KATINGAN PEATLAND RESTORATION AND CONSERVATION PROJECT

MONITORING & IMPLEMENTATION REPORT

Document Prepared by PT Rimba Makmur Utama

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The Katingan Project's goal is to protect and restore 149,800 hectares of peatland ecosystems, to offer local people sustainable sources of income, and to tackle global climate change – all based on a solid business model. The project area stores vast amounts of CO_2, and plays a vital role in stabilizing water flows, preventing devastating peat fires, enriching soil nutrients and providing clean water. It is rich in biodiversity, being home to large populations of many high conservation value species, including some of the world's most endangered; such as the Bornean Orangutan (*Pongo pygmaeus*) and Proboscis Monkey (*Nasalis larvatus*). It is surrounded by villages for which it supports traditional livelihoods including farming, fishing, and non-timber forest products harvesting.

This 4th monitoring report covers the period from 1st January 2018 through 31st December 2018. During this time, the project continued and built upon activities conducted during the first three monitoring periods and introduced new activities as appropriate. Conservation and reforestation efforts focused on fire prevention and awareness training and seedling nursery development. Community activities included ongoing support of community-based businesses and microfinance operations, advancing the community participatory planning efforts, and additional funding for public health clinics and improved sanitation.

During the 2018 monitoring period, the project avoided the emission of 5,133,319 tonnes CO_2e. Zero leakage was recorded, and non-permanence risk was determined to be the minimum. A small fire, affecting around 330.17 ha contributed to emission losses of 35,596.66 tonnes CO_2e, while a small amount of deforestation occurred affecting around 64.28 ha, but losses in terms of emissions (against prior predictions) were small in comparison to the total credits generated.

1.2 Sectoral Scope and Project Type

The Katingan Project is categorized as an Agriculture, Forestry and Other Land Use (AFOLU) project under the Reduced Emissions from Deforestation and Degradation (REDD) project category. The project activities are categorized under the VCS as a combination of REDD+WRC and ARR+WRC; specifically, as Avoiding Planned Deforestation (APD) and Reforestation (ARR), in combination with Conservation of Undrained and Partially drained Peatland (CUPP) and Rewetting of Drained Peatland (RDP) activities. This is not a grouped project.

1.3 Project Proponent

The Katingan Project is developed and managed by PT. Rimba Makmur Utama (RMU). By collaborating with the project-zone communities and partner organizations, PT. RMU takes full responsibility to manage, finance and implement project activities for the duration of the project. Table 1 shows the project proponent's information.

Table 1. Project proponent information

Organization name	PT. Rimba Makmur Utama (PT. RMU)
Role in the project	PT. RMU is the project developer, ERC licenses holder and lead implementer. It is responsible for the overall management, financing and implementation of the Katingan Project. Proposed project activities are to be carried out in collaboration with communities in the project zone and project partners as described below.
Contact person	Dharsono Hartono
Title	Director
Address	Menara BCA, Fl. 45, Jl. MH Thamrin No. 1, Jakarta, Indonesia

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1.4 Other Entities Involved in the Project

Key implementing and technical partners are shown below.

Organization name	Yayasan Puter Indonesia
Role in the project	Community development activities, including: • Participatory land-use mapping • Community consultations and REDD+ awareness building • Livelihood programs
Contact person	Andaman Muthadir
Title	Program Manager
Address	Jalan Ahmad Yani II, Nomor 11A, Bogor, 16151, Indonesia
Telephone	Tel/Fax: +62 (0)251-831-2836
Email	andaman.muthadir82@gmail.com

Organization name	Wetlands International
Role in the project	Wetlands International leads technical aspects of MRV-related activities, including: • MRV methodology and platform development for monitoring above- and below-ground carbon emissions; • The provision of technical expertise including biodiversity management, fire management, land-use management and community development
Contact person	I. Nyoman Suryadiputra
Title	Director Indonesia Programme, Wetlands International
Address	Indonesia Programme office: Jl. Bango 11, Bogor, 16161, Indonesia
Telephone	+62 251 8312189
Email	nyoman@wetlands.or.id

Organization name	Permian Global
Role in the project	Technical advice and support, including: • MRV methodology design and technical support • Remote sensing • Carbon commercialization and marketing • Technical management advice including protection and restoration methods
Contact person	Dr. Nick Brickle
Title	Asia Director
Address	Savoy Hill House, 7-10 Savoy Hill, London, WC2R 0BU, UK

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Email	info@permianglobal.com

1.5 Project Start Date

The project start date is 1st November 2010.

1.6 Project Crediting Period

The duration of the VCS project crediting period is 60 years, beginning on the project start date of 1st November 2010 and ending on 31st October 2070.

1.7 Project Location

1.7.1 Project geographic boundaries

The project is located in the Mendawai, Kamipang, Seranau and Pulau Hanaut sub-districts of Katingan and Kotawaringin Timur districts, Central Kalimantan, Republic of Indonesia (see Map 1). The project lies within the following geographic boundaries: S2° 32' 36.8" to S3° 01' 43.6" E113° 00' 29.7" to E113° 18' 57.4".

Map 1. Location of the Katingan Project in Kalimantan, Indonesia

1.7.1.1 Project area

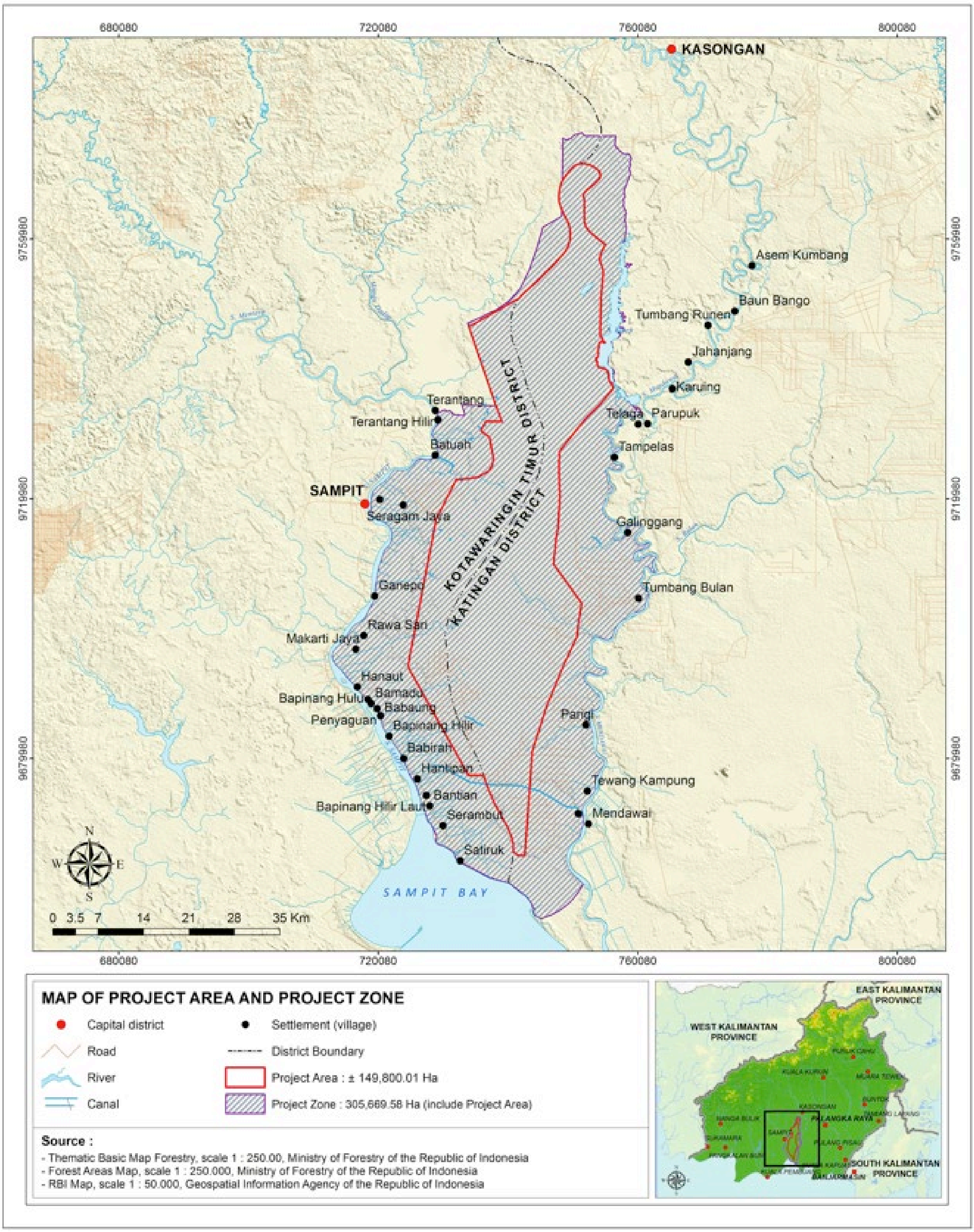
The project area encompasses 149,800 ha of land with a total perimeter of 254.12 km (see Map 2). The project area boundary delineates the area in which GHG emission reductions are quantified.

The project area is in the process of being physically demarcated using concrete and wooden marker posts, in line with prevailing regulation concerning Ecosystem Restoration Concessions: where the bordering land-use is of an equivalent legal status (i.e. Production Forest/Hutan Produksi), and/or the border marks the edge of the concession, then wooden marker posts every 100m should be used (Directorate General Forest Planology Decree Number P.5/VII-KUH/2011). Where the bordering land use is a different status (e.g. Conversion Forest/Hutan Produksi Konversi), then concrete posts every 700-1100m should be used (Directorate General Forest Planology Decree Number: P.6/VII-KUH/2011). By the end of this monitoring period 144 km of the project area boundary has already been physically demarcated, with the remainder scheduled to be completed in 2019.

1.7.1.2 Project zone

The wider project zone represents the extent of the area in which the project activities are implemented. It extends to the banks of the Mentaya River in the west and the Katingan River in the east, and encompasses bordering areas to the north and south of the project area, covering an area of 305,669 ha (see Map 2). The project zone was selected based on the dominant ecological, landscape and socio-economic features and in particular to include the main river catchments and to encompass the land of 34 villages likely to be affected by the project. No additional areas beyond the project zone are expected to be directly affected by the project.

Map 2. The location of the project area and project zone



1.8 Title and Reference of Methodology

The Katingan Project applies the latest version of approved VCS methodology VM0007 (version 1.5), including all applicable modules as detailed in this report.

1.9 Other Programs

Emission Trading Programs and Other Binding Limits: During this monitoring period, activities carried out by the project are not covered by any emission trading programs or other binding limits in relation to GHG emissions. Presidential Decree No. 61/2011 regarding the National Action Plan for Reducing Green House Gas Emissions requires government agencies to set reduction targets for specific sectors and identify plans for achieving these goals. The project is not currently subject to these targets nor will its reductions be used to demonstrate achievement of the agency goals.

Other Forms of Environmental Credit: The Katingan Project currently only seeks carbon credits under the VCS program and has not received other forms of environmental credits from its activities.

Participation under Other GHG Programs: The Katingan Project has not been registered under any emissions trading programs but may seek to do so in the future. In this case applicable requirements in the VCS Standard, AFOLU Requirements, and the Registration and Issuance process will be followed. The project will not claim credit for the same GHG emission reduction or removal under the VCS Program and another GHG program.

1.10 Sustainable Development

Indonesia's sustainable development priorities are now closely aligned with the UN Sustainable Development Goals. Indonesia assisted in the creation of the UN SDGs and has expressed its strong commitment to the 2030 Agenda and the SDGs overall. The current President Joko Widodo instructed the National Development Planning Agency (Bappenas), to map the goals and targets of Indonesia's national plan to the SDGs, finding that 108 out of 169 SDG targets are addressed already in the national plan. A Presidential Regulation has now been passed (Perpres 59-2017) to establish governance mechanisms for the SDGs, to guide mainstreaming of the SDGs into sectoral development plans and budgets, and to ensure provincial governments lead implementation of the SDGs at their level.

The Katingan Project supports the achievement of the SDGs and has carefully mapped its activities and measurable achievements to the Indonesian SDG indicators so that they can be incorporated at the national level. This led to the identification of nine SDGs that the Katingan Project will directly contribute, including:

- SDG 1: No poverty
- SDG 3: Good health and well-being for people
- SDG 5: Gender equality
- SDG 6: Clean water and sanitation
- SDG 8: Decent work and economic growth
- SDG 13: Climate action
- SDG 15: Life on land
- SDG 16: Peace, justice and strong institutions
- SDG 17: Partnerships for the goals

For each SDG the Katingan Project identifies national level targets and aims to map these against the output and outcomes of project activities. Table 2 provides an example for SDG 1 of this implementation framework mapping. The full analysis, drafted only in Indonesian, is available on request.

In addition to this mapping and monitoring process, the Katingan project is carefully evaluating the prospect of seeking further accreditation under the fledgling 'SD-Vista' standard being promoted by Verra to allow projects to track and report on their contribution to SDG targets.

Table 2. Example of SDG 1 implementation framework mapping

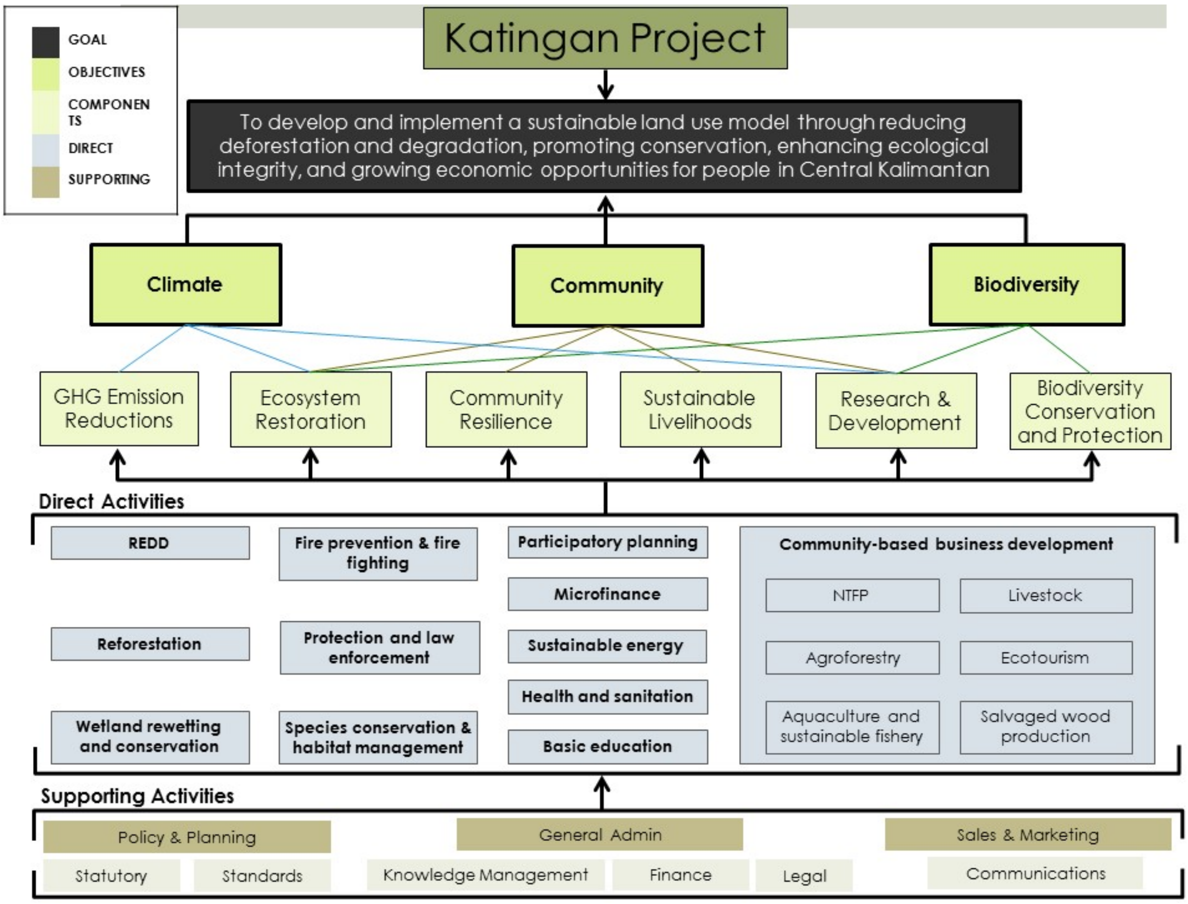
National objectives (Bappenas)	Katingan Project programs
• Eradication of extreme poverty (<USD 1.25/day • 50% decrease in population living below the poverty line • Equal rights to economic resources, access to basic services, ownership and control of land and natural resources, appropriate financial services including micro finance	• Staff salaries above 50% of minimum wage. • Benefit distribution to support sustainable small business • Participatory planning • Facilitating social forestry • Providing access to technological breakthrough in clean water, energy agriculture and processing • Providing microfinance
Katingan Project specific targets	**Katingan Project activities**
• Increase of income for field staff by 50% above minimum wage by 2020 • 20,000 hectares of social forestry	• Conducting periodic data collection and analysis • Developing and implementing a Community Investment Fund • Developing inventory of appropriate technology for clean water, energy agriculture and processing • Implementing *kelola sosial* plan • Facilitating Village Forest in Sub Districts of Kamipang and Mendawai as well as social forestry in District Kotawaringin Timur

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The Katingan Project's activities continue to successfully conserve a vast ecosystem of peat swamp forest which would have otherwise been converted to industrial acacia plantations. All project activities are implemented within the context of the project framework show in Figure 1. A summary of project activities and their achievements during the monitoring period is provided below. No unexpected biodiversity or community impacts occurred as a result of the project's activities during this monitoring period.

