

# Assessing impacts on ecosystem services under various plausible oil palm expansion scenarios in Central Kalimantan, Indonesia

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## Key messages

- The land-use change caused by oil palm expansion results in adverse impacts on ecosystem functions and services provided by natural forests.
- This study assesses the impacts of oil palm expansion on key ecosystem services and analyzes the trade-offs among ecosystem services under four plausible future land-use scenarios in Central Kalimantan, Indonesia: business as usual, moratorium, zero gross deforestation and sustainable intensification.
- A trade-off between carbon benefit and habitat quality was observed in the area with low carbon stock. Providing some habitat quality in areas of oil palm expansion enhanced the carbon benefit.
- A synergy between carbon sequestration and water yield was evident due to oil palm expansion on Dry Rice Land with Mixed Scrub under the zero gross deforestation scenario.
- Among the four plausible LULC scenarios, zero gross deforestation is the most desirable option for the study area in Central Kalimantan.
- A successful implementation of zero gross deforestation requires a review of the forest moratorium to encompass all forest types, a clear land-use policy strategy and a detailed land-use plan involving all jurisdictions and engagement of stakeholders.
- Sustainable intensification is the second-best land use and land cover option for oil palm expansion with an assumed average yield enhancement to 5 tCPO ha<sup>-1</sup> yr<sup>-1</sup>. However, enhancing yield in smallholder farms by 78% is highly challenging. It may be achievable by providing appropriate and adequate technical and management supports to smallholder farms and by ensuring off-take markets for oil palm produced by smallholders.

## Ecosystem services from oil palm landscapes

Ecosystems and the biological diversity contained within them provide a wide range of ecosystem goods and services (EGS). A continued delivery of these goods and services is essential to human survival and economic prosperity. Among the multitude of definitions and classification systems of EGS, the Economics of Ecosystems and Biodiversity (TEEB) define ecosystem services as “the

direct and indirect contributions of ecosystems to human well-being” (TEEB 2010). They are classified as provisioning, regulating, habitat and cultural services.

Many researchers have studied the change in ecosystem services after the establishment of oil palm plantation in primary forest and peatland (e.g. Sumarga and Hein 2014). The impacts of oil palm plantation include increased negative social and environmental consequences due to loss of multiple ecosystem services. Loss of biodiversity

(e.g. Savilaakso et al. 2014) and a significant contribution to global climate change through carbon emissions are the issues of most concern (Wicke et al. 2010).

The ecosystem services approach introduces a new perspective to underpin our understanding of the natural environment. It accounts for all goods and services derived from nature in economic terms (e.g. Costanza et al. 1997, 2014; Kubiszewski et al. 2013). Changes in land use and land cover affect the ability of landscapes to continue providing the quality and quantity of ecosystem goods and services required for human health and well-being.

Identification and assessment of ecosystem services from oil palm-dominant landscape can serve many purposes. These include (1) raising clarity and awareness of the relative importance of different land use and land cover (LULC) in the landscape, (2) assessing the impacts on ecosystem services under the projected future land-use land cover changes, (3) evaluating the trade-off of ecosystem services among the current and future LULC scenarios; and (4) supporting the evidence-based decision making, policy development and management ensuring sustainable development with enhanced ecosystem services.

## Increasing trend of oil palm expansion in Indonesia

Palm oil production has become a key to the Indonesian economy. It provides revenues and generates employment for millions of people, supporting their livelihoods across the production and supply chain (e.g. World Growth 2011; Budidarsono et al. 2012). With the extensive expansion of oil palm plantations since 1990 (Gunarso et al. 2013), Indonesia has become the global leader in palm oil production and export (World Factbook 2016). To leverage the economic and social benefits, Indonesia targets increasing palm oil production to 40 million tonnes by 2020 (World Growth 2011). An additional production of palm oil is needed to supplement biofuel for domestic consumption in order to reduce dependency on fossil fuel and achieve the climate benefits (Kharina et al. 2016). The outlook for 2050 predicts a significant increase in global demand in the range of 93–256 million tonnes per year (Corley 2009).

