by 2020, deforestation scenarios will yield higher socio-economic benefits than conservation scenarios. The reasons being: (a) the greatest revenues were derived from logging and selling non-timber forest products; (b) the negative impacts of deforestation were still manageable. But after 2020, the net benefit of conservation was more than the benefits obtained from the logging activities.

Ecosystem services frameworks are commonly used by ecologists and economists in systems to bridge the interaction between humans and nature, by taking into account environmental externalities and supporting conservation efforts (Daily et al., 2000). The framing of the valuation of ecosystem services carried out using the conceptual metaphor of economic production has led to a focus on ecosystem benefits for humans that are valued in the natural processes of delivering supplies and goods (Daily et al., 2000, Armsworth et al., 2007), coupled with economic calculations of costs and costs for the provision of ecosystem services and goods (Bryan, 2010, Newton et al., 2012). By including the human-environment interaction, a multi-directional interaction flow will be seen so that beneficial and adverse relationships and feedback can be determined. Such framing implicitly indicates that an ecosystem is an entity that humans can degrade, maintain, restore, or enhance (Raymond et al., 2013).

It cannot be denied that the opening of oil palm plantations, even though it is done by clearing forests, also certainly has benefits for the community. Therefore, in assessing the feasibility of clearing forests for oil palm plantations, it is necessary to compare all costs and benefits of forest conservation strategies and the opening of oil palm plantations. Head to head comparative analysis (HHCA) is the tool to carry out the feasibility of the two strategy options. The results of this HHCA calculation imply that humans have the right to use ecosystem services as long as these services can be used sustainably or can be replaced with natural or man-made services which are equivalent in terms of costs and benefits (see Raymond et al., 2013). Measurement of conservation results must be carried out appropriately so that the impact evaluation carried out provides useful results in making conservation decisions. Avoided deforestation is not a good measure to see the impact of conservation because avoided deforestation is a physical act that ignores variations in the benefits and costs of a conservation program because it would be inappropriate when a conservation action costs too many scarce funds (Vincent, 2016).

This paper focuses on the concept of insurance value in assessing forest ecosystem services and the evaluation of the forest ecosystem services to compare the cost-benefits of converting forest areas into palm oil plantations in Melawi District. This concept has advantages over the benefit-cost analysis method because it emphasizes that the value of ecosystem services, particularly forests and their contents, may not provide benefits to current generations but may benefit people in the future (future value) (see Chan et al., 2012).

RESEARCH METHODOLOGY

In this study, a survey was conducted to determine community perceptions about forest converting for oil palm plantation development. The survey was conducted on 105 respondents consisting of 90 farmers living in the vicinity of oil palm plantation locations from 7 villages in Melawi District, 3 oil palm companies, 6 people from government elements, 2 people from NGOs, and 2 people from the legislature. The results of this survey showed that 80.2 percent of respondents agreed to convert forests into oil palm plantations. The arguments of respondents who agreed with this conversion action were because they could directly experience the existence of oil palm plantations. The benefits include working on plantations (57.34%), being able to trade around the plantation location (18.18%), being able to become suppliers for company needs (9.09%), being able to enjoy facilities from oil palm companies (2.80%), and increasing regional income (12.59%) (primary data, processed).

The survey results show that there is a bias in the way of community views for the value of environmental services, especially farmers who live around oil palm plantations. This is due to the low level of education (Nurmansyah, 2018) and the low level of farmer income (Lisa, 2019). This led the farmers to agree to convert forests into oil palm plantations because they could immediately receive the benefits from oil palm plantations. Meanwhile, if the forest is still being conserved, it is possible that the farmers only receive a few benefits or even do not receive the current benefits at all.

This research aimed to explore and develop the existing theory/concept (exploratory research). The forestry data in Melawi Regency was obtained from Spatial Planning in 2004, where it is stated that the forest area in Melawi Regency was 1,064,400 ha. This research employed the HHCA (Head to Head Comparative Analysis) approach, which is an analytical approach to compare similar components in 2 (two) or more research

TABLE 1 | Methods to answer research objectives.