Figure 1. Katingan project framework



2.1.1 Avoided Deforestation and peat drainage (REDD + WRC)

The project continues to avoid the deforestation, degradation and drainage of a vast area of peat swamp forest in comparison to the baseline scenario. During this monitoring period some small areas were affected by small-scale illegal logging, while other areas continue to be affected by existing drainage. Activities to address both issues are described below in Sections 2.1.5 and 2.1.3 respectively, and the resulting project emissions are fully quantified in Section 3.

2.1.2 Reforestation (ARR)

At the outset of the project only a relatively small percentage of the project area was non-forest, totalling 4,433 ha. This area is in the process of being reforested using three different approaches: replanting with natural tree species (reforestation), community-led agroforestry and fire break plantations. In all cases, saplings are grown in on-site nurseries and regular maintenance is conducted to improve the rate of tree survival and to control fire risk.

During 2018 around 43 ha had been replanted as part of the ongoing replanting plan. This was made up of 6,800 saplings, of 18 different native tree species (Figure 2. see Section 4.2.3.1 for full details). Local communities are fully involved in the process, including in the management and operation of the nurseries, provision of seedlings, providing biodegradable bags for the seedlings and assisting with the planting and subsequent maintenance.

The community-led agroforestry initiative was focused alongside the transport canal in the south of the project area in areas claimed by local communities. Through the project's community-based business development program, planting began in 2018 with an area of 38 ha planted with 7,600 saplings, all comprised of the economically-valuable native peat-forest species Jelutong (*Dyera lowii*). When mature, these agroforests will generate incomes for local communities and also lower the risk of fire incidents by providing the otherwise open areas with biomass cover. For further details see Section 4.2.3.3.

Small fire-break plantations that were established along the east and west boundaries of the Hantipan canal areas during earlier monitoring periods continue to be maintained. These areas were primarily planted with two local fire-resistant species; Galam (*Melaleuca spp*) and Tumih (*Combretocarpus rotundatus*) and seek to prevent the spread of outside fires into the project area while it is being rehabilitated. For further details see Section 4.2.3.2.

Figure 2. Replanting saplings in the degraded canal zone of the project area.

2.1.3 Peatland rewetting and conservation (RDP)

Peatland rewetting and conservation activities are crucial to maintain the integrity of the peatland ecosystem. Rewetting of the drained peatland (RDP) is being conducted in areas where drainage canals already exist (see Map 3 and Figure 3), while the conservation of undrained and partially drained peatlands (CUPP) will take place in the rest of the project area.

There are two main types of existing drainage canals within the project area; 1) small logging canals (narrower than 2 meters and shallower than 1 meter; see Figure 3) historically made by loggers to access the forest and transport logs; and 2) navigation or irrigation canals (wider than 2 meters; see Figure 4) made by the local government for the purpose of transportation and irrigation for the nearby communities.

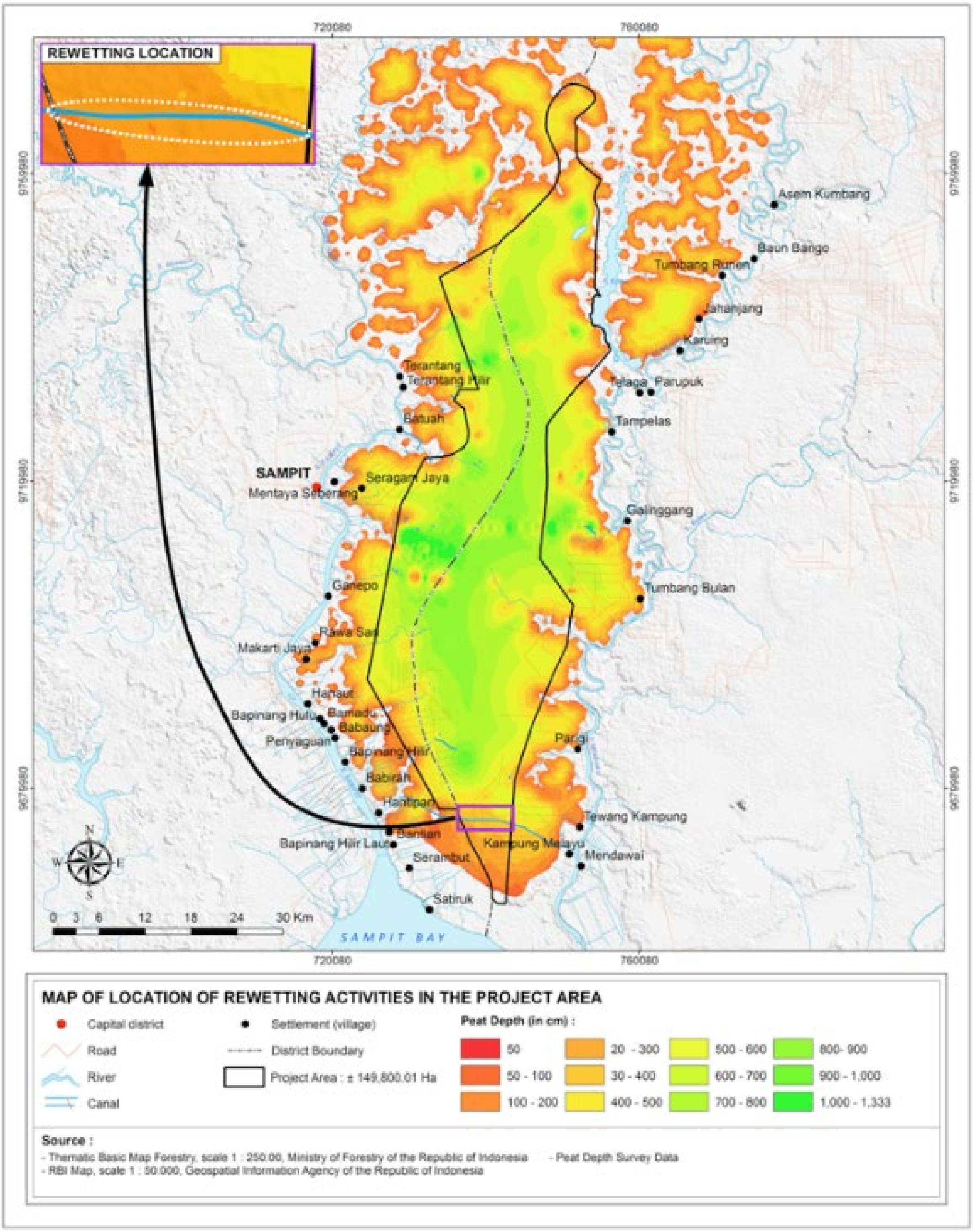
During the monitoring period rewetting efforts were focused on testing approaches to blocking small old ‘logging’ canals, with three dams constructed to test different approaches (Figure 4). Plans to address the larger Hantipan transport canal (Figure 3) continued, but for operational reasons, and due to the need to conduct intensive consultation with local communities and government were stalled in 2018. Plans are now in place, with agreement from local communities, to pilot large-scale dam/sluice designs in 2019. These are intended to reduce the water flow significantly, while still allowing access for transportation between the Katingan and Mentaya rivers.

Protection and conservation measures within undrained areas continued throughout the monitoring period, focused on fire prevention (see below), protection against the creation of any new drainage (see below), and protection against the loss of peat soil by maintaining and replanting tree vegetation in non-forest areas (as above).

Figure 3. A section of the Hantipan Canal used as the main transportation route between the Katingan and Mentaya rivers in the southern part of the project zone

Figure 4. The project team piloting a dam design on a small former ‘logging’ canal.

Map 3. Location of planned rewetting activities in the project area



2.1.4 Fire prevention and suppression

Forest and peatland fires occur almost every year during the dry season on non-forest and drained peatland areas in the project zone. They can spread quickly and travel long distances, and pose immediate threats to all climate, community and biodiversity benefits of the project. They are typically caused by the extreme weather (drought) combined with unsustainable land-use practices, primarily land clearing using fire. As a result, most fires spread from near settlements and adjacent agricultural land. Prior to the start of the project, the most heavily affected region was the area adjacent to the transport canal in the south. This is the area now targeted for reforestation (see above).

Given the highly damaging nature of fires, the Katingan Project takes fire prevention and response very seriously. Key activities throughout the project zone include:

- Participatory fire mapping to identify locations with potential risks to communities and the project zone;
- Development of early warning systems through continuous weather forecasting, water level monitoring, patrolling and community radio systems;
- Establishment of monitoring posts and watch towers in fire prone areas;
- Development of firefighting teams (Regu Siaga Api or RSA) staffed by local community members and provision of fire extinguishing equipment and training; and
- Awareness building programs for communities in the project zone.
- Early warning systems based on automated messaging in response to satellite detected hotspots.

All of these activities were continued during the 2018 monitoring period. During this time over 500 trained community fire fighters, from 21 villages surrounding the project area, were involved in fire-fighting response teams during the dry season. In addition, a further 92 local villagers were involved in deep well installation, logistical support, and clearing access in preparation for the dry season. Despite these efforts 15 fires were detected in the project zone (Table 3), all of which were responded to by the project. Unfortunately, four of these fires spread into the project area before they could be extinguished by the fire response teams. All fires occurred in previously burned areas where the fire risk remains very high. In total 330.17 ha of the project area was affected. Further details, including calculation of the emissions arising from these fires, are included in Section 4.

Table 3. Fire events recorded in the project zone and project area during the 2018 dry season

Event	Month	Village Area	Project Zone/Area
1	January	Desa Babirah	Project Zone
2	July	Selatan(Batembak)	Project Zone
3		Kampung Melayu	Project Zone
4	August	Mendawai	Project Zone
5		Babirah	Project Zone
6		Bantian/selatan	Project Zone
7		Kelampan	Project Area
8		Hantipan(Handil Sekawan)	Project Area
9	September	Batuah	Project Area
10		Kampung Melayu	Project Zone
11		Satiruk	Project Zone
12		Serambut (selatan)	Project Area
13	October	Mendawai	Project Zone
14		Satiruk	Project Zone
15		Bapinang Hulu	Project Zone

2.1.5 Protection and law enforcement

Protection and law enforcement activities seek to prevent illegal exploitation of the project area, including illegal logging, poaching, encroachment, illegal gold mining, peat drainage and forest clearance with fire. This is achieved through a combination of activities, all of which were conducted during the current monitoring period, including:

- Physical demarcation of the project boundary (already completed for entire eastern boundary, now underway for western boundary);
- Identification of specific locations, agents, targeted species, methods, frequency and the typical season of improper activities to be monitored and refrained; including investigative work to identify the downstream supply chain and financial backers of illegal logging (ongoing);
- Mobilization of forest rangers and patrol teams consisting of local community members (ongoing), targeted on main access points;
- Development of community-led monitoring and reporting systems to enforce laws and village regulations (ongoing), including the identification of illegal poachers and loggers, so that they can be targeted for inclusion in alternative livelihood initiatives;
- Establishment of monitoring posts at main entry-exit points to the forest (4 permanent posts, plus 14 temporary posts already established); Establishment of security cameras on main access points (planned for 2019);
- Provision of necessary equipment and training to participating community members (ongoing);
- Awareness building programs for communities in the project zone to enhance their understanding on potential socio-ecological impacts of illegal resource extraction and unsustainable land-use practices (ongoing).
- Collaboration with Police and Forestry Department enforcement staff to initiate coordinated action to address the threat of illegal logging by targeting the financial backers and supply chain (ongoing).

Despite these efforts, in 2018, 64.28 ha of the project area was deforested by illegal logging during the monitoring period. The emissions from this loss are accounted for in Section 4. In line with methodology requirements, emissions losses from degradation (short of deforestation) are accounted for in every other year, and so will be assessed for the period 2018-2019 at the end of the 2019 monitoring period.

2.1.6 Species conservation and habitat management

The vast majority of the biodiversity within the project zone requires no active management beyond the protection of their habitat and prevention of unsustainable exploitation or hunting. These objectives are being delivered through the activities described above and below.

Biodiversity monitoring has continued throughout this monitoring period, most notably with a significant increase in the intensity and scope of the camera trapping program to monitor terrestrial wildlife, with 100 new cameras deployed. This program was started in mid-2016 and will continue on a rolling basis.

The full results of the biodiversity monitoring program are reported every other year as part of the combined VCS-CCB monitoring reports, as such the results for 2018 will be fully reported at the end of the 2019 monitoring period.

2.1.7 Collaborative Management

Collaborative management remains the cornerstone of the Katingan Project's approach to working with communities. As described in previous reports (particularly CCB reporting) The Katingan project's approach to collaborative management is multi-tiered and ongoing, consisting of baseline surveys, initial collaboration agreements, participatory mapping and boundary agreements, village-level planning processes and long-term collaboration agreements. The Katingan Projects' community-based activities are designed to address needs which the project-zone communities have identified through the participatory village planning process. A variety of methodologies are used, including focus-group discussions, interviews, household surveys and others. The maps developed through the community mapping process are used as a basis for dialogue. Through the village planning process, local communities are to discuss and determine short- to medium-term development goals and plan specific activities that can be implemented between them and the Katingan Project.

In addition, as a continuation of the village planning process, the project is now piloting a program of assistance to allow villages to seek formal recognition and tenure over forest estate land in the immediate vicinity of the village (within the project zone, adjacent to the project area) where the project can in turn support sustainable agricultural development (without drainage or the use of fire). During this monitoring period the project facilitated the process for two villages in the east of the project zone, and in 2019 the project is aiming to implement a much larger initiative spanning several villages in the west of the project zone.

To facilitate clear communication with communities, the project employs representatives in every village and manages a grievance reporting process.

2.1.8 Sustainable livelihoods

Community livelihood development is a core priority of the Katingan Project. The goal is to bring substantial benefits to the project-zone communities through sustainable economic development and land use, through support for activities identified during the participatory planning process. A range of activities were supported during 2018 and a selection of these are summarise in Table 4. These activities are reported in full detail on a biennial basis through CCB monitoring. The next such report will be produced in early 2020 covering the period 2018-2019.

Table 4. Example project support for community livelihoods in the project zone in 2018

Type of support	Summary of activities in 2018
Microfinance	Microfinance programs were active in three villages (Mendawai, Rawa Sari and Makarti Jaya) involving 94 women and 58 men. The funds allow the participants to finance small-business and agricultural improvement activities, in line with the objective of creating new sustainable livelihoods.
Business Units	The project supported the creation of two new village business units ("Badan Usaha Milik Desa"/BUMDesa) in Tumbang Runen and Babirah villages. The business units then in turned financed the procurement of a new ferry crossing to support transportation for the villagers in the surrounding area.
Rattan	The project continued to support local rattan weaving business and was able to facilitate a further export of finished products direct to a buyer in the UK (including the export of rattan coffins!).
Ecotourism	Ecotourism on the Katingan river continued to increase in 2018, and through the project's collaboration with one tour operator (WOW Borneo) the project was able to provide ecotourism training to groups from Telaga and Mendawai villages.
Fibre Bags	The project continues to support production of bio-degradable fibre bags used in the tree nurseries. Women from three villages (Kampung Melayu, Tewang Kampung, Parigi) are all now involved in production, with the project buying all stock produced.

Type of support	Summary of activities in 2018
Tree Nurseries	The project continues to support community-run tree nurseries by purchasing seedlings used in reforestation efforts. A women-run nursery in Desa Parupuk was established as a village business unit (BUMDesa) and has now planted around 20,000 seeds, mainly of Jelutung.
Coconuts	The project's program to support coconut growers in the project zone to produce value-added products, particularly coconut sugar, has gone from strength to strength. The program now supports a permanent training centre and processing facility and has supported farmers to establish purchasing contracts with local supermarkets. The program is now experimenting with other value-added products from coconuts and seeking to expand its geographical scope in Pulau Hanaut Sub-district. Revenue from coconut sugar, at a minimum, is around three times higher than revenue from selling the fresh fruit to the market.
Bamboo	In 2018 the project initiated a new program to experiment with growing bamboo to meet a growing domestic demand. Bamboo, utilising local peat-swamp species, has considerable potential to be used in sustainable management of degraded peat areas of the project zone. A number of training events and workshops were held in late 2018 and a large expansion of the program is planned for 2019.
Agriculture	The project continues to invest heavily in initiatives to improve agricultural management to reduce the use of artificial chemicals (which create a huge financial burden for growers) and to avoid the use of fire in land clearance. The project held training initiatives in a number of villages, arranged study tours, and continues to maintain an active agroecology school visited by farmers from across the project zone. The agroecology school is also the centre of focus for experimenting with new crops and promoting their use to local farmers.
Agroforestry	As with agriculture, agroforestry remains a focus for the Katingan Project, largely due to the role it can play in supporting local livelihoods and in reducing the fire risk on degraded peat areas of the project zone. In 2019 much of the focus of agroforestry work with be targeted towards the new village forest initiative underway in the western side of the project zone.
Biogas/Cattle	The project continues to support an initiative in Jahanjang village, also backed by Toyota Bio, to use Napier grass as a source of cattle fodder as part of a system that also captures biogas.