From 1990 to 2015, Kalimantan (Indonesian part of Borneo) expanded oil palm by 4.67 million ha. About three-quarters of the plantation (3.47 million ha) occurred in the areas previously occupied by natural forests and the remaining one-quarter in non-forest land (Gaveau et al. 2014). In addition to the industrial oil palm plantation,

smallholder oil palm plantations have significantly increased. They can generate relatively high profits using less labor and fewer additional inputs than other activities such as rattan production or agriculture (Jelsma et al. 2009; Feintrenie et al. 2010). In 2013, smallholder oil palm plantation accounted for more than 40% of the total oil palm plantation in Indonesia (Glenday and Paoli 2015).

## Sustainable palm oil production – a challenge

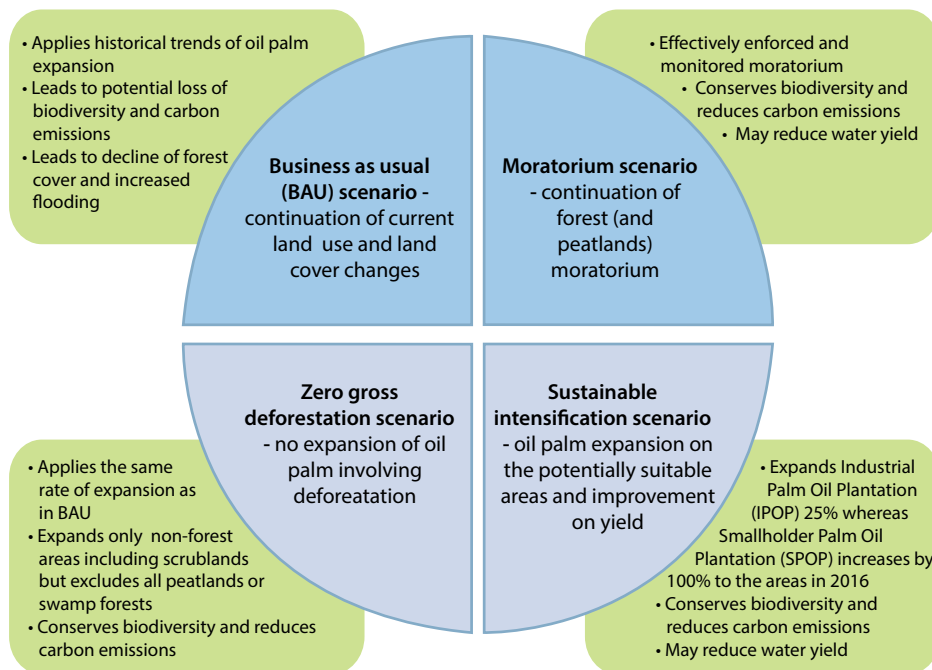
Sustainable palm oil production has become a prerequisite for clean and green palm oil to supply global markets. The Roundtable on Sustainable Palm Oil Standard (RSPO) developed by multi-stakeholders and the Indonesian government's Sustainable Palm Oil Standard (ISPO) are instrumental in strengthening sustainability in palm oil production and supply chains (EFECA 2016). Both require companies to adhere to the principles and criteria for sustainable palm oil production. Nevertheless, the global demand for palm oil creates a powerful financial incentive to expand oil palm in forests and peatland.

Indonesia's forest moratorium, in effect since May 2011, is directed to prevent deforestation of the primary forests and peatlands for oil palm expansion, timber plantation or logging (Murdiyarso et al. 2011). However, the moratorium is criticized for its narrow scope (Busch et al. 2014) and lack of enforcement and monitoring at the ground level due to limited institutional capacity and support to the local government (Austin et al. 2014).