Research Objectives	Methods	Analytical Instruments
Calculate the total of the Net Present Value (NPV) of palm oil plantation's activity feasibility in Melawi Regency, based on the insurance value concept and HHCA approach if the forest is converted into palm oil plantation	Calculate benefit—financial cost, environmental cost, socio-economic cost of palm oil plantation and forest ecosystem, based on the insurance value and HHCA approach.	Extended Cost-Benefit Analysis
Calculate the total benefit value of the forest ecosystems in Melawi Regency based on the insurance value concept and HHCA approach, if the forest is not converted into palm oil plantation	Calculate benefit—financial cost, environmental cost, socio-economic cost of palm oil plantation and forest ecosystem, based on the insurance value for the forest ecosystems.	Extended Cost-Benefit Analysis
Find a model to determine the total area of palm oil plantation within a forest ecosystem area.	Conduct feasibility analysis (at maximum limit) for palm oil plantation area with regards to the potential of land reserve within a forest area.	Comparative analysis on net total benefit of palm oil plantation and forest ecosystem using the HHCA approach

TABLE 2 | Cost-benefit components for palm oil plantation.

Components	Aspects	Calculation
Benefit	Financial	Sales income from fresh fruit production **($X1_{PKS}$)**, oil, palm oil and palm kernels **($X2_{PKS}$)**, logging value obtained from forest conversion **($X3_{PKS}$)**.
Cost	Financial	Plant investment cost **($X12_{PKS}$)**, non-plant investment cost (**$X13_{PKS}$**), maintenance cost of productive plants **($X14_{PKS}$)**, cultivating and transportation cost (**$X15_{PKS}$**), processing cost **($X16_{PKS}$)**, labor cost **($X17_{PKS}$)**, general cost **($X18_{PKS}$)**, depreciation **($X19_{PKS}$)**.
Benefit	Environment	Benefits of Empty Fruit Bunch (EFB), shell, and fibers for fertilizer **($X4_{PKS}$),** as well as the value of palm oil plantation as water regulator (**$X5_{PKS}$**), erosion controller **($X6_{PKS}$)**, water nutrient cycle regulator **($X7_{PKS}$)**, and carbon absorber **($X8_{PKS}$)**.
Cost	Environment	Refers to the opportunity cost of the lost ecosystem benefits occurring due to forest conversion. The components of palm oil plantation's environmental cost encompass the potential value of logging stands **($X1_{EH}$)** and non-logging products **($X2_{EH}$)** within the forest ecosystem. Forest ecosystem value as the controller of natural disturbance **($X3_{EH}$)**, nutrient cycle controller **($X4_{EH}$)**, flood controller **($X5_{EH}$),** biodiversity source (**$X6_{EH}$**), soil formation **($X7_{EH}$)**, erosion controller (**$X8_{EH}$**), water controller **($X9_{EH}$)**, and carbon absorber **($X10_{EH}$)**, as well as heritage value of forest ecosystems **($X11_{EH}$)**, and other elective values of forest ecosystems **($X12_{EH}$)**.
Benefit	Socio-economics	Income for palm oil plantation's labor **($X9_{PKS}$)**, the values of social facilities built by palm oil corporation **($X10_{PKS}$)**, and society income derived from the activities surrounding palm oil plantation **($X11_{PKS}$)**.
Cost	Socio-economics	Refer to the opportunity cost from the social-economic benefits of the forest ecosystems. The components of the social-economic benefits of palm oil plantation encompass the loss of society income derived from logging and non-logging sales **($X13_{EH}$)** and health care cost **($X14_{EH}$)**, which refers to society's expense to take care of their health as the forest is converted into palm oil plantation

objects. The methods employed to answer the research objectives are presented in the **Table 1**.

The data to calculate all the benefits and costs for both palm oil plantations and forest ecosystems were obtained from a survey of 105 samples from communities surrounding palm oil plantations. Several variables were used in calculating the benefits and costs of forest conversion in Melawi District, which were derived from all the costs and benefits of palm oil plantations and forest ecosystems. The definitions of the variables are presented in the **Table 2**. The research tools used are presented in the following **Tables 3**, **4**.

RESULT AND DISCUSSION

The analysis of the financial cost-benefit encompasses an activity or project that should be an indicator to determine the feasibility of the aforementioned activity/project. With respect to the cost-benefit analysis of palm oil plantations, this analysis is employed as an indicator to determine the financial feasibility (cash flow) of palm oil plantations. A similar analysis is also conducted on the forest ecosystem management. The results are then compared to determine more favorable leverage options based on financial cost-benefit analysis, environmental cost-benefit analysis, and socio-economic cost-benefit analysis. Based on the calculation of the financial cost-benefit analysis for palm oil plantation and forest ecosystem protection, the results are presented in the **Tables 5–7**.