2.1.9 Improved public health and sanitation services

Currently, the project-zone communities only have close access to very basic health care. The Katingan Project is seeking to improve this by working closely with local government to improve access to public services and to assist local government in providing health education at the village level. During 2018 the project supported integrated healthcare services at four community health posts ('Posyandu'; Figure 5) in Mentaya Seberang and Seragam Jaya sub-districts. Support from the project was used to provided training and financial assistance to purchase basic equipment including body measuring instruments, digital scales, baby scales and blood testing kits.

Figure 5. Posyandu in action!


The Katingan Project has also continued to support initiatives to improve sanitation, focusing on the elimination of river latrines, and in support of a regional directive seeking to phase them out. This has led to a number of requests from villages for support, including from Parupuk Village. The project then agreed a cofounding arrangement with the village leading to improvements in the village water storage and supply facilities and the construction of 29 new latrines to replace old river latrines (Figure 6).

Figure 6. Old river latrines replaced by new sanitary latrines in Parupuk village.


2.1.10 Basic education support

Project-zone communities all have the right of access to basic education; however, the accessibility and the quality of schools and teaching remains a challenge. Students in villages with no middle school often need to travel at their own cost to other villages to attend classes. The Katingan Project aims to support the local government's efforts to improve the quality of basic education and the number of enrolment and encourage the youth to pursue higher education. The project did not conduct educational support at the primary or secondary level during this monitoring period as the communities have prioritized different activities. However, such activities are planned for 2019. The project was able to continue to support several students conducting undergraduate and graduate level research however, by supported their field efforts and providing logistical and operations assistance. These relationships furthered the project's understanding of the project area and provides an opportunity for more immediate information sharing with the entire scientific community.

2.2 Deviations

2.2.1 Methodology Deviations

No methodology deviations were made during this monitoring period.

2.2.2 Project Description Deviations

No new project description deviations were introduced during this monitoring period but three PD deviations from previous monitoring periods were still in effect during this monitoring period:

- The PD monitoring plan describes the use of multispectral Landsat imagery to monitor and quantify any forest disturbances. Due to the frequent cloud cover around the Katingan project and the revisit time of the sensor the data's availability is poor and unpredictable. The team therefore opted to use data from the Advanced Land Observing Satellite Phased Array L-band Synthetic Aperture Radar 2 sensor (ALOS PALSAR 2) to monitor forest disturbances as it collects data unhampered by cloud cover. This data provides an accurate method of quantifying forest disturbance. Additional detail on the cross calibration of Landsat and ALOS Palsar2 is provided in Section 3.3.3.1 in Monitoring Report 2016. This deviation is still in affect but, as no radar imagery was used during this monitoring period, does not apply to this monitoring period.
- A Participatory Rural Appraisal (PRA) was conducted in 2017 and, per M-MON, applies during the current period. At the time the PRA was conducted in 2017 the project elected to conservatively assume that illegal logging had occurred, and used the PRA to determine penetration distance. For more details see previous monitoring report (Section 3.2.2.2.2) and Section 4.2.2.2 below.
- The annual Global Forest Watch data's publishing data varies from year to year and is often not available at time of monitoring report submission. When unavailable, the most conservative value is used instead. The 2018 Global Forest Watch data was available for this report so this deviation did not apply during this monitoring period. Additional detail is provided in Section 4.3.

2.3 Grouped Project

This is not a grouped project.

2.4 Safeguards

2.4.1 No Net Harm

The project is a conservation and restoration project. There are no potential negative environmental impacts resulting from the project in either the project area or the surrounding region. Project activities preserve intact forest from commercial conversion and drainage, illegal logging and unsustainable hunting, minimize forest loss due to man-made fires, improve forest resiliency and community response against natural fires, and support community development through education and financial support for community-led projects. Community-led projects are designed to be sustainable and often have positive environmental impacts such as improving watershed quality.

The project does not anticipate any negative socio-economic impacts. As described above, and in the PD, communities lead the development of community maps and plans that drive the project activities. This close collaboration results in activities and community-led projects that address the short and long-term goals of the communities on issues such as infrastructure, health, sanitation, and employment. The participatory model used ensures that all community members have a voice in the process and ongoing consultation is used to adjust plans as appropriate.

The Climate, Community and Biodiversity Standard was used to develop the community and biodiversity monitoring plans. The project's plan was successfully validated and initially verified for the first five years in 2016, and again in 2018 for the subsequent two years – achieving the triple gold standard on each occasion. The project plans to continue CCB verification on a periodic basis (every two years) throughout the lifetime of the project to ensure the continued net positive benefits.

If the project fails, there may be negative environmental or socio-economic impacts. The project manages risks to project benefits during the project lifetime in a variety of ways. These have been implemented as planned in the PD and are summarized in the non-permanence risk assessment conducted by the project (next section). This assessment was designed to address the risk to climate benefits but is equally applicable to the risks associated with community and biodiversity benefits. No additional risks to project benefits were identified.

The Katingan Project is based on 60-year concession licenses, extendable to 100 years. Project benefits are expected to extend beyond this time scale. The effective protection status of the forest and peatlands is anticipated to be maintained and extended, either through a further concession license or directly by state designation as the global importance of the stored carbon stocks and biodiversity are fully recognized as a result of the project. The project's close working relationship with the government established before the project began and strengthened during this monitoring period will support this outcome. In parallel, the future actions of the project to restore both hydrology and degraded areas will result in the project area being more resilient to the threat of fire. Similarly, activities targeting community benefits have been and will continue to be designed to be managed in the future by the local communities themselves, without the need for further external interventions. The community work completed to date demonstrates this commitment. Ensuring the communities are able to undertake and manage the activities themselves is the most secure means of ensuring the activities will continue even after project's lifetime. Finally, the project itself is anticipated to set an example of sustainable land use management in the region, leading to wider adoption of the practices it is pioneering. The project has and will continue to offer tours to government agencies, other non-profits and any other groups interested in learning about its activities in order to spread best practices and lessons learned throughout the region. In this way the Katingan Project is and will continue to contribute to a wider region managed more sustainably with respect to carbon emissions, biodiversity conservation and equitable development of local communities.

2.4.2 Non-permanence risk assessment

A non-permanence risk assessment was carried out in accordance with the most recent AFOLU Non-Permanence Risk Tool v.3.3 (update with latest tool and redo the documentation). The resulting risk rating and non-permanence risk buffer is 10%. The summary of non-permanence risk assessment is provided in Table 5, and the full assessment is provided in Appendix 1.

Table 5. Summary of non-permanence risk assessment

VCS AFOLU non-permanence risk category	Score
Internal Risk	
Project Management (PM) Risk Value	-4

Financial Viability (FV) Risk Value	0
Opportunity Cost (OC) Risk Value	0
Project Longevity (PL) Risk Value	0
	0
Total External Risk	
Total Land Tenure (LT) Risk Value	2
Total Community Engagement (CE) Risk Value	-5
Total Political (PC) Risk Value	0
	0
Natural Risk	
Fire (F)	2
Pest and Disease Outbreaks (PD)	0
Extreme Weather (W)	0
Geological Risk (G)	0
Other natural risk (ON)	0
	2
Total Overall Risk Rating	**2%**
Non-Permanence Buffer	**10%**

2.4.3 Local Stakeholder Consultation

2.4.3.1 Stakeholder consultations

Since 2007, and continually thereafter, the Katingan Project has conducted a series of stakeholder consultations at different levels – national, provincial, district, sub-district and village. Through this process, the project has disseminated information on the ecosystem restoration concession concept, planned activities, expected impacts from the project, management plans and project boundary setting processes, and has adapted feedback from the stakeholders into agreed plans and legal approval.

During this monitoring period the project held over 120 separate events with stakeholders, ranging from workshops, discussion forum, training, formal planning meetings, to awareness-rasing events. These events were attended by over 2,000 participants (over 30% of which were women). Full details of all events are available on the project database.

During all consultations with communities, strenuous efforts have been made to ensure that adequate, understandable, honest and accurate information is provided as a basis for any decisions, including information on costs, risks and benefits. This process has been ensured by a number of means, including:

- Written Standard Operating Procedures that all project staff must follow when working with local communities. These documents describe the need to ensure any information is presented in a form that can be fully understood and in a timely manner to allow due consideration, together with guidelines as to how that should be achieved. Copies of the relevant SoPs are available on the project database.
- During the development of all written agreements (including MoUs and PKS agreements) a period of 1-2 months was allocated to allow each village time to discuss internally, raise questions, seek clarification and amend the draft agreement. This iterative process is evidenced by a comparison of early drafts of each agreement, written notes of feedback from each community, and the revised final agreements.
- The project has offered, and accepted requests from prospective villages to visit other project zone villages where activities have already been conducted in order to more clearly understand the nature of collaboration. This has allowed villages to directly raise questions to members of those villages about the project.

2.4.3.2 Community involvement during project design and implementation

As described above, the vast majority of the Katingan Project's activities have been both designed and implemented in close consultation and collaboration with local communities. This is key to achieving the long-term sustainability of the initiatives, without need for further external interventions. The consultation processes are ongoing with regular meetings organized to evaluate the progress of each initiative and adapt initiatives to changing needs and conditions. The Katingan Project conforms to all relevant Indonesian laws and regulations throughout its lifetime, and thus will not be involved in or complicit in any form of discrimination or sexual harassment during the process of project design and implementation.

2.4.4 Public comment

The Katingan Project will publicize a variety of project documentation and monitoring plans in both Indonesian and English languages through appropriate means by which local communities and stakeholders can have the opportunity to provide comments. They include a combination of media such as newsletters, workshops, meetings, and the project website.

PT. RMU will also take measures to communicate the project's verification process to the project-zone communities and other stakeholders. A summary of the Monitoring Report will be prepared in the Indonesian language and will be disseminated to the local stakeholders.

2.4.5 Implementation of feedback and grievance redress procedure

The Katingan Project maintains a formal grievance and redress procedure to prevent and handle any conflicts with and among communities and other stakeholders which may arise during the implementation of project activities. This process has been detailed in previous monitoring reports are remains unchanged during this monitoring period.

One of the most important elements of the grievance redress procedure is to prevent potential conflicts before they arise. Such precautionary approaches include the implementation of FPIC-based community consultations, participatory planning and regular communication. This helps to identify underlying grievances well in advance and allow them to be addressed. The formal village level planning processes also help to strengthen the bargaining position of project-zone communities when dealing with other stakeholders.

If any grievances occur and are reported from the project-zone communities and/or other relevant stakeholders in the form of letters, short messages or verbal communication, and from 2018 onwards by way of comment boxes placed in villages (Figure 7). PT. RMU will quickly respond to all grievances by following the formal handling process. All reported cases will be assessed to identify and verify the cause, actors and scale of grievances, and PT. RMU's verification team will recommend resolution options based on the feedback from the stakeholders. The degree of intervention and process will depend on the nature of disputes, and PT. RMU will continue to monitor the cases.

In case where a grievance is not amicably resolved after this process, it will be submitted to an unbiased third party for a formal mediation and arbitration process, and subject to a hearing at which both disputing parties have the opportunity to testify. All cases will be referred and examined to the extent allowed by Indonesian laws and regulations of the relevant jurisdiction before decisions are made, and both parties are bound to satisfy the result of arbitration.

Local facilitators, community organizers and PT. RMU staff have all been contacted with questions or comments directly. Almost all of these questions have been addressed successfully without the formal grievance process. The formal process has been used to successfully resolve issues five times during the monitoring period demonstrating stakeholder awareness of and engagement with the process. The issues and resolutions have been logged and disseminated to the affected individuals and communities.

Figure 7. An example of a project notice board and grievance comment box


PAPAN INFORMASI DESA
PT Rimba Makmur Utama
PT RMU
GRIEVANCE BOX
KOTAK KELUHAN

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data and parameters available at validation per VCS methodology VM0007 MF are provided in the tables below. A full list of all relevant data and parameters are further provided in the Climate MRV Tracker (Appendix 2) and supporting documents.

Data / Parameter	$\Delta C_{BSL,planned}$
Data unit	t CO_2-e
Description	Net greenhouse gas emissions in the baseline from planned deforestation
Equations	3
Source of data	Module BL-PL
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module BL-PL
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$\Delta C_{BSL-ARR}$
Data unit	t CO_2-e
Description	Net GHG removals in the ARR baseline scenario up to year t*
Equations	5
Source of data	Module BL-ARR
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module BL-ARR
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$GHG_{BSL-WRC}$
Data unit	t CO_2-e
Description	Net GHG emissions in the WRC baseline scenario up to year t*
Equations	6
Source of data	Module BL-PEAT
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module BL-PEAT
Purpose of Data	Calculation of baseline emissions
Comments	N/A

3.2 Data and Parameters Monitored

Data and parameters monitored per VCS methodology VM0007 MF are provided in the tables below. A full list of all relevant data and parameters are further provided in the Climate MRV Tracker (Appendix 2) and supporting documents.

Data / Parameter:	$\Delta C_{WPS-REDD}$
Data unit:	t CO_2-e
Description:	Net GHG emissions in the REDD project scenario up to year t*
Equations	2
Source of data:	Module M-MON
Description of measurement methods and procedures to be applied:	See Module M-MON
Frequency of monitoring/recording:	See Module M-MON
QA/QC procedures to be applied:	See Module M-MON
Purpose of data:	Calculation of project emissions

Data / Parameter	$\Delta C_{LK-AS,planned}$
Data unit	t CO_2-e
Description	Net greenhouse gas emissions due to activity shifting leakage for projects preventing planned deforestation
Equations	4
Source of data	Module LK-ASP
Value applied	n/a
Justification of choice of data or description of measurement methods and procedures applied	See Module LK-ASP
Purpose of Data	Calculation of leakage
Comments	

Data / Parameter	ΔC_{LK-ME}
Data unit	t CO_2-e
Description	Net greenhouse gas emissions due to market-effects leakage
Equations	4
Source of data	Module LK-ME
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	See Module LK-ME
Purpose of Data	Calculation of leakage
Comments	

Data / Parameter:	$\Delta C_{WPS\text{-}ARR}$
Data unit:	t CO_2-e
Description:	Net GHG emissions in the ARR project scenario up to year t*
Equations	5
Source of data:	Module M-ARR
Description of measurement methods and procedures to be applied:	See Module M-ARR
Frequency of monitoring/recording:	See Module M-ARR
QA/QC procedures to be applied:	See Module M-ARR
Purpose of data:	Calculation of project emissions
Calculation method:	See Module M-ARR
Comments:	

Data / Parameter:	$\Delta C_{LK\text{-}ARR}$
Data unit:	t CO_2-e
Description:	Net GHG emissions due to leakage from the ARR project activity up to year t*
Equations	5
Source of data:	Module LK-ARR
Description of measurement methods and procedures to be applied:	See Module LK-ARR
Frequency of monitoring/recording:	See Module LK-ARR
QA/QC procedures to be applied:	See Module LK-ARR
Purpose of data:	Calculation of leakage
Calculation method:	See Module LK-ARR
Comments:	

Data / Parameter:	$GHG_{WPS\text{-}WRC}$
Data unit:	t CO_2-e
Description:	Net GHG emissions in the WRC project scenario up to year t*
Equations	6
Source of data:	Module M-PEAT
Description of measurement methods and procedures to be applied:	See Module M-PEAT
Frequency of monitoring/recording:	See Module M-PEAT
QA/QC procedures to be applied:	See Module M-PEAT

Purpose of data:	Calculation of project emissions
Calculation method:	See Module M-PEAT
Comments:	See Module M-PEAT

Data / Parameter	$GHG_{LK\text{-}ECO}$
Data unit	t CO_2-e
Description	Net GHG emissions due to ecological leakage from the WRC project activity up to year t
Equations	6
Source of data	Module LK-ECO
Value applied	n/a
Justification of choice of data or description of measurement methods and procedures applied	See Module LK-ECO
Purpose of Data	Calculation of leakage
Comments	

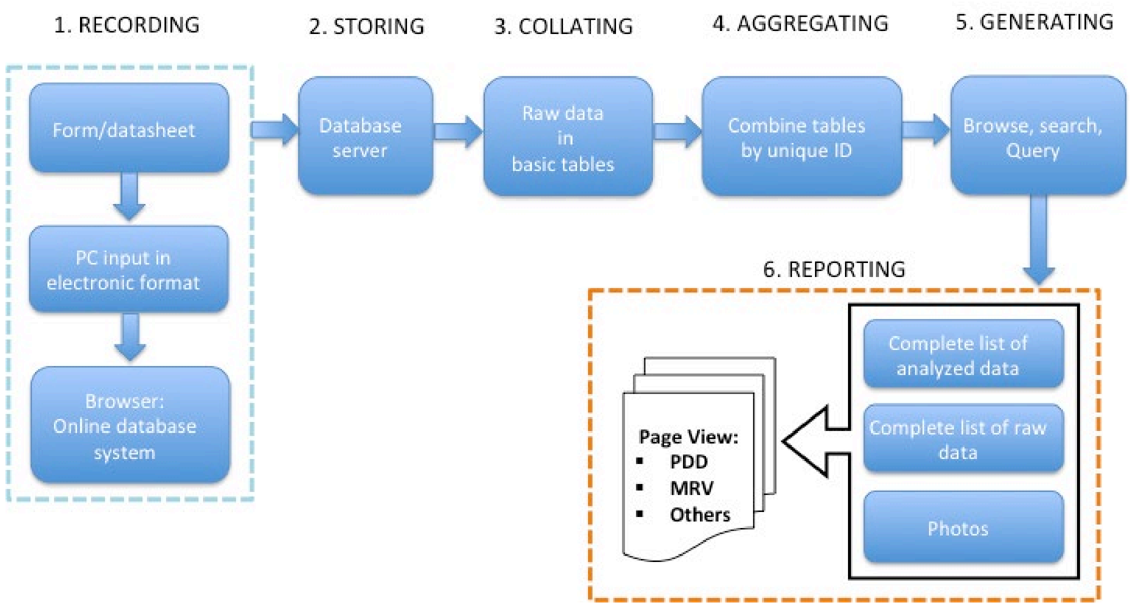
3.3 Monitoring Plan

3.3.1 Data management methods and structure

All data generated by the Katingan Project is centrally managed in an online-based database. Hard copies of all data sheets are archived in field offices, with duplicate copies stored centrally in PT. RMU's headquarter in Bogor (Figure 8). Field data is uploaded directly into the online database system from the field office, allowing simultaneous multi-user input through a local server network. After the data is collated by the database server, it can be adapted to fulfil all monitoring and reporting needs using standard and custom-made report formats. Hard and soft copies of all data will be stored for a minimum of two years beyond the end of the project crediting period (31st October 2070).