There are two main options to support expansion of oil palm without exerting pressure on forests and peatlands, while supporting sustainable palm oil production. The first option is to expand oil palm in degraded lands. This concurs with the land-use policy announcement in 2010 that encourages oil palm expansion only in degraded land (Gingold et al. 2012). The policy aims to provide adequate land for oil palm expansion and also help avoid emissions due to deforestation of natural forest and peatlands. The second option is to enhance palm oil yield per unit of land (e.g. Wicke et al. 2010). This tactic can address issues undermining productivity in smallholder oil palm plantations as highlighted by Lee et al. (2011). In this way, smallholders can play a pivotal role in sustainable palm oil production in Indonesia.

## Assessing impacts on ecosystem services from oil palm expansion

Given the dynamics of oil palm expansion and its projected future growth, it is critical to assess its impacts on key



**Figure 1. Four future LULC scenarios and associated outcomes on ecosystem services**

ecosystem services and analyze the trade-offs under plausible future land-use scenarios for oil palm expansion. This Infobrief summarizes the research findings from five regencies of Central Kalimantan conducted under the Governing Oil Palm Landscapes for Sustainability (GOLS) Project.

## Plausible land use and land-cover scenarios of oil palm expansion

The plausible scenario is a projection of likely land use and land-cover change (LULC) in an ecosystem or ecosystems within a landscape or defined geographic area. The trajectory of past and current land uses, social need, economic development and future change in land-use policy are often used to determine future land-use scenarios (Sumarga and Hein 2014; Sharp et al. 2016). Consultation with the members of GOLS research team identified four LULC scenarios, which stakeholders subsequently validated (Figure 1). The stakeholders represented the government, non-governmental organizations, companies and local communities. They were consulted through a workshop in Pangkalan Bun in Central Kalimantan on 22 November 2016.

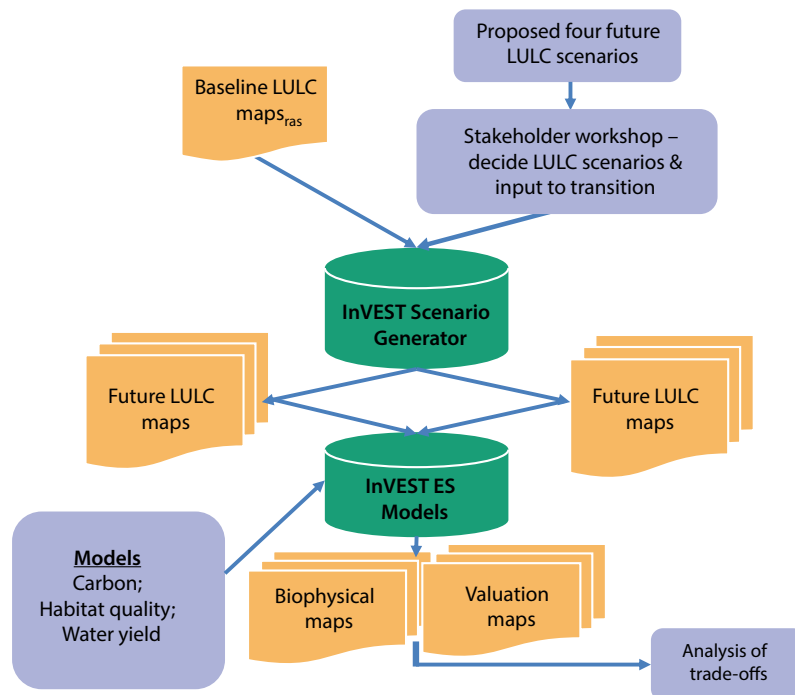
The future land-use scenarios were modeled using Scenario Generator embedded in the Integrated Valuation

of Ecosystem Services and Trade-offs Tool (InVEST), developed by the Natural Capital Project (Sharp et al. 2016). For assessing the impacts on the selected key ecosystem services, the InVEST modules were run for each future land-use scenario. Outputs are analyzed for spatial and temporal distribution of the ecosystem services and their trade-offs resulting from the land-use change under these scenarios.