Based on the calculation of the cost-benefit for the financial feasibility above, it can be concluded that forest ecosystem protection is more feasible to implement than land clearing activities, which are then converted into palm oil plantations. This is indicated by a larger B/C ratio value recorded by the forest ecosystem protection activities (4.24) than opening palm oil plantations (1.17).

TABLE 3 | Cost-benefit components of forest ecosystem.

Components	Aspects	Calculation
Benefit	Financial	Potential value of logging stands (**X1**$_{EH}$) and non-logging values of forest products (**X2**$_{EH}$) existing within forest ecosystem.
Cost	Financial	Loss of income derived from Empty Fruit Bunch sales (**X1**$_{PKS}$), palm oil and palm kernels (**X2**$_{PKS}$).
Benefit	Environment	The value of forest ecosystem as natural disturbance controller (**X3**$_{EH}$), nutrient cycle controller (**X4**$_{EH}$), flood controller (**X5**$_{EH}$), biodiversity source (**X6**$_{EH}$), soil formation (**X7**$_{EH}$), erosion controller (**X8**$_{EH}$), water regulator (**X9**$_{EH}$), carbon absorber (**X10**$_{EH}$), heritage value of forest ecosystem (**X11**$_{EH}$), and other elective values of forest ecosystem (**X12**$_{EH}$).
Cost	Environment	Refer to the opportunity cost of the environmental benefits of palm oil plantation, which was lost because the forest ecosystem is not converted into palm oil plantation. The components of environmental cost of forest ecosystem encompass the benefits of Empty Fruit bunch, shells, and fibers for fertilizer (**X4**$_{PKS}$), ecosystem value of the plantation as water regulator (**X5**$_{PKS}$), water erosion controller (**X6**$_{PKS}$), water nutrient cycle controller (**X7**$_{PKS}$), and carbon absorber (**X8**$_{PKS}$).
Benefit	Socio-economics	The loss of society income is derived from logging, and non-logging sales (**X13**$_{EH}$) and health care cost (**X14**$_{EH}$), which refers to society's expense to take care of their health as the forest is converted into palm oil plantation.
Cost	Socio-economics	Refer to the opportunity cost of the socio-economic benefits of palm oil plantation. The components of socio-economic cost encompass the income of the society members working in palm oil plantation (**X9**$_{PKS}$), the value of social facilities built by palm oil corporations (**X10**$_{PKS}$), and society income derived from any activities surrounding palm oil plantation (**X11**$_{PKS}$).

TABLE 4 | Research tools.

Palm oil Plantation	Forest Ecosystem
NPV Financial Benefit of Palm Oil Plantation (**MF**$_{PKS}$)	NPV Financial Benefit of Forest Ecosystem (**MF**$_{EH}$)
NPV Environmental Benefit of Palm Oil Plantation (**ML**$_{PKS}$)	NPV Environmental Benefit of Forest Ecosystem (**ML**$_{EH}$)
NPV Socio-economic Benefit of Palm Oil Plantation (**MSE**$_{PKS}$)	NPV Socio-economic Benefit of Forest Ecosystem (**MSE**$_{EH}$)
NPV Total Benefit of Palm Oil Plantation (**MT**$_{PKS}$)	NPV Total Benefit of Forest Ecosystem (**MT**$_{EH}$)
NPV Financial Cost of Palm Oil Plantation (**BF**$_{PKS}$)	NPV Financial Cost of Forest Ecosystem (**BF**$_{EH}$)
NPV Environmental Cost of Palm Oil Plantation (**BL**$_{PKS}$)	NPV Environmental Cost of Forest Ecosystem (**BL**$_{EH}$)
NPV Social-economic Cost of Palm Oil Plantation (**BSE**$_{PKS}$)	NPV Social-economic Cost of Forest Ecosystem (BSE$_{EH}$)
NPV Total cost of Palm Oil Plantation (**BT**$_{PKS}$)	NPV Total cost of Forest Ecosystem (**BT**$_{EH}$)
NPV Net Income of Palm Oil Plantation (**YB**$_{PKS}$)	NPV Net Income of Forest Ecosystem (**YB**$_{EH}$)

TABLE 5 | Results of the comparison for cost-benefit of financial feasibility for palm oil plantation and forest ecosystem protection (in thousands IDR*).