All climate monitoring parameters, including both raw and processed data, together with their frequency, are detailed in Appendix 2 and supporting documents.

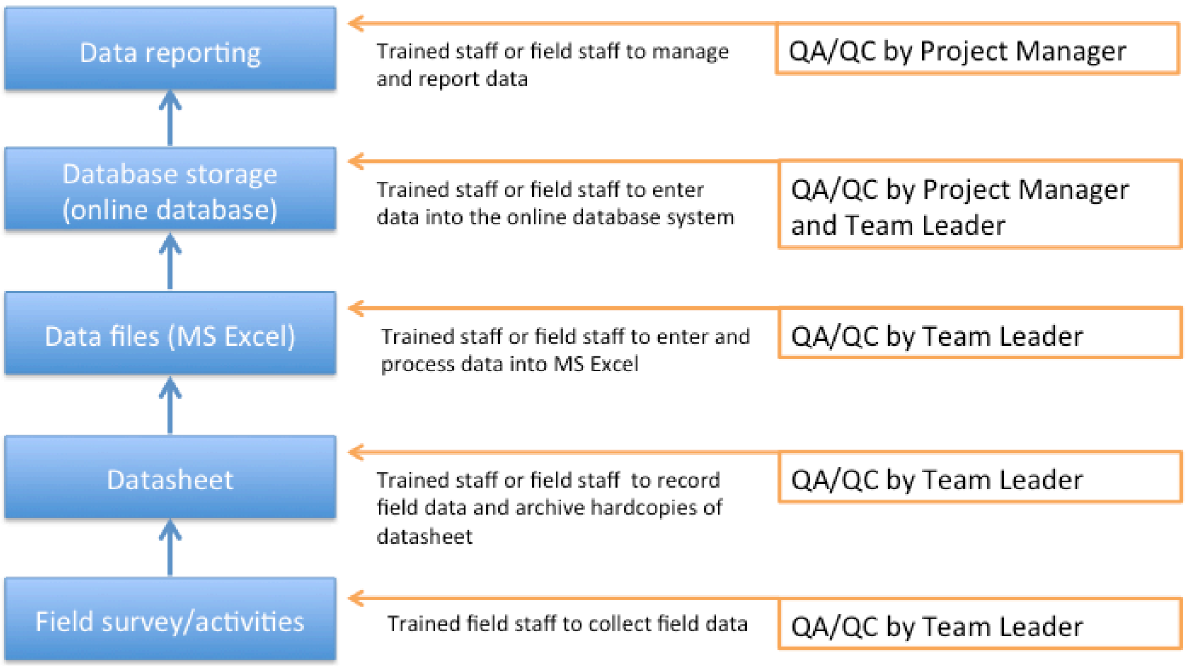
Figure 8. Simple schematic of data management structure



3.3.2 Procedures for handling internal auditing and non-conformities

Internal auditing and non-conformities are addressed through standard operation procedures (SOPs) that incorporate multiple quality assurance and quality control (QA/QC) measures (Figure 9). All data collected, recorded, stored and reported are subject to review and approval by team leaders and/or project managers with reference to written SOPs covering each level of data management. In order to ensure the security and traceability of data entry and QA/QC procedures, all users are allocated unique user IDs and passwords in order to access the database, and in turn their access and roles can be restricted as appropriate.

Figure 9. Data management QA/QC procedures



3.3.3 Climate impact monitoring plan and methodological approach

Climate impacts have been monitored, reported and evaluated according to the Climate MRV Tracker (Appendix 2). This includes monitoring changes as per the VCS VM0007 methodological requirements and GHG emissions associated with relevant land uses in the project area. A summary of the main monitoring methods followed during this reporting period is given below. For further details consult the PD and relevant Annex.

The formal monitoring period reported in this report extends from 1st January 2018 to 31st December 2018. In general, all reported data refers to this exact period.

3.3.3.1 Remote sensing

As the original project description only included 'forest' and 'non-forest' classes, monitoring during this reporting period focused on the integrity of these two strata.

In both the PD, and the previous monitoring reports (2010-2015, 2016 and 2017), multispectral satellite imagery was used to assess the forest integrity. During this monitoring period the project continued to use multispectral data from Landsat, Sentinel 2 and PlanetLabs for the regular monitoring of deforestation in the project site. Unsupervised classifications on PlanetLabs high resolution multispectral imagery, acquired in georeferenced and orthorectified format from Planet, from the 4th of January 2019, 18th of March 2019 and 20th of March 2019 was used to assess deforestation during the 2018 monitoring period. NASA Fire Information for Resource Management System (FIRMS) data continued to be used during the monitoring report for the near-real time detection of fires in the project area and project zone.

In cases where forest changes were detected, the procedures outlined in VCS methodology VM0007 module M-MON were used to quantify the relevant parameters. See Section 4.2.2 for full results.

3.3.3.2 Monitoring GHG Emissions from microbial decomposition of peat

GHG emissions from microbial decompositions of peat were quantified by monitoring land use change (as described above) in combination with IPCC default emission factors and the procedures provided in the VSC methodology VM0007, module M-PEAT (see Section 4.2.6.1 for results). In addition, direct monitoring of water table depth was initiated in 2015 using dip-wells (point-based monitoring) installed along transects designed to be representative of each stratum. In the future this data can be used as an additional proxy for future analysis, but it was not used for any emission calculations in this monitoring report.

3.3.3.3 Monitoring GHG Emissions from water bodies

GHG emissions from water bodies were estimated based on IPCC default values applied to the estimated area of water bodies in the project area, as described in the PD Section 5.4. As per section 3.3.3.1 of this report, the forest's integrity was monitored using remote sensing analysis. Any land cover changes indicative of new water features were followed up with ground checks to verify the change and, if confirmed, the water body's dimensions were measured. Additionally, the field team travelled down all waterway access points within the project to search for new canals that weren't visible in the satellite imagery.

3.3.3.4 Monitoring GHG Emissions from peat and biomass burning

MODIS FIRMS hotspot data were collected for the entire monitoring period. Potential fire alert response times from the field staff were improved by automating the hotspot alerts using two online tools, Twilio and Mail Parcer, in the Zapier platform. This automated system allows the GPS locations of new hotspots to be automatically extracted from the FIRMS email alerts and directly sent to the field staff via cellular text message.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

This section describes baseline emissions based on the VCS methodology VM0007 REDD+ MF and its modules BL-PL, BL-ARR, AR ACM 003, and BL-PEAT. The analysis and results presented in this section is unchanged from that presented in the PD (Section 5.3) and the previous monitoring report (Section 6.1).

4.1.1 General procedures and assumptions

Baseline emissions and changes in baseline emissions and carbon stocks were determined based on analyses of the most likely baseline scenario as described in the PD.

Emissions that are accounted result from:

- Above ground biomass stock changes due to conversion to plantations
- Peat microbial decompositions
- Peat burning
- Dissolved Organic Carbon from Water bodies

It is assumed that no non-human induced rewetting (e.g. collapse of dikes or canals that would have naturally closed over time, progressive subsidence leading to raising relative water table depths, increasingly thinner aerobic layers and reduced CO_2 emission rates) will occur in the baseline scenario. For peatland areas that were abandoned before the project started, this assumption was based on expert judgment taking account of verifiable local experience and/or studies and/or scientific literature in a conservative way.

It is assumed that the baseline agents perform regular maintenance of canals for drainage and transportation purposes. Due to limitations of available information on volume and frequency of dredging of the baseline agents, emissions from dredging (emissions from peat exposed to aerobic decomposition by spreading or piling following the establishment or maintenance of canals) is conservatively omitted in the baseline calculations. Note that the omission of this source of GHG emissions is very conservative, resulting in lower emission estimates in the baseline water body stratum compared to strata at the same location in the project scenario, since emissions from water bodies are lower than emissions resulting from peat microbial decomposition.

CO_2 and CH_4 are accounted for in the baseline, while N_2O emissions were conservatively omitted. It was assumed that uncontrolled burning of peat occurs only in part of the deforested project area. These emissions are accounted for since the loss is significant. GHG emissions from biomass burning in the baseline were conservatively omitted.

Baseline changes in land cover classes and drainage status during the project life-time determines (changes in) emissions of CO_2 and CH_4. Baseline emissions therefore have been calculated on an annual basis (For further details see PD Section 5.3).

4.1.2 Proxy area analysis

4.1.2.1 Proxy area selection

Since the project area does not have a verifiable plan for the rate of deforestation, per module BL-PL, a minimum of 6 proxy areas are required to determine the baseline rate of deforestation, as well as 5 proxy areas to demonstrate the risk of abandonment. According to the methodology, all proxy areas must meet the following criteria:

- Land conversion practices shall be the same as those used by the baseline agent or class of agent;

- The post-deforestation land use shall be the same in the reference regions as expected in the project area under business as usual;
- The reference regions shall have the same management and land use rights type as the proposed project area under business as usual;
- If suitable sites exist they shall be in the immediate area of the project; if an insufficient number of sites exists in the immediate area of the project, sites shall be identified elsewhere in the same country as the project; if an insufficient number of sites exists in the country, sites shall be identified in neighbouring countries;
- Agents of deforestation in reference regions must have deforested their land under the same criteria that the project lands must follow (legally permissible and suitable for conversion);
- Deforestation in the reference region shall have occurred within the 10 years prior to the baseline period; and
- The three following conditions shall be met:
    - The forest types surrounding the reference region or in the reference region prior to deforestation shall be in the same proportion as in the project area (±20%).
    - Soil types that are suitable for the land-use practice used by the agent of deforestation in the project area must be present in the reference region in the same proportion as the project area (±20%). The ratio of slope classes “gentle” (slope<15%) to “steep” (slope≥15%) in the reference regions shall be (±20%) the same of the ratio in the project area.
    - Elevation classes (500m classes) in the reference region shall be in the same proportion as in the project area (±20%).

Suitable reference regions were identified using a database, provided by the Indonesian Ministry of Forestry[1], of pulp and paper concessions in Indonesia whose licenses were granted between 2000 and 2010. Using peat distribution geospatial data for Indonesia, obtained from Wetlands International Indonesia [2], the pulp and paper concessions with similar peat proportions as the project area were identified. Next, NASA Shuttle Radar Topography Mission’s (SRTM) 90m Digital Elevation Model (DEM) data, downloaded via the Consultative Group on International Agricultural Research’s online database[3], was analysed to identify the concessions that met the slope and elevation requirements. To determine which of the remaining concessions met the forest type and forest cover percentage criteria, medium-resolution satellite imagery was used. Table 6 shows proxy area requirements based on the project area’s land cover.

Table 6. Reference region selection criteria

Project area	Reference region Requirement
96.65% forest cover	At least 77.32% forest cover
97.44% peat	At least 77.95% peat
100% of area in the 0-500m class	At least 80% of the area must fall in the 0-500m class
100% of area has “gentle” (slope<15%) slopes	At least 80% of the area must have “gentle” slopes

[1] Ministry of Forestry (2010), downloaded from Global Forest Watch Commodities (http://commodities.globalforestwatch.org/#v=home)
[2] Wahyunto, S. Ritung dan H. Subagjo (2004). Peta Sebaran Lahan Gambut, Luas dan Kandungan Karbon di Kalimantan / Map of Peatland Distribution Area and Carbon Content in Kalimantan, 2000 – 2002. Wetlands International - Indonesia Programme & Wildlife Habitat Canada (WHC).
[3] Available at http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp

4.1.2.2 Satellite imagery analysis

A) Data acquisition

For each concession, Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) or Landsat 8 Operational Land Imager (OLI) data was downloaded from the United States Geological Survey's online database[4]. All Landsat Level 1 data provided by USGS is geometrically corrected, using precision ground control points and SRTM DEM data, orthorectified and meets all standards laid out by the GOFC-GOLD 2013 handbook. For the first time-step, imagery from the concession grant date was downloaded. Due to Landsat's long revisit time and the high level of cloud cover in Indonesia, a compromise had to be made between cloud cover and the imagery acquisition date's proximity to the concession grant date.

B) Landsat pre-processing

All Landsat data was atmospherically corrected using the ATCOR2 for IMAGINE software. For optimal results, the radiometric rescaling values from each Landsat scene's metadata were used to create the scene's calibration file. Landsat 7 imagery acquired after 31/05/2003, when the sensor's Scan Line Corrector (SLC) failed, were also masked using the Landsat 7 gap-mask layer to remove all pixels affected by the scan line error.

C) Landsat classification

To increase the classification's accuracy, the concession shapefile data was used to subset the Landsat scene in order to remove all spectral data outside of the area of interest. The Unsupervised Classification ISODATA algorithm, with the standard clustering parameters, was then used to classify all concessions into forest and non-forest classes. The clouds, cloud shadows and scan line error gaps were masked out for all images and cross-applied to both time-steps to ensure only data available in both time-steps was used to calculate deforestation rates. When necessary, additional imagery from the same calendar year was processed and used to fill in cloud gaps to reduce overall cloud cover below 10%. All images were further processed with a 3*3 majority filter to remove noise and improve the classification accuracy. Lastly, an accuracy assessment was run on each map to ensure the overall classification accuracy was at least 90%. 100 points, with a 50-meter buffer between points, were randomly created for both forest and non-forest classes and compared with the unprocessed Landsat data and high-resolution imagery from Google Earth (when available). The accuracy was then calculated using the equation (1).

$$\text{Overall Classification Accuracy} = \frac{\text{Number of Pixels Classified Correctly}}{\text{Total Number of Classified Pixels}} \qquad (1)$$

All maps had a satisfactory overall accuracy with the lowest accuracy being 91%.

4.1.2.3 Area of deforestation

Using the module BL-PL, a total of 7 suitable proxy areas were identified (see Table 7 and Map 4).