Figure 2 shows the conceptual research framework that outlines the research methods and tools. It presents a logical approach to this study to accomplish the objectives stated earlier.

## Ecosystem services under future LULC scenarios

Among the ecosystem services listed by the stakeholders at the workshop, four key ecosystem services were selected for further analysis because they are most likely to be impacted by LULC change: (1) carbon storage and sequestration, (2) biodiversity conservation, (3) water yield, and (4) palm oil production. Since palm oil is a commodity and used by humans, it is considered an ecosystem service (e.g. Sumarga and Hein 2014). Further, palm oil is similar to agriculture products. They are both produced from a modified landscape by replacing primary forest or peatlands, or other land uses. These ecosystem services



**Figure 2. A conceptual research framework for the ecosystem services study under future land-use scenarios**

were analyzed in the medium timeframe (present to 2030) for assessing the impacts of plausible LULC scenarios.

## Carbon storage and sequestration

Land use and land-cover change contributes greenhouse gas (GHG) emissions, carbon storage and sequestration. The InVEST Carbon Storage and Sequestration model was used for mapping, quantifying and valuing carbon stored and sequestered under a LULC scenario. It applies carbon stock in the above and below ground biomass, soil and dead organic matter to the current and future LULC maps, as well as the current and future harvesting schedule. This allows for mapping and quantifying carbon in the current and future LULC.

Results indicate that carbon stock will be reduced under all four future LULC scenarios in the order of: zero gross deforestation, sustainable intensification, business as usual and moratorium. In the moratorium scenario, oil palm expansion occurred on swamp forests based on the World Resource Institute's peatland map 2012 (Gingold et al. 2012). It resulted in loss of carbon stock exceeding the business as usual scenario (Figure 3A).

## Biodiversity conservation

The direct measurement of biodiversity (in terms of genes, species or ecosystems and their abundance and frequency)

is beyond the scope of this study. Such measurements are complex and require significant resources and time to undertake. Therefore, this study used the InVEST Habitat Quality model to assess biodiversity indirectly. To that end, it mapped the habitat quality for various LULC classes using the threat level to biodiversity. As this model applies habitat-based approaches, it is relatively simple. It requires minimal data inputs for mapping areas of varying conservation priorities in a landscape. Habitat quality is determined by adding the habitat quality values across the landscape. Thus the sustainable intensification scenario with 25% less expansion of industrial oil palm plantations provides the highest value of habitat quality. This is followed by the zero gross deforestation, business as usual and moratorium scenarios (Figure 3B).

## Water yield

The provisions of water (availability) and water quality have become a major global concern for the functioning and survival of many biological systems. The InVEST Water Yield model was used to derive water yield maps and quantify water volume under the future LULC scenarios. A LULC scenario with high forest covers produces low water yields and vice versa. Among the four LULC scenarios in the Central Kalimantan study area, water yield is predicted to be relatively low under zero gross deforestation and the highest under sustainable