Components	Palm oil Plantation	Forest Ecosystem
PV Total Benefits	10,049,180,275	44,286,460,585
PV Total Cost	8,594,436,770	10,456,045,027
NPV	1,454,743,504	33,830,435,558
B/C Ratio	1.17	4.24
NPV per hectare	146,075	3,383,044
B/C per hectare	1.17	4.24

**IDR is the Indonesian Currency.*

TABLE 6 | Results of the comparison for cost-benefit of environment feasibility for palm oil plantation and forest ecosystem protection (in thousands IDR).

Components	Palm oil Plantation	Forest Ecosystem
PV Total Benefits	1,207,895,320	44,286,460,585
PV Total Cost	255,428,458,905	10,456,045,027
NPV	−254,220,563,585	33,830,435,558
B/C Ratio	0.005	4.24
NPV per hectare	−25,422,056	3,383,044
B/C per hectare	0.005	4.24

Based on the calculation of the cost-benefit analysis for environment feasibility, forest ecosystem protection activities are considered more feasible to implement than land clearing activities. This is indicated by the larger B/C ratio for forest ecosystem protection activities (8.36) than opening palm oil plantations (0.005). Based on the calculation of the cost-benefit for socio-economic feasibility, forest clearing activities are more feasible to implement than forest ecosystem protection activities. This is indicated by the larger B/C ratio of the activities in palm oil plantations (5.11) than in forest ecosystem protection activities (0.16).

Meanwhile, based on the calculation of the total cost-benefits, which is the sum of the financial, environmental, and socio-economic feasibility, we can conclude that forest ecosystem protection activities are more feasible to implement than forest clearing activities. This is indicated by the higher B/C ratio for forest ecosystem protection (3.16), compared to land clearing for palm oil plantations (0.06). The full calculation is presented in **Table 8**.

Even though the calculation of the total cost-benefit indicates that palm oil plantation activities are not feasible, it does not

TABLE 7 | Results of the comparison for cost-benefit of socio-economic feasibility for palm oil plantation and forest ecosystem protection (in thousands IDR).

Components	Palm oil Plantation	Forest Ecosystem
PV Total Benefits	5,490,694,891	982,484,063
PV Total Cost	1,073,941,844	6,036,087,459
NPV	4,416,753,048	−5,053,603,396
B/C Ratio	5.11	0.16
NPV per hectare	978,652	−505,360
B/C per hectare	5.11	0.16

TABLE 8 | Results of the comparison of total cost-benefit feasibility for palm oil plantation and forest ecosystem protection (in thousands IDR).

Components	Palm oil Plantation	Forest Ecosystem
PV Total Benefits	16,747,770,486	56,385,621,338
PV Total Cost	265,096,837,519	17,822,271,431
NPV	−248,349,067,033	38,563,349,907
B/C Ratio	0.06	3.16
NPV per hectare	−24,834,907	3,856,355
B/C per hectare	0.06	3.16

mean that such activities cannot be implemented. In this respect, the study attempts to find a model to optimize the palm oil plantation areas within the forest ecosystem in Melawi Regency by comparing the total cost-benefits of palm oil plantation and forest ecosystems protection, which will determine the feasibility index (Ky). The calculation period comprises twenty-five years.

The calculation of the Ky index obtained a value equal to−6.4401. This indicates that every 10,000 ha of palm oil plantation that was converted from forest will cause damage equal to 6.4401 times the possible benefit if 10.000 ha forest area is not converted to palm oil plantation. In other words, every activity for 10,000 ha in palm oil plantations must be balanced by maintaining 64,401 ha of forest ecosystem; so that the environmental damage caused by palm oil plantation can be offset by forest ecosystem benefits.

The limitation from this study is insufficient representation of respondents who were involved in the survey to see people's perceptions about forest converting for oil palm plantations, especially from the legislature and from communities who did not receive direct benefits from the existence of oil palm plantations.

CONCLUSION

In respect of the feasibility analysis of an activity related to natural capital, such as forest ecosystem, it would be more appropriate if the insurance approach is employed. This is because the forest has a long-term usage, and once the forest is destroyed, it is difficult to restore.

However, this does not mean that forest conversion for beneficial socio-economic activities for society cannot be carried out. It merely emphasizes that forest conversion should heed the element of eligibility. Any activity changing forest function should be carried out simultaneously with activities that maintain the forest ecosystem under certain limitations.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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