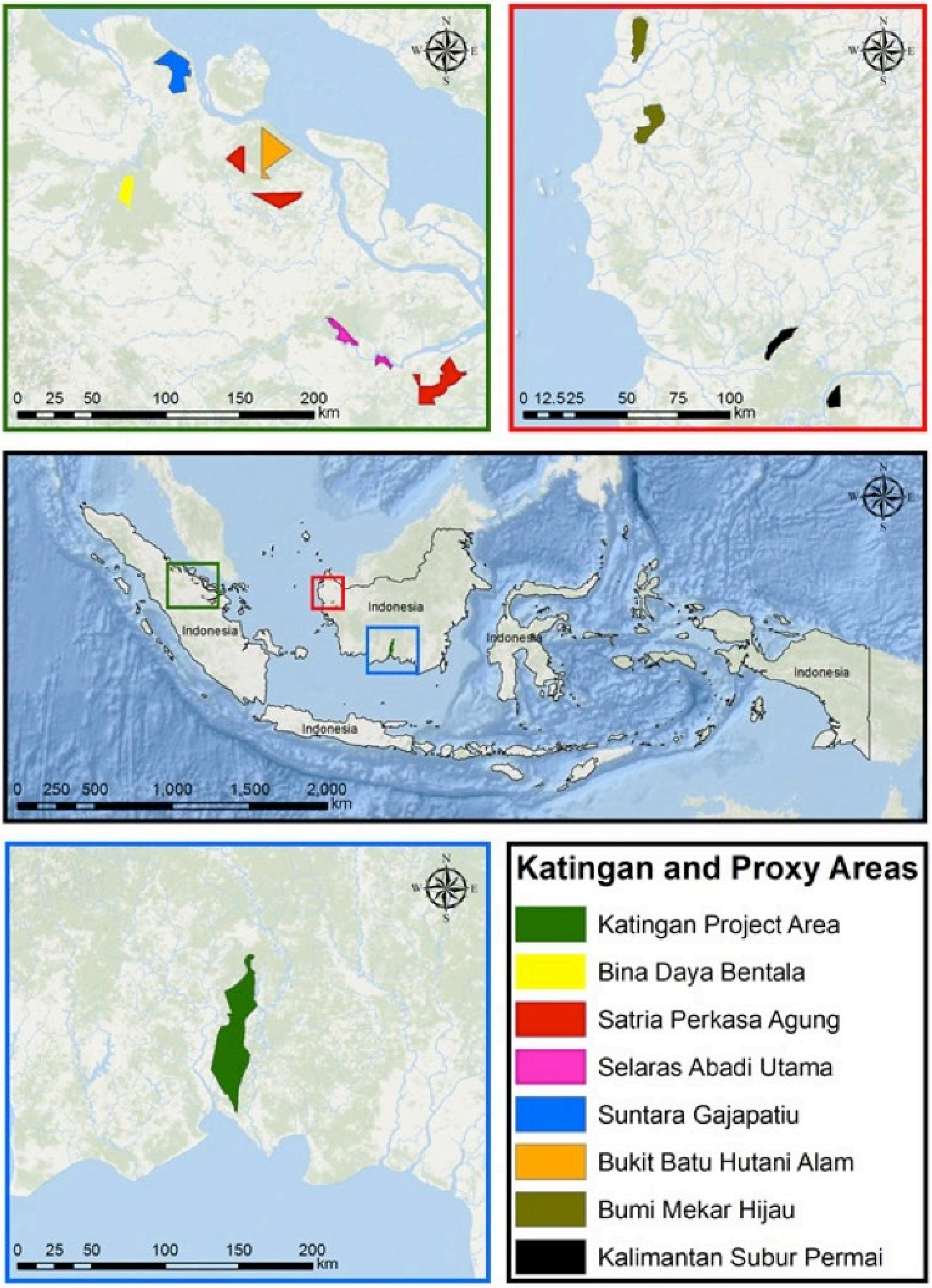
[4] Available at http://earthexplorer.usgs.gov

Table 7. Summary of suitable reference regions

Reference region	Deforestation Rate	Area in Ha	Province	Concession Grant Date	Peat %	Timestep 1 date	Forest % at Timestep 1	Timestep 2 date	Forest % at Timestep 2	Cloud Gap
Satria Perkasa Agung full concession	7.31%	97533.25	Riau	22/08/2000	88.31%	26/04/2000[a] 21/05/2000[b] 23/02/2000[c] 06/12/2000[d] 01/09/2000[d]	84.50%	09/10/2005[a] 15/02/2009[b] 01/05/2007[c] 19/06/2005[d]	42.55%	3.04%
Suntara Gajapatiu	6.42%	34258.30	Riau	15/03/2001	100%	20/09/2001	92.26%	28/08/2010	34.48%	8.30%
Bukit Batu Hutani Alam	14.31%	33030.50	Riau	30/10/2003	100%	21/05/2000	88.07%	09/10/2005	16.55%	7.85%
Selaras Abadi Utama	8.13%	17434.80	Riau	30/12/2002	100%	02/10/2002	92.40%	15/02/2009	35.52%	1.47%
Kalimantan Subur Permai	**3.91%**	13246.02	West Kalimantan	04/04/2006	92.11%	12/08/2005	93.42%	11/05/2009 30/07/2009 18/10/2009	77.79%	1.42%
Bumi Mekar Hijau	4.40%	25118.70	West Kalimantan	01/05/2007	85.93%	05/07/2006 13/07/2006	83.88%	12/10/2010 15/12/2010	66.27%	7.38%
Bina Daya Bentala	10.63%	14124.76	Riau	22/12/2006	100%	03/08/2004	77.55%	15/10/2010 13/09/2010	13.76%	1.86%

a. Plot 1 of the Satria Perkasa Agung concession; b. Plot 2 of the Satria Perkasa Agung concession; c. Plot 3 of the Satria Perkasa Agung concession. d. Plot 4 of the Satria Perkasa Agung concession

Map 4. Geographic location of the Katingan Project and reference regions for the baseline deforestation rate calculation



The baseline deforestation rate was calculated using the following equation (2).

$$D\%_{planned,i,t} = \left(\sum_{pn=1}^{n} \left(D\%_{pn} / Yrs_{pn} \right) \right) / n \qquad (2)$$

Where:

$D\%_{planned,i,t}$	Projected annual proportion of land that will be deforested in stratum I during year t. If actual annual proportion is known and documented (e.g. 25% per year for 4 years), set to proportion; %
$D\%_{pn}$	Percent of deforestation in land parcel pn etc of a reference region as a result of planned deforestation as defined in this module; %
Yrs_{pn}	Number of years over which deforestation occurred in land parcel pn in reference region; years
n	Total number of land parcels examined
pn	1, 2, 3, …n land parcels examined in reference region
i	1, 2, 3, …M strata

The average projected annual deforestation rate for these proxy areas was estimated to be 7.82%. However, in order to guarantee that a conservative approach was used, the deforestation rate applied in the baseline emission calculation was the lowest rate of the 7 proxy areas, **3.91%** (see Table 7). Since this approach is unquestionable conservative, the baseline rate of deforestation uncertainty was set to zero.

4.1.2.4 Likelihood of Deforestation

Since all pulpwood plantation concessions are zoned for deforestation and are not under government control for the duration of the concession license, the likelihood of deforestation ($L\text{-}D_i$) is assumed to be equal to 100%.

4.1.2.5 Risk of Abandonment

To assess the risk of abandonment, 5 proxy areas with concession grant dates of at least ten years before the project start date were selected using the criteria outlined in Sub-subsection 4.1.2.1. After confirming the elevation, slope and soil criteria were met, Landsat 5 TM, Landsat 7 ETM+ and Landsat 8 OLI imagery was downloaded for three time-steps and visually analysed to determine if any areas were abandoned for forest regrowth. All 5 proxy areas showed clear signs of continued deforestation and plantation activities for all three time-steps, therefore the BL-PL module is applicable to this project.

4.1.2.6 Area of Deforestation

The annual area of deforestation in the baseline is calculated using equation 3.

$$AA_{planned,i,t} = \left(A_{planned,i} * D\%_{planned,i,t} \right) * L\text{-}D_i \qquad (3)$$

Where:

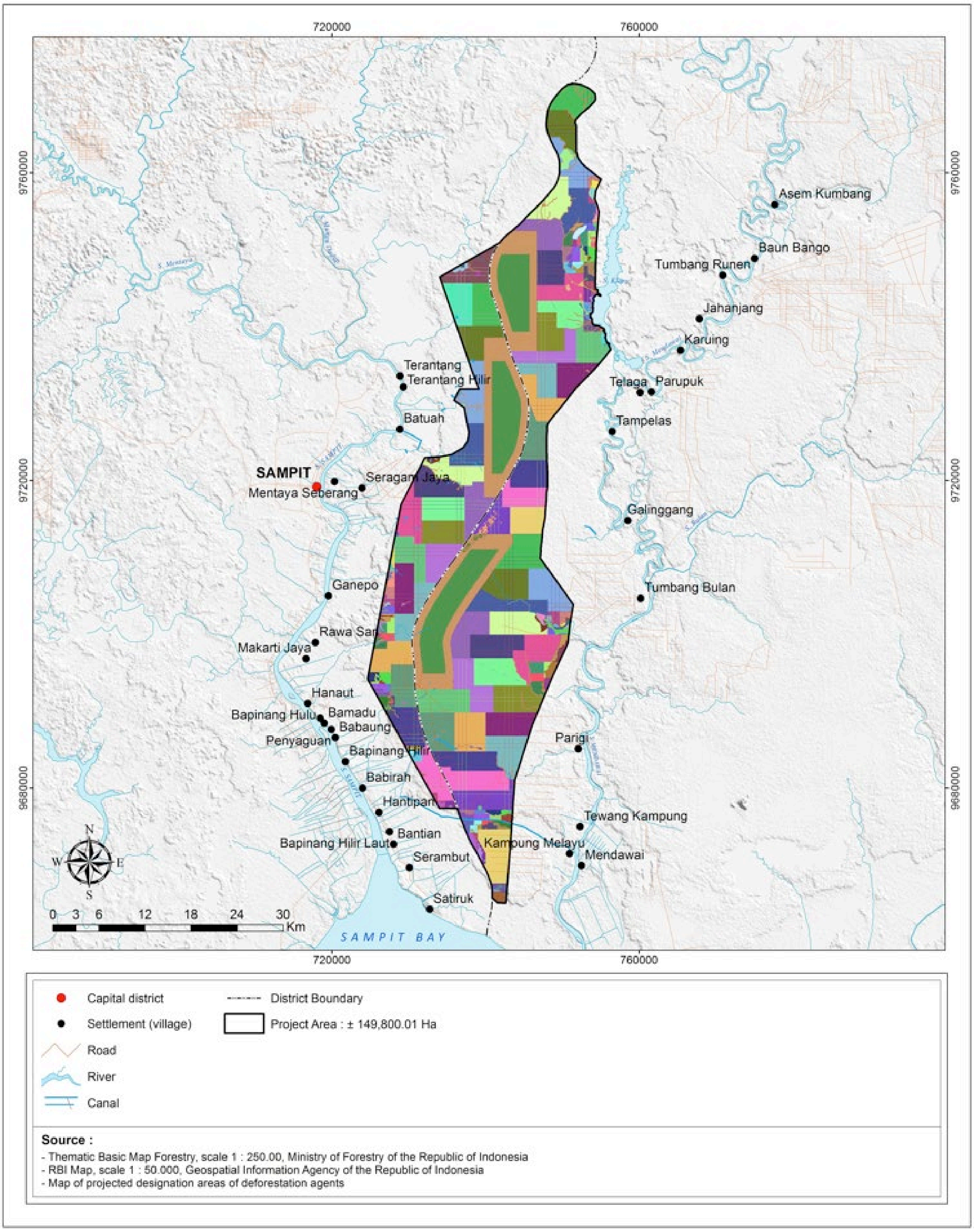
$AA_{planned,I,t}$	Annual area of baseline planned deforestation for stratum I at time t; ha
$D\%_{planned,I,t}$	Projected annual proportion of land that will be deforested in stratum I during year t. If actual annual proportion is known and documented, set to proportion; %
$A_{planned,I}$	Total area of planned deforestation over the baseline period for stratum I; ha
$L\text{-}D_i$	Likelihood of deforestation for stratum I; %

4.1.3 Projection of deforestation under the baseline scenario

Following the determination of the total annual area deforested in the baseline ($AA_{planned,i,t}$), the area was allocated spatially to produce a spatial map of the baseline scenario. The project area was stratified into six strata (Table 8) based on five land use classes, two drainage statuses and one water body class through a Combination-Elimination process as described in Annex 14 of the PD. A baseline scenario map is provided in Map 5. The mapping process involved the following steps:

- Delineation of forest and non-forest area at the project start date. This process is described in Section 4.4.1.1 in the PD.
- Delineation of water bodies present at the project start date (rivers and canals)
- Division of the project area into three assumed concession areas, corresponding to different baseline agents. The division is in compliance with historical records that timber plantation license being given is decreasing with size range from 30,000 to 70,000 ha. Strengthened in 2014 by Ministry of Forestry Decree no P.8/Menhut-II/2014 that limits concession sizes in Indonesia to a maximum of 50,000 hectares.
- Division of each concession area into five zones (acacia plantations, conservation areas, indigenous species area, infrastructure, and areas for community crops) in line with specific regulation (see Table 32 in PD).
- Delineation of 50 meters width river buffers (25 meters from both sides of natural rivers). Forest cover inside the buffers are prohibited to log or convert under regulation.
- Drainage canals were laid out in a step wise approach complying with applicable regulations, common practice and hydrotopography of the project area. Primary canals that enclose the concession areas (mandatory by regulation) were delineated first; then secondary canals that act as main outlets for tertiary canals and discharging channels into main canals or natural streams. Considering the hydrotopograhy of the area, baseline agents were assumed to construct secondary canals perpendicular to elevation contour-lines. Tertiary canals are not necessarily perpendicular to elevation contour-line and act as planting block borders, therefore the delineation was carried out in step 8. All the canals were placed in *Acacia* plantations and community crop zones only.
- Division of the *Acacia* plantation area of each assumed agent's concession into 4 Major Blocks (termed Blok RKT, Rencana Kerja Tahunan), resulting in 12 Major blocks in the project area.
- Division of each Major Blocks into smaller planting blocks (termed Blok Tanam) of 500 by 500 meter square parcels
- Division of all Major Blocks into deforestation/planting zones based on deforestation rate (D%) resulting in analysis of Reference Region. Each planting zone consists of several planting blocks.
- Division of all community crop zones into agriculture planting zones based on deforestation rate (D%) resulting in form the analysis of the proxy area analysis
- Assigning canals' construction years, starting from the closest area to access points, in this case rivers
- Assigning deforestation/planting years to deforestation/planting zones, starting from the closest area to access points, in this case rivers
- Assigning planting years to community crop zones
- Choosing and delineating locations for camps and log yards
- Assigning camps and log yards construction years, starting from the closest area to access points, in this case rivers

Map 5. Baseline scenario map[5]



[5] Legend of this map is continued to the box below the map. Numbers preceding alphabet symobols denote year of drainge/deforestation in reference to project start date. Abbreviations: AC=Acacia, CA= Community crops, IF=Ground fascility, IS=Indigineous species area, CF=Conservation area.

4.1.4 Emission characteristics in the baseline scenario

4.1.4.1 Stratification of emission characteristics for CUPP activities under the baseline scenario

Baseline strata of relative homogeneous emission characteristics were mapped on the basis of the Master Baseline Scenario Map (see Map 5) by taking into account (1) Coverage of land use / cover / drainage status; (2) Timing of land use change / drainage status under the assumed baseline; and (3) the delineation of peat. The stratification map of emission characteristics presents the following information:

- Land use (vegetation cover, water bodies, etc.) and the related emission factors: different land uses translate into different emission factors.
- Timing of deforestation or conversion (*Acacia* plantings) other agriculture plantings and canal constructions. Temporal variability of these activities and the different drainage status translate into different emissions. For example, if a peatland parcel belongs to the acacia

stratum (forest planned to be drained in year 3 and to be deforested and converted to acacia in year 6) and was initially undrained and forested, then the Emission Factor (EF) of undrained peatland forest will be used for year 1 – 2, the EF for drained peatland forest for year 3 – 5, and finally the EF for acacia for year 6 onwards.

- Area of peatland, outside which peat-related emissions are absent

In the baseline scenario, the six strata that significantly differ in peat GHG emission characteristics are summarized in Table 8 and Map 5. A summary of dynamics of these strata is presented in Map 6, and Appendix 4 of the PD.