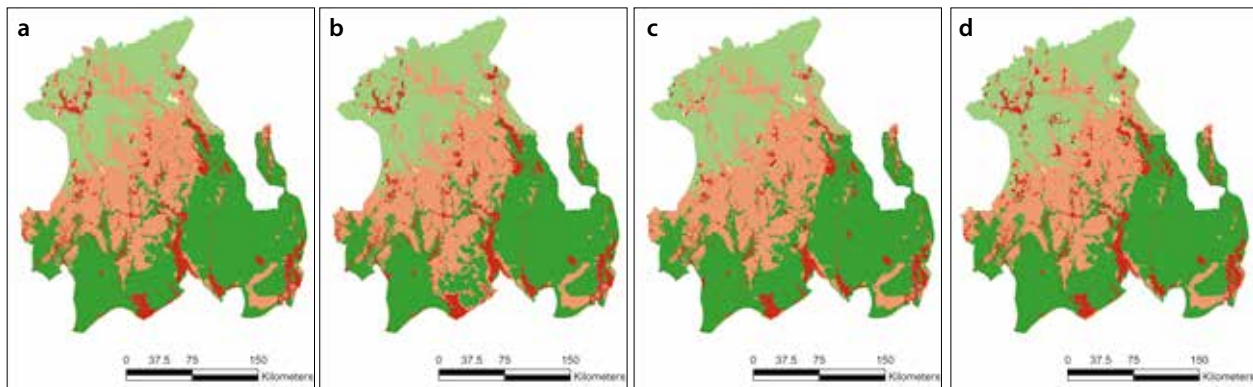


Figure 3A. Carbon stock (tC/ha) in the LULC classes under business as usual (a), moratorium (b), zero gross deforestation, (c) sustainable intensification, and (d) scenarios in Central Kalimantan study area. The darker green refers to the highest carbon stock up to 2320 tC/ha and the dark red refers to the lowest carbon stock of below 70 tC/ha.

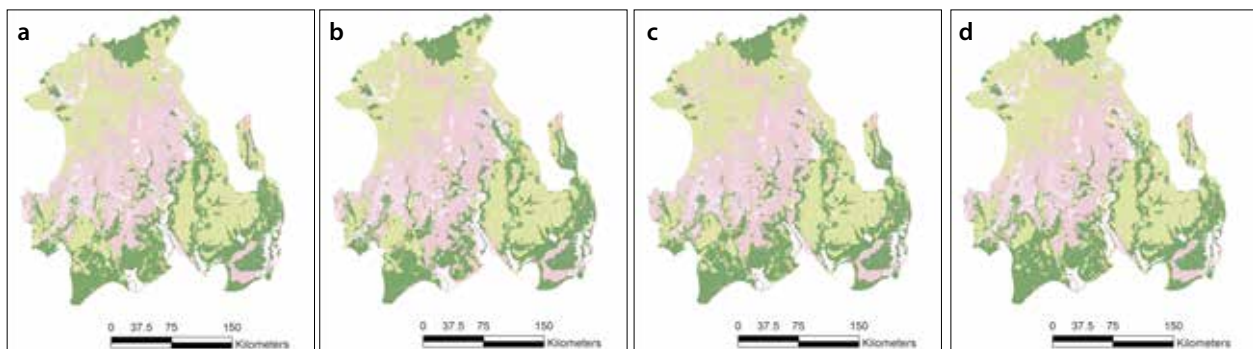


Figure 3B. Habitat quality under business as usual (a), moratorium (b), zero gross deforestation, (c) sustainable intensification, and (d) scenarios in Central Kalimantan study area. The darker green represents the highest habitat quality with value 1 and white represents the lowest habitat quality with value 0.