Map 6. Baseline stratification of the project area for CUPP activities

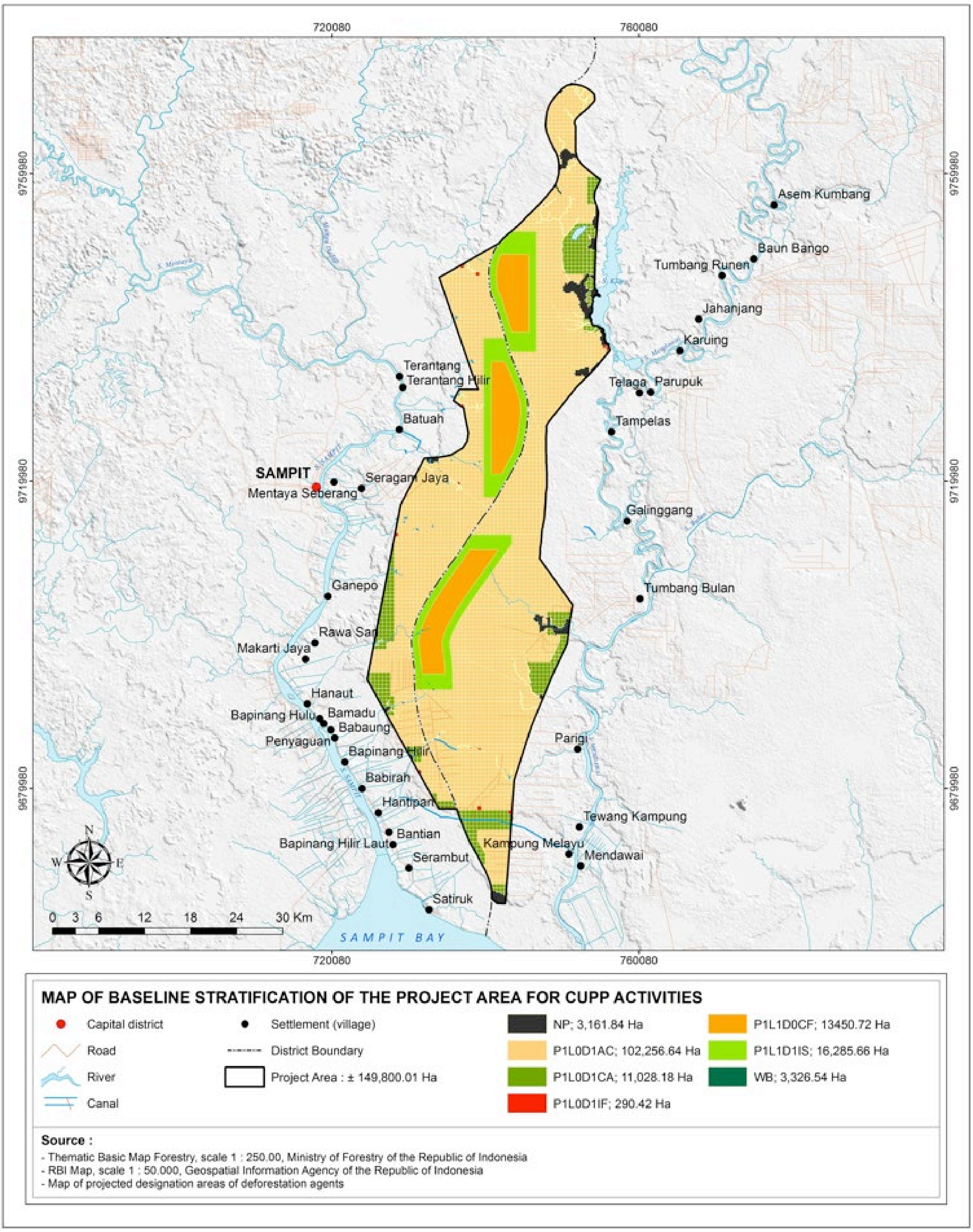
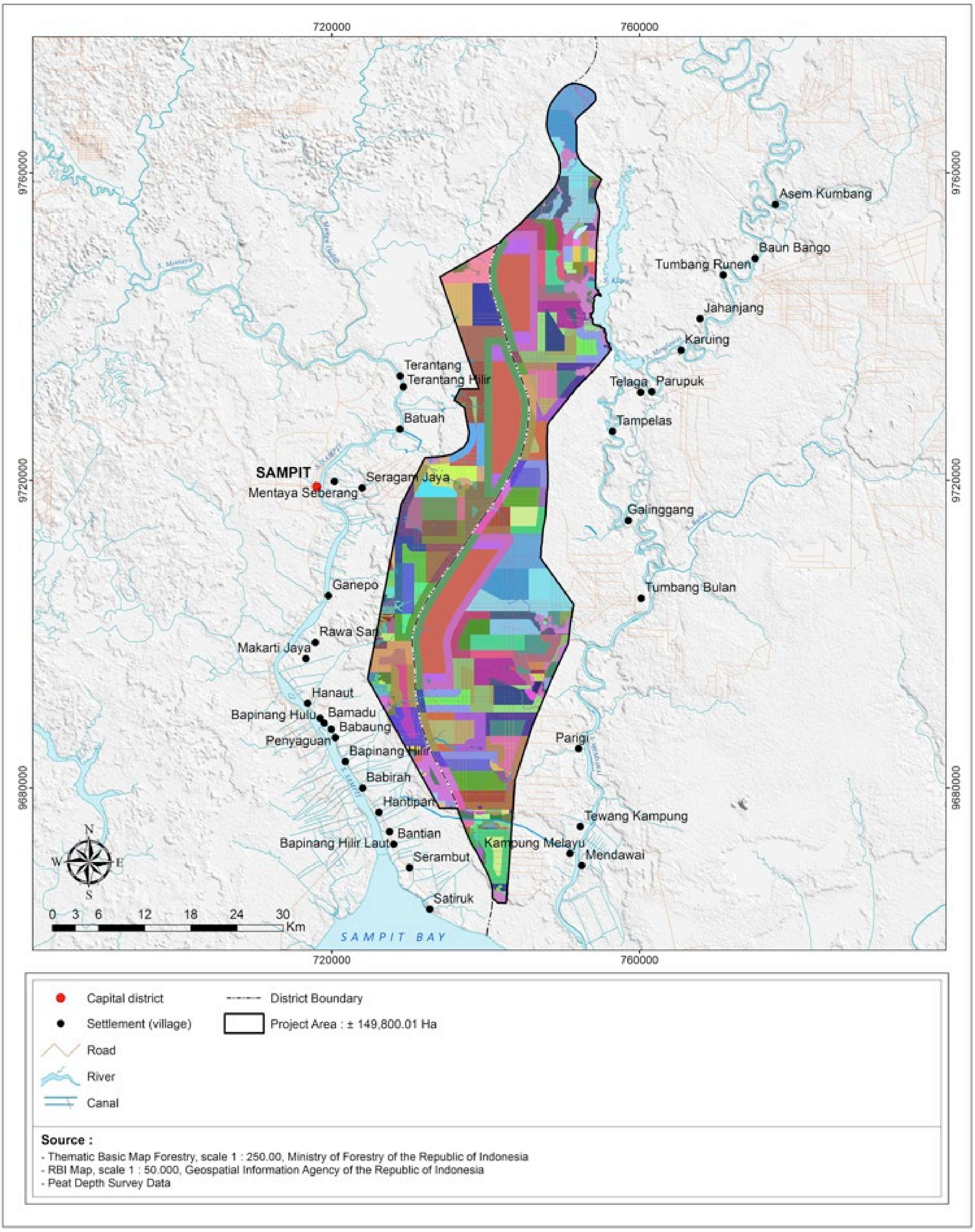


Table 8. Baseline stratification of peatlands and water bodies based on relative homogeneous emission characteristics

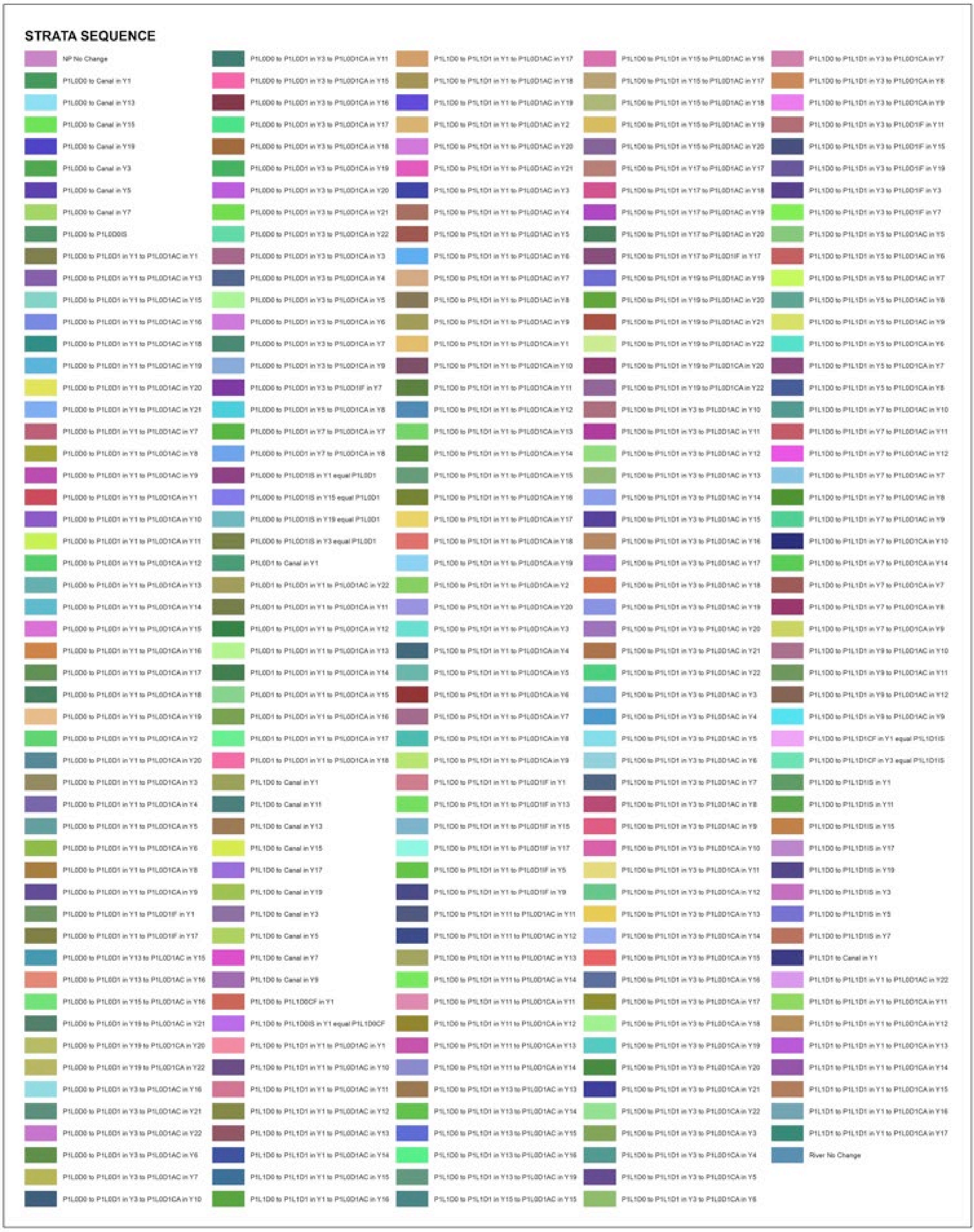
Strata	Description	Area (ha)	Percentage of Project Area	Assumed water table depth (cm-ss)
P1L0D1AC	Acacia Plantation on drained peatland. This stratum represents typical acacia plantations on peatland in Indonesia. For this stratum, drainage is required and forest covers are removed if present. Acacia planting starts in the same year as deforestation. The development of drainage constructions is assumed to happen just before- or at the same year as the deforestation/planting	102,257	68.3	80
P1L1D0CF	Conservation Forest (undrained peatland forest). This stratum represents peatlands where forest covers are not removed and drainage is absent. This stratum remains unchanged since the project start date. The locations of these strata have been selected and positioned in areas where forest cover and peat were present at the project start date	13,451	9.0	20
P1L0D1CA	Community crops on drained peatland. This stratum represents areas nearby community villages that are or will be utilized for agriculture crops. The locations of these strata have been selected in or near deforested areas and with sufficient transportation access, in this project, rivers.	11,028	7.4	80
P1L0D1IF	Infrastructures on drained peatland. This stratum represents lands within acacia plantations planting that would be used for company operation supports, such as base camps, station camps and log yards. Infrastructure areas are usually drained (when on peatland) and barren. The locations have been selected as close as possible to transportation access (rivers).	290	0.2	80
P1L1D1IS	Native Tree species area and river buffer (drained peatland forest). This stratum consists of 2 types of drained forested peatlands in the project area. The indigenous species areas were positioned as c.a. 1 km buffer zone around each conservation area (stratum P1L1D0CF). Peatlands in this stratum are assumed to experience drainage impacts from the surrounding drained areas, but the forest cover remains unchanged during the project duration. Boundary canals are also	16,286	10.9	50

Strata	Description	Area (ha)	Percentage of Project Area	Assumed water table depth (cm-ss)
	constructed along the periphery of the indigenous species area. River buffers were positioned as a 50 m belt extending from both sides of rivers in the project area			
WB	Water bodies. This stratum represents rivers and drainage canals on peatlands. Rivers remain unchanged during the project period, while drainage canals coverage gradually expands following the assumed yearly operation of the baseline agents.	3,327	2.2	NA
Total		146,638	97.9	

Map 7. Stratification changes in the baseline scenario for CUPP activities[6]



[6] Legend of this map is extended to the box below.



4.1.4.2 Stratification based on the emission characteristics for REDD under the baseline scenario

Carbon stock changes and emissions regarding aboveground biomass under the baseline scenario are driven by land cover changes before, during and after the occurrences of deforestation. In the project area, GHG emissions as a result of deforestation occurred over 114,694 ha of forest land designated as acacia plantations, community crops, and infrastructure. Ministry of Forestry regulation[7] mandates that 30,348 ha of forest land must be set aside, of which 15,123 ha designated as conservation forest and 14,966 ha designated as native tree species area. These areas were therefore excluded from emission calculations. Given that no land cover change would occur in these areas, they are referred as non-relevant strata and therefore excluded from emission calculations.

A total 114,778 ha of the forest in the project area is planned to be deforested in the baseline scenario, of which 103,364 ha will be transformed into areas designated as acacia plantation areas. In areas designated as 'community crops', 7,980 ha of forested area will be deforested and replaced by rubber tree plantations. While in areas designated as 'infrastructure area', 3,346 ha of forest area will be deforested and converted into canals, drainage ditches and other infrastructures. Given relatively small impacts (compared to peat/belowground), the carbon loss of AGB due to uncontrolled burning under the baseline scenario is excluded in the calculation.

In the baseline scenario, the stratification of AGB and land cover changes which significantly differ in GHG emission characteristics were estimated and summarized as summarized in Map 8 and Table 9. The dynamics of strata changes are provided in more detail in Appendix 4 of the PD.

[7] Ministry of Environemnt and Forestry. (1995). Keputusan Mentri Kehutanan Nomor: 70/Kpts-II/95 tentang pengaturan tata ruang hutan tanaman industri.

Map 8. Stratification of aboveground biomass in the baseline scenario for REDD

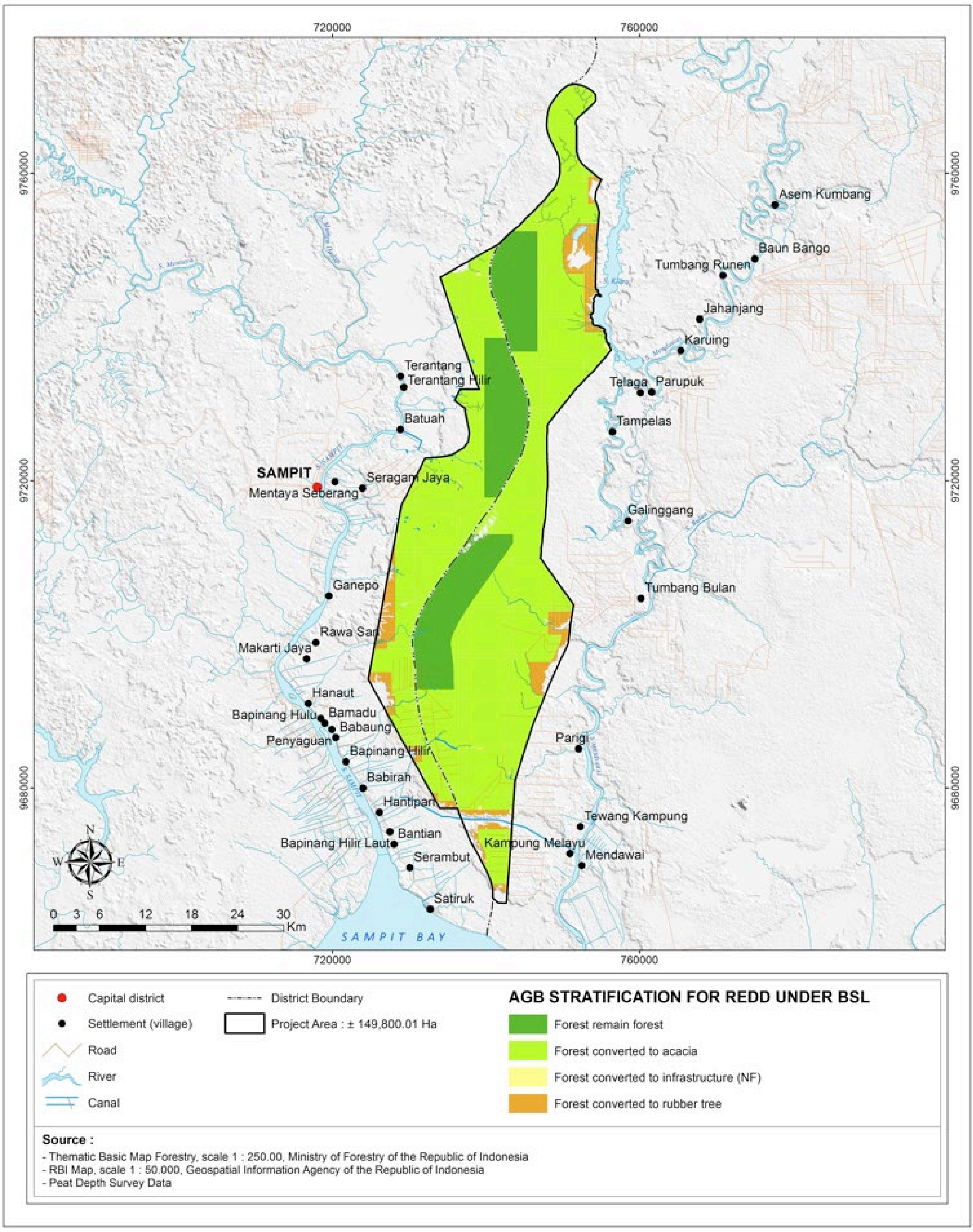


Table 9. Land cover changes strata in the baseline scenario for REDD

Strata	Description	Land use	Area (ha)	Proportion
F0F1*	Forest to forest	Protected area	15,122.82	10.45%
F0F1*	Forest to forest	Native tree area	14,965.81	10.34%
F0Ac1	Forest to *Acacia* plantation	Acacia plantation area	103,363.53	71.39%
F0Rbr1	Forest to rubber tree plantation	Community crops	7,980.38	5.51%
F0NF1	Forest to Non-forest	Infrastructure	3,345.73	2.31%
Total			144,778.26	100.00%

*Non relevant strata as there is no land cover change in baseline scenario

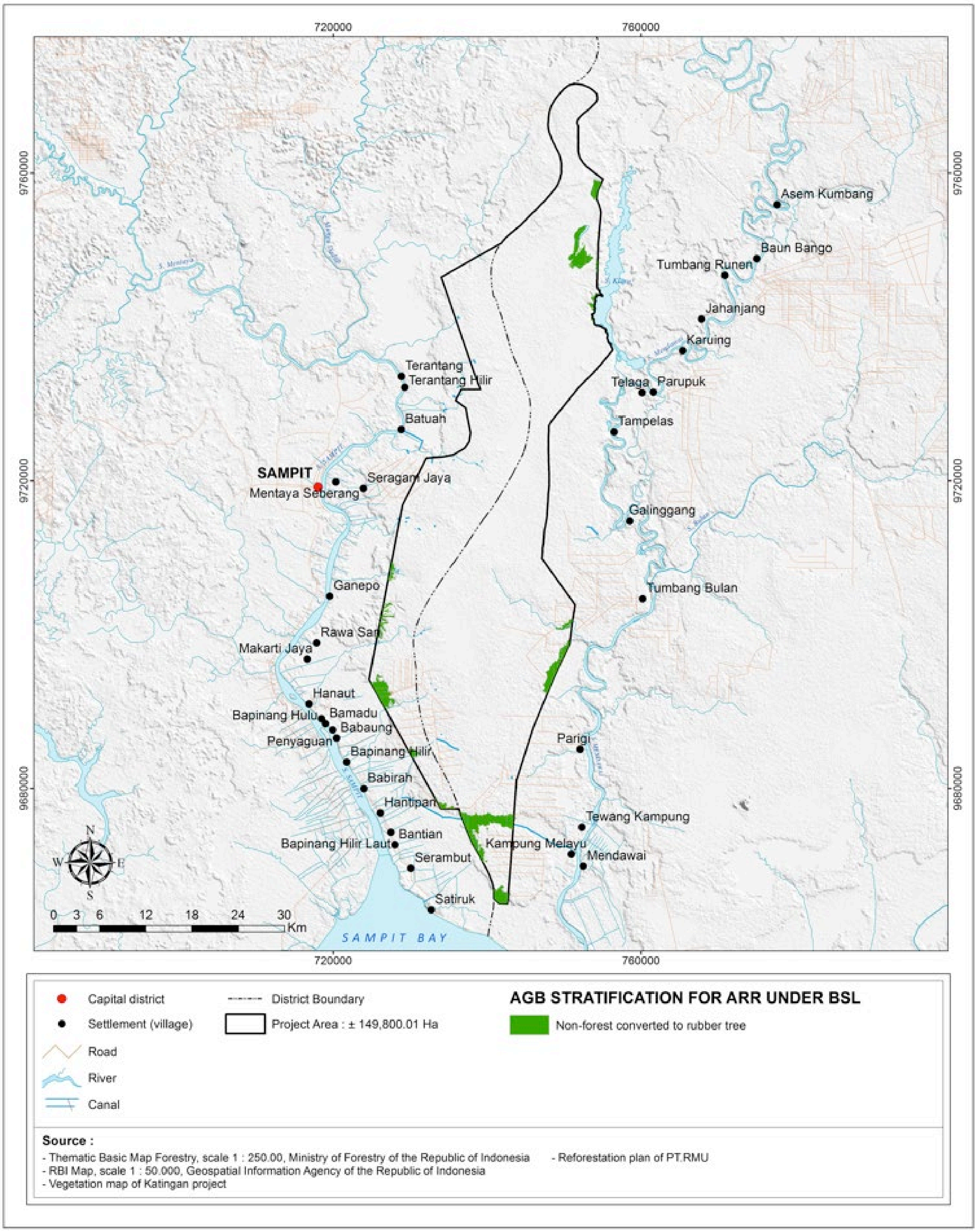
4.1.4.3 Stratification of emission characteristics for ARR activities under the baseline scenario

Replanting under the ARR activities in the areas designated for 'community crops' in the baseline will increase carbon stocks and will therefore be subtracted from the emissions resulting from other baseline activities such as deforestation and forest degradation. Spatial analysis showed that 4,227.72 ha of non-forest area would be transformed to rubber tree plantation (as an ARR activity). A rubber plantation is harvested and renewed every 25 year. Map 9 shows the stratification map of ARR activities under the baseline scenario. The dynamics of changes in the rubber plantation strata are presented in Table 10.

Table 10. Land cover changes strata in the baseline scenario for ARR

Strata	Planting Agent	Land use	Area (Ha)	Planting Start year
NF0Rbr1	Agent A	Community crops	1,004.37	2010
	Agent B	Community crops	1,018.52	2012
	Agent C	Community crops	2,204.82	2012
Total			4,227.72	

Map 9. Stratification of aboveground biomass in the baseline scenario for ARR



4.1.5 Baseline emissions from deforestation

Annual emissions from deforestation are estimated based on the carbon stock losses as a result of conversion of the original forest to acacia plantation area (103,715.55 ha), infrastructure (3,528.26 ha), and rubber tree plantation area (12,208.10 ha) by the three deforestation agents as described in Sub-section 4.4.2. The rate of conversion applied for acacia and rubber plantations is conservatively estimated as the lowest rate of deforestation found in proxy area (3.91%) to determine $AA_{planned,l,t}$. GHG dynamics in the acacia baseline are determined based on the changes in land cover, the soil emissions related to these land cover changes, the emissions from drainage canals and emissions resulting from uncontrolled burnings. The changes in carbon stock in AGB are a result of the conversion of forest to acacia or other land uses, the plantings schemes (rotational and year-by-year) that are applied for the establishment of the acacia plantations and forest degradation as a result of various illegal threads such as illegal logging in undeveloped or conservation areas.

The predicted drainage layout and drainage density of each proportion of the converted land is estimated based on the predicted annual deforestation rate, local hydrotopographic conditions, common practice among acacia plantations and existing regulations. Existing regulations require acacia plantation operators to construct main canals along the concession borders. These canals must be constructed at an early stage of the plantation development, collect water from all other canals in the concession area, and discharge it to nearby rivers. Local topographic conditions play a role in the baseline agents' decisions in designing secondary canals which would act as the main outlets for tertiary canals. The canals need to be constructed with minimal flow resistance, hence positioning them perpendicular to general contour line is optimal. Common practice shows that acacia plantation operators do not necessarily layout tertiary canals perpendicular to the contour line, as long as all of them connect to secondary canals.

As a result of the spatial layout of the baseline deforestation activity, the remaining forest in the project area would have been converted as shown in Table 11 below.

Table 11. Projection of annual forest conversion in project area under the baseline scenario

Year	Forest (ha) deforested and converted to									TOTAL
	Acacia plantation			Infrastructure			Rubber tree plantation			
	A	B	C	A	B	C	A	B	C	
2010	-	-	-	-	-	-	-	-	-	-
2011	1,589	-	-	423	-	-	133	-	-	2,146
2012	1,640	-	-	-	-	-	155	-	-	1,795
2013	1,646	1,527	2,052	-	374	406	181	130	213	6,529
2014	1,636	1,527	2,041	-	-	-	155	88	259	5,705
2015	1,655	1,517	2,022	189	-	-	150	173	255	5,961
2016	1,646	1,619	1,930	-	-	-	125	77	196	5,593
2017	1,656	1,575	2,017	-	158	207	175	207	82	6,076
2018	1,683	1,630	1,945	-	-	-	127	191	282	5,857
2019	1,719	1,518	1,949	189	-	-	179	75	181	5,811
2020	1,695	1,550	1,986	-	-	-	174	180	235	5,819
2021	1,650	1,519	1,996	-	145	190	195	170	66	5,930
2022	1,649	1,550	1,942	-	-	-	141	58	117	5,456
2023	1,629	1,666	2,097	161	-	-	57	34	83	5,727
2024	1,624	1,517	2,043	-	-	-	10	173	92	5,459
2025	1,608	1,540	1,819	-	168	192	24	155	81	5,585
2026	1,595	1,515	1,844	-	-	-	156	178	127	5,415
2027	1,658	1,544	1,955	182	-	-	92	106	60	5,598
2028	1,616	1,566	1,916	-	-	-	133	135	-	5,367
2029	1,655	1,578	1,935	-	157	204	85	158	64	5,837
2030	1,550	1,484	2,041	-	-	-	117	161	104	5,455
2031	-	1,323	1,962	-	-	-	-	146	136	3,567
2032	-	1,527	2,282	-	-	-	-	186	5	4,000
2033	-	-	-	-	-	-	-	-	-	-

Year	Forest (ha) deforested and converted to									TOTAL
	Acacia plantation			Infrastructure			Rubber tree plantation			
	A	B	C	A	B	C	A	B	C	
2070	-	-	-	-	-	-	-	-	-	-
Total	32,798	30,792	39,773	1,145	1,002	1,199	2,562	2,781	2,637	114,690
	103,364			3,346			7,980			

Per BL-PL, net carbon stock changes in the baseline are equal to pre-deforestation stocks minus the long-term average carbon stock in the post-deforestation land-use (acacia and rubber plantation), as defined in the following equation 4.

$$\Delta C_{AB_{tree},i} = C_{AB_{tree_{bsl}},i} - C_{AB_{tree_{post}},i} \quad (4)$$

Where :

$\Delta C_{AB\ tree,i}$ = Baseline carbon stock change in aboveground tree biomass in stratum i; t CO2-e ha-1

$C_{AB\ treeBSL,i}$ = Forest carbon stock in aboveground tree biomass in stratum i; t CO2-e ha-1

$\Delta C_{AB\ treepost,i}$ = Post-deforestation carbon stock in aboveground tree biomass in stratum i; t CO2-e ha-1

Pre-deforestation stock is equal to the average carbon density estimated from biomass plots in the project area (98.38 tC/ha). Referring to the baseline stratification, long-term average carbon stock is dependent on the post deforestation land-use of acacia plantations and rubber tree plantations. For *Acacia crassicapa*, the long-term average carbon stock is calculated from the biomass dynamics of *Acacia crassicarpa* in plantations with the rotation of 5 year. For rubber tree (*Hevea brasiliensis*) plantations the long-term average carbon stock is estimated from the biomass dynamic of rubber tree plantation with a 25 year rotation cycle based on RSPO default value. Applying the VCS AFOLU guidance[8], calculation of the long-term average carbon stockof *Acacia crassicarpa* and *Hevea brasiliensis* was calculated as 17.66 tC/ha and 21.09 tC/ha, respectively. Carbon stock change ($\Delta AB_{tree,i}$ or EF) of forest conversion to *Acacia* plantation, rubber tree plantation, and infrastructure is 296.00 tCO_2-e ha^{-1}, 283.41 tCO_2-e ha^{-1}, and 352.81 tCO_2-e ha^{-}1, respectively. Table 12 provides an overview of the carbon stock changes and emissions within the project life time.

It is assumed that 100% of the deforested areas will be converted to plantations in the year of conversion. GHG emissions from fertilizer application and aboveground biomass loss due to fires are conservatively excluded in the baseline.

Stock changes in aboveground biomass is accounted for at the time of deforestation, and is estimated using the following equation 5:

$$\Delta C_{BSL,i,t} = AA_{planned,i,t} * \Delta C_{ABtree,i} \quad (5)$$

Where :

$\Delta C_{BSL,i,t}$ = Sum of the baseline carbon stock change in all pools in stratum i at time t, t CO2-e

$AA_{planned,i,t}$= Annual area of baseline planned deforestation for stratum i at time t; ha

[8] AFOLU Guidance: example for calculationg Long Term Average Carbon Stock for ARR project with harvesting

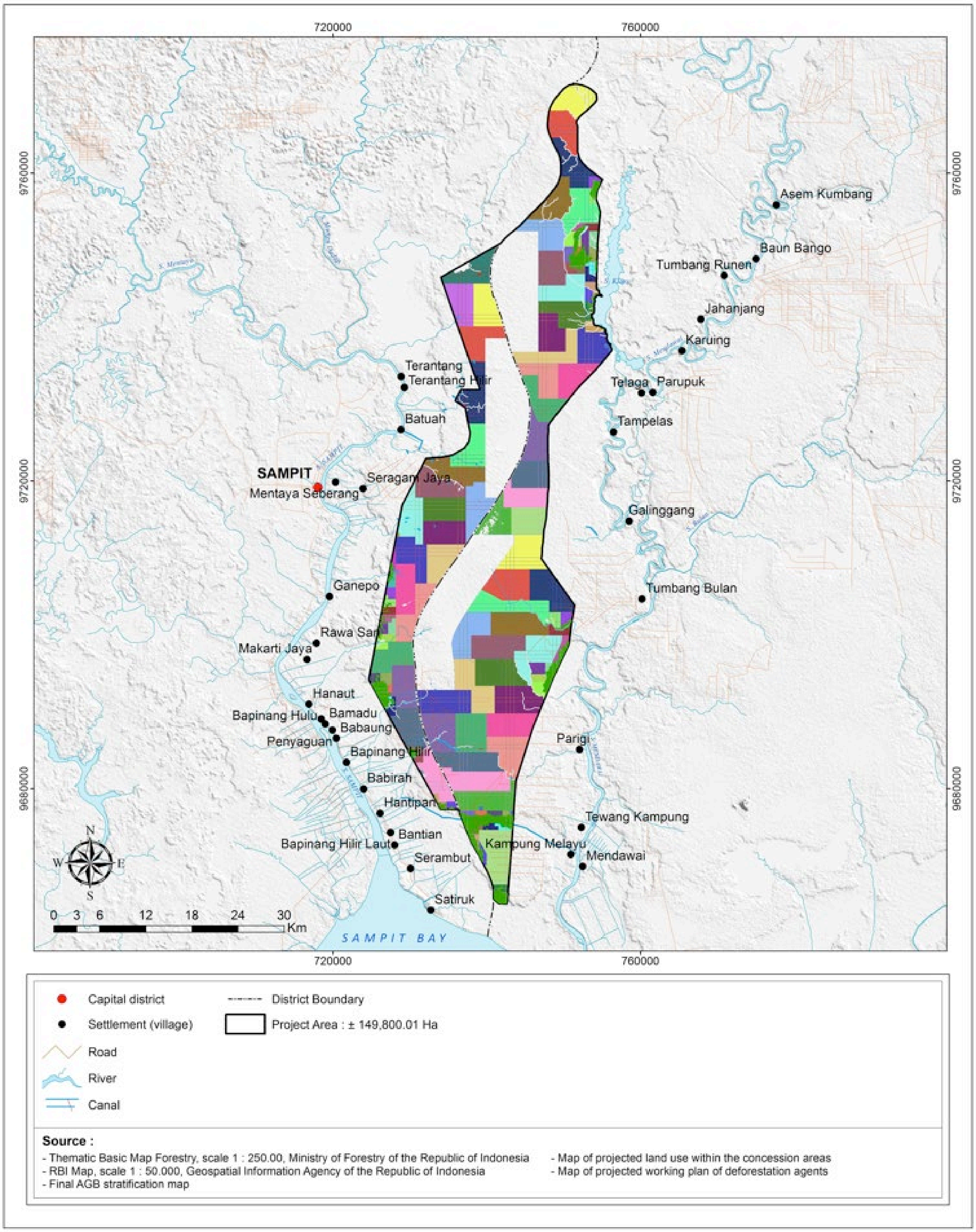
$\Delta AB_{tree,i}$ = Baseline carbon stock change in aboveground tree biomass in stratum i; t CO2-e ha-1

Total emissions from deforestation in the project crediting period are estimated as 34,037,000 tCO2 which is released from forest conversion from 2011 to 2031 (see Table 12 and Map 10 below).