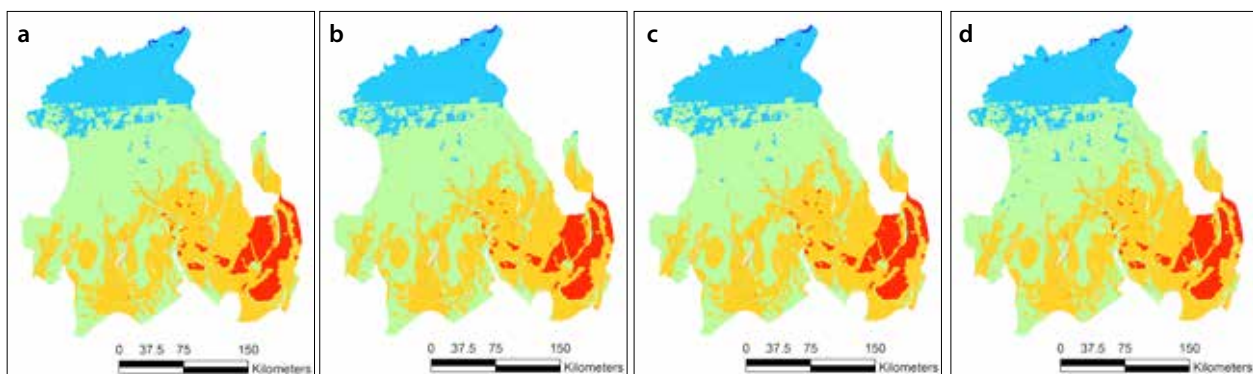


Figure 3C. Water yield map for business as usual (a), moratorium (b), zero gross deforestation, (c) sustainable intensification, and (d) scenarios in Central Kalimantan study area. Red represents the lowest water yield per year between 601-1000 mm and dark blue represents the highest water yield per year between 2501 – 3000 mm.



intensification. The latter can be attributed to the relatively low forest cover (Figure 3C).

## Palm oil production

A price of USD 690 per tonne of crude palm oil (tCOP) from the Malaysian Palm Oil Council (MPOC) was used to evaluate palm oil production ([http://www.mpoc.org.my/Daily\\_Palm\\_Oil\\_Prices.aspx](http://www.mpoc.org.my/Daily_Palm_Oil_Prices.aspx)). Despite less area of oil palm under the sustainable intensification scenario, this service generates gross revenue of USD 1390 million in Central Kalimantan study areas (i.e. equivalent to USD 2070 ha<sup>-1</sup> yr<sup>-1</sup>). This figure reflects enhanced productivity under the intensive management regime. Both IPOP and SPOP assumed an average yield of 5 tCPO ha<sup>-1</sup> yr<sup>-1</sup>, which is on par with the average yield under the RSPO-certified plantation. By using an average yield of 3.7 tCPO ha<sup>-1</sup> yr<sup>-1</sup> in IPOP and 2.8 tCPO ha<sup>-1</sup> yr<sup>-1</sup> in SPOP, the other three scenarios generate the same gross revenue of USD 1298 million (i.e. equivalent to USD 1514 ha<sup>-1</sup> yr<sup>-1</sup>) due to the same production level in the study area.

## Trade-offs or synergies and overall impacts on ecosystem services under various LULC scenarios

The flows of the ecosystem services are assessed to analyze their trade-offs or synergies under a LULC scenario. A trade-off implies conflicts between ecosystem services (ES) where both ES cannot be maximized at the same

time under a LULC scenario (Turkelboom et al. 2016). By contrast, synergy indicates an enhancement of two or more ecosystem services at the same time under a LULC scenario (Turkelboom et al. 2016).

In the study area, a trade-off between carbon benefit and habitat quality was noticed under LULC scenarios. For example, in the zero gross deforestation scenario, oil palm expansion in low carbon area with some habitat quality (such as scrubland) enhanced the carbon benefit. However, the habitat quality was negatively impacted relative to the previous land use after replacement by oil palm plantation.

The conversion of non-forest land into oil palm plantation can reduce water yield due to an increase in evapotranspiration from the previous land use. A synergy between carbon benefit and (reducing) water yield was evident due to oil palm expansion on Dry Rice Land with Mixed Scrub (DRLMS) under the zero gross deforestation scenario.

All four-ecosystem services were combined for each LULC scenario through a qualitative approach. These ecosystem services were ranked lowest to highest (1–4). A rank of 2 and 3 represent fair and good ecosystem services, respectively. These rankings are pulled together and illustrated in Figure 4 for all four LULC scenarios. Overall, the zero gross deforestation scenario is the most desirable LULC option followed by sustainable intensification, business as usual and moratorium in terms of the four ecosystem services assessed in this study (Figure 4).

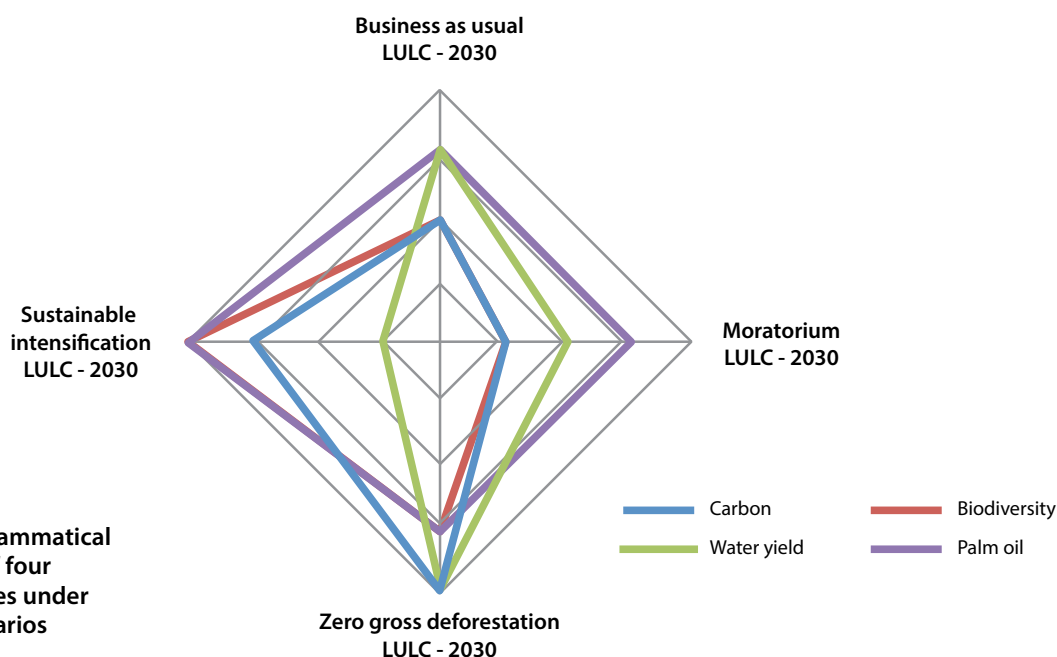


Figure 4. A diagrammatical representation of four ecosystem services under future LULC scenarios

## Conclusions

Among the four plausible LULC scenarios, zero gross deforestation is the most desirable option. This conclusion is based on analysis of the key ecosystem services comprising carbon stock and storage, habitat quality, water yield and palm oil production. The next most desirable scenario is sustainable intensification for the study area in Central Kalimantan. Sustainable intensification avoided release of almost four times less carbon stock (-31 million tC) as the business as usual scenario (-119 million tC), saving an equivalent net present value of USD 993 million.

With the oil palm expansion on DRMLS, zero gross deforestation resulted in the lowest water yield. It also avoided disservice in the form of high water runoff with soil loss due to high water yield in contrast to the sustainable intensification scenario. Zero gross deforestation also adheres to sustainability principles and criteria for clean and green palm oil production. Successful accommodation of this option requires a review of the forest moratorium. It should encompass all forest types, and a clear land use policy, strategy and detailed land-use plan involving all jurisdictions and stakeholders. Firm commitments and coordination are needed to implement the policy and plans, and monitor and report to the relevant authorities on actual progress on the ground.

With an assumption of enhanced palm oil productivity, sustainable intensification was the second best LULC option for oil palm expansion. This scenario generated about 37% more average gross revenue per hectare per year than zero gross deforestation. However, enhancing yield in smallholder farms from 2.8 ha<sup>-1</sup> yr<sup>-1</sup> to the average yield of 5.0 ha<sup>-1</sup> yr<sup>-1</sup> on par with the RSPO-certified farms is highly challenging. It may be achievable by providing smallholder farms with appropriate and adequate technical and management supports and by ensuring markets for their palm oil.

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