Table 12. Carbon stock changes and emissions from deforestation in project area within project life time

Year	Emission (x1000 tCO2-e) resulted from the conversion from forest to									TOTAL
	Acacia plantation			Infrastructure			Rubber tree plantation			
	A	B	C	A	B	C	A	B	C	
2011	470	-	-	149	-	-	38	-	-	657
2012	485	-	-	-	-	-	44	-	-	529
2013	487	452	607	-	132	143	51	37	60	1,970
2014	484	452	604	-	-	-	44	25	73	1,682
2015	490	449	598	67	-	-	43	49	72	1,768
2016	487	479	571	-	-	-	35	22	56	1,651
2017	490	466	597	-	56	73	50	59	23	1,813
2018	498	482	576	-	-	-	36	54	80	1,726
2019	509	449	577	67	-	-	51	21	51	1,725
2020	502	459	588	-	-	-	49	51	67	1,715
2021	488	450	591	-	51	67	55	48	19	1,769
2022	488	459	575	-	-	-	40	16	33	1,611
2023	482	493	621	57	-	-	16	10	24	1,702
2024	481	449	605	-	-	-	3	49	26	1,612
2025	476	456	538	-	59	68	7	44	23	1,670
2026	472	448	546	-	-	-	44	51	36	1,597
2027	491	457	579	64	-	-	26	30	17	1,664
2028	478	464	567	-	-	-	38	38	-	1,585
2029	490	467	573	-	55	72	24	45	18	1,744
2030	459	439	604	-	-	-	33	46	29	1,610
2031	-	392	581	-	-	-	-	41	39	1,052
2032	-	452	676	-	-	-	-	53	1	1,181
2033	-	-	-	-	-	-	-	-	-	-
2070	-	-	-	-	-	-	-	-	-	-
TOTAL	9,708	9,114	11,773	404	353	423	726	788	747	34,037
	30,595			1,180			2,262			

Map 10. Projected emissions from deforestation in the project area



4.1.6 Baseline emissions from ARR activities

Under the baseline scenario, ARR activities are carried out in the non-forest community buffer areas of the three deforestation agents (timber plantation companies). Based on spatial analysis, in total 4,227.72 ha will be planted with rubber tree (*Hevea brasiliensis*); 1,004.37 ha by agent A, 1,018.52 ha by agent B, and 2,204.82 ha by agent C.

The annual planting rate is set equal to the deforestation rate that resulted from analyses in the reference region. For rubber, the plantation was assumed to operate on a 25 year rotation (i.e. harvested and replanted every 25 years). We assumed 3 planting times and 2 harvesting times within the project period. Activities and sequences associated with the establishment of rubber tree plantation under baseline scenario are summarized in Table 13 below.

Table 13. The assumed annual planting and harvesting under ARR activities within the project period

	Planting									Harvesting					
Agent	Agent A			Agent B			Agent C			Agent A		Agent B		Agent C	
Year/Rotation	1	2	3	1	2	3	1	2	3	1	2	1	2	1	2
2010	-														
2011	44														
2012	49			-			-								
2013	-			91			66								
2014	27			98			14								
2015	29			3			12								
2016	47			53			171								
2017	-			1			214								
2018	58			9			0								
2019	15			125			103								
2020	3			0			42								
2021	30			25			135								
2022	66			142			100								
2023	119			166			139								
2024	158			61			130								
2025	152			29			134								
2026	30			-			83								
2027	65			93			141								
2028	18			36			187								
2029	75			12			152								
2030	22			33			88								
2031	-			37			70								
2032	-			3			223								
2033	-			-			-								

	Planting									Harvesting					
Agent	Agent A			Agent B			Agent C			Agent A		Agent B		Agent C	
Year/Rotation	1	2	3	1	2	3	1	2	3	1	2	1	2	1	2
2034	-			-			-								
2035	-	-		-			-			-					
2036	-	44		-			-			44					
2037	-	49		-	-		-	-		49		-		-	
2038	-	-		-	91		-	66		-		91		66	
2039	-	27		-	98		-	14		27		98		14	
2040	-	29		-	3		-	12		29		3		12	
2041	-	47		-	53		-	171		47		53		171	
2042	-	-		-	1		-	214		-		1		214	
2043	-	58		-	9		-	0		58		9		0	
2044	-	15		-	125		-	103		15		125		103	
2045	-	3		-	0		-	42		3		0		42	
2046	-	30		-	25		-	135		30		25		135	
2047	-	66		-	142		-	100		66		142		100	
2048	-	119		-	166		-	139		119		166		139	
2049	-	158		-	61		-	130		158		61		130	
2050	-	152		-	29		-	134		152		29		134	
2051	-	30		-	-		-	83		30		-		83	
2052	-	65		-	93		-	141		65		93		141	
2053	-	18		-	36		-	187		18		36		187	
2054	-	75		-	12		-	152		75		12		152	
2055	-	22		-	33		-	88		22		33		88	
2056	-	-		-	37		-	70		-		37		70	
2057	-	-		-	3		-	223		-		3		223	
2058	-	-		-	-		-	-		-		-		-	
2059	-	-		-	-		-	-		-		-		-	

	Planting									Harvesting					
Agent	Agent A			Agent B			Agent C			Agent A		Agent B		Agent C	
Year/Rotation	1	2	3	1	2	3	1	2	3	1	2	1	2	1	2
2060	-	-	-	-	-		-	-		-	-	-		-	
2061	-	-	44	-	-		-	-		-	44	-		-	
2062	-	-	49	-	-	-	-	-	-	-	49	-	-	-	-
2063	-	-	-	-	-	91	-	-	66	-	-	-	91	-	66
2064	-	-	27	-	-	98	-	-	14	-	27	-	98	-	14
2065	-	-	29	-	-	3	-	-	12	-	29	-	3	-	12
2066	-	-	47	-	-	53	-	-	171	-	47	-	53	-	171
2067	-	-	-	-	-	1	-	-	214	-	-	-	1	-	214
2068	-	-	58	-	-	9	-	-	0	-	58	-	9	-	0
2069	-	-	15	-	-	125	-	-	103	-	15	-	125	-	103
2070	-	-	3	-	-	0	-	-	42	-	3	-	0	-	42
	1,004	1,004	268	1,019	1,019	380	2,205	2,205	580	1,004	268	1,019	380	2,205	580

According to module BL-ARR, GHG emissions and removal are estimated using the procedure provided in AR-ACM0003 Afforestation and reforestation lands except wetlands and associated pool. Net GHG removals under the ARR baseline scenario up to time t*; t CO2-e ($\Delta C_{BSL\text{-}ARR}$) is equal to the summation from t=1 to t* of the baseline net GHG removals by sinks in year t;(ΔC) in AR-ACM0003, as describe in equation 6:

$$\Delta C_{BSL-ARR} = \sum_{t=1}^{t^*} (\Delta C_{BSL,t\ ACM0003}) \qquad (6)$$

Where:

$\Delta C_{BSL\text{-}ARR}$ Net GHG removals under the ARR baseline scenario up to time t; t CO2-e

$\Delta C_{BSL,t\ ACM0003}$ Baseline net GHG removal by sinks in year t (from AR-ACM0003) (t CO2-e)

t = 1,2,3,... t time since project start

$C_{TREE,BSL,t}$ Change in carbon stock in tree biomass under baseline scenario, in year t: tCO2-e

t = 1,2,3,... t time since planting start

Net GHG removals under the ARR baseline scenario within the project period are estimated at 445,017.19 tCO2-e. Annual GHG removals and emissions (carbon losses because of harvesting are subtracted) under ARR are presented in Table 14 below.

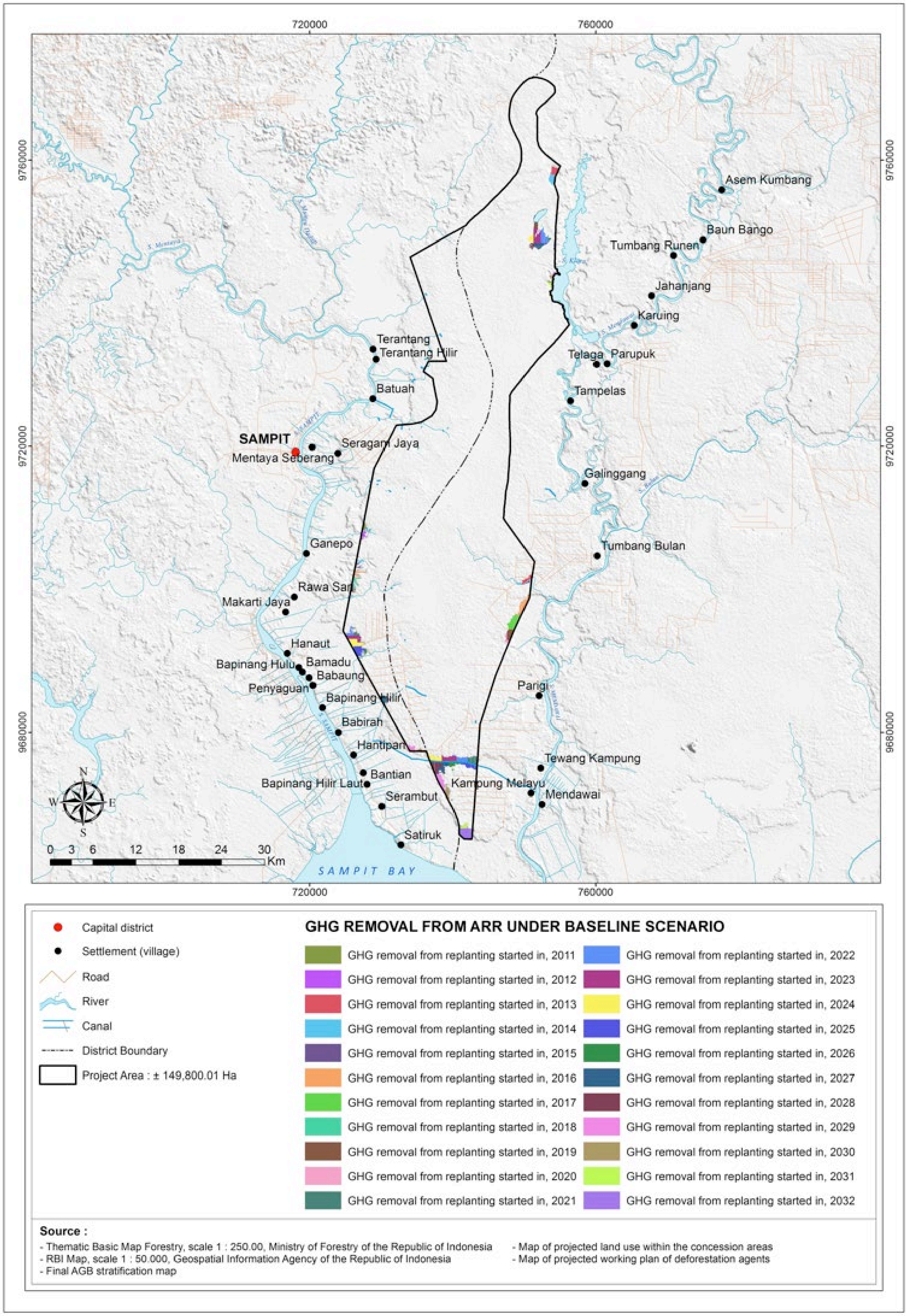
Table 14. Baseline net GHG removal from ARR activities in project area within the project period

Year	NET GHG removal from ARR (tCO2-e)			
	Agent A	Agent B	Agent C	Total
2010	-	-	-	-
2011	295.26	-	-	295.26
2012	627.61	-	-	627.61
2013	627.61	614.85	443.25	1,685.71
2014	812.35	1,279.02	540.50	2,631.87
2015	1,005.45	1,297.58	620.71	2,923.75
2016	1,323.53	1,653.95	1,779.78	4,757.26
2017	1,323.53	1,663.70	3,226.08	6,213.31
2018	1,713.96	1,724.03	3,226.09	6,664.08
2019	1,813.52	2,567.54	3,924.44	8,305.51
2020	1,833.52	2,569.33	4,205.61	8,608.45
2021	2,033.10	2,739.54	5,119.77	9,892.42
2022	2,477.39	3,701.74	5,793.70	11,972.83
2023	3,278.98	4,823.03	6,736.93	14,838.95
2024	4,347.82	5,235.67	7,617.13	17,200.62
2025	5,375.53	5,432.88	8,522.22	19,330.64
2026	5,577.71	5,432.88	9,085.99	20,096.59

Year	NET GHG removal from ARR (tCO2-e)			
	Agent A	Agent B	Agent C	Total
2027	6,017.45	6,064.77	10,041.17	22,123.40
2028	6,139.46	6,306.49	11,306.38	23,752.33
2029	6,646.71	6,389.04	12,332.16	25,367.91
2030	6,793.19	6,613.50	12,929.09	26,335.77
2031	6,793.19	6,865.32	13,403.43	27,061.94
2032	6,793.19	6,888.91	14,912.58	28,594.68
2033	6,793.19	6,888.91	14,912.58	28,594.68
2034	6,793.19	6,888.91	14,912.58	28,594.68
2035	6,793.19	6,888.91	14,912.58	28,594.68
2036	(588.25)	6,888.91	14,912.58	21,213.24
2037	(1,515.60)	6,888.91	14,912.58	20,285.89
2038	6,793.19	(8,482.22)	3,831.28	2,142.25
2039	2,174.59	(9,715.45)	12,481.34	4,940.47
2040	1,965.67	6,424.92	12,907.27	21,297.86
2041	(1,158.68)	(2,020.40)	(14,064.16)	(17,243.23)
2042	6,793.19	6,635.45	(21,244.78)	(7,816.14)
2043	(2,967.52)	5,371.00	14,912.17	17,315.64
2044	4,304.02	(14,208.74)	(2,546.12)	(12,450.83)
2045	6,293.36	6,834.57	7,883.41	21,011.34
2046	1,803.53	2,623.70	(7,941.44)	(3,514.20)
2047	(4,313.97)	(17,175.85)	(1,935.69)	(23,425.52)
2048	(13,246.71)	(21,152.96)	(8,668.17)	(43,067.84)
2049	(19,927.74)	(3,436.77)	(7,092.32)	(30,456.83)
2050	(18,899.52)	1,751.51	(7,714.86)	(24,862.86)
2051	1,738.68	6,681.94	818.32	9,238.94
2052	(4,200.38)	(9,115.17)	(8,966.91)	(22,282.46)
2053	3,742.92	638.92	(16,717.48)	(12,335.64)
2054	(5,887.89)	4,618.14	(10,731.98)	(12,001.74)
2055	3,131.16	1,070.53	(10.63)	4,191.07
2056	6,793.19	386.43	3,053.91	10,233.52
2057	6,793.19	6,092.22	(22,816.09)	(9,930.68)
2058	6,793.19	6,681.94	14,912.58	28,387.71
2059	6,793.19	6,681.94	14,912.58	28,387.71
2060	6,793.19	6,681.94	14,912.58	28,387.71
2061	(588.25)	6,681.94	14,912.58	21,006.28
2062	(1,515.60)	6,681.94	14,912.58	20,078.92
2063	6,793.19	(8,689.19)	3,831.28	1,935.28
2064	2,174.59	(9,922.42)	12,481.34	4,733.51
2065	1,965.67	6,217.95	12,907.27	21,090.89

Year	NET GHG removal from ARR (tCO2-e)			
	Agent A	Agent B	Agent C	Total
2066	(1,158.68)	(2,227.36)	(14,064.16)	(17,450.20)
2067	6,793.19	6,691.69	(21,244.78)	(7,759.90)
2068	(2,967.52)	5,183.53	14,912.17	17,128.17
2069	4,304.02	(14,446.78)	(2,546.12)	(12,688.88)
2070	6,293.36	6,594.74	7,602.24	20,490.34
TOTAL	116,123.60	100,941.92	224,209.19	441,274.71

Map 11. Projected spatial GHG removal from ARR under baseline scenario



4.1.7 Baseline emissions from microbial decompositions of peat, peat burnings and water bodies in peatlands

4.1.7.1 Spatial and temporal variability

Quantification of GHG emissions from microbial decompositions of peat, peat burnings and water bodies in peatlands has been carried out by using a spatially and temporally explicit approach. Each baseline stratum as set out in Table 8 and accompanying sub-section was discretized into parcels of the smallest land or water body unit with relatively uniform combinations of spatial variables as given in Table 15. Temporal discretization has been used by sequencing the calculation into 1-year time-step, while temporal variables determine the sequence of strata changes, temporal variability of GHG emission parameters and temporal restrictions to GHG emissions as given in Table 15. The schematization provides an assurance of the proper use of GHG emission parameters at the correct spatial location and the correct time.

Table 15. Variables used in the schematization of quantification of GHG emissions from microbial decompositions of peat, peat burnings and dissolved organic carbon from water bodies in peatlands in the baseline scenario

Variables	Description
(A) Spatial Variables	
(A1) Soil Type	Distinction between peat or non-peat. This is used to exclude all non-peat parcels from GHG calculation
(A2) Initial peat thickness available for microbial decompositions and burnings	Derived from DEM, DEL and Peat Thickness maps as described in Section 4.4.1.3. These maps are used to determine the initial condition for subsequent calculations of the remaining peat layer available for microbial decompositions and burnings.
(A3) Initial stratum	Stratum of the corresponding parcel at the project start date (as derived in Annex 14 of the PD and Section 5.4.2.1 of the PD) before conversion into baseline stratum takes effect. This is used to determine the correct Emission Factor for the corresponding parcel for the duration before B1 and B2 (in this table, below) take effect.
(A4) Peat burning tag	This is used to identify whether the corresponding parcel has been marked as possible area for peat burning (PBA_{BSL}). All parcels without tag are excluded from peat burning calculation.
(B) Temporal Variables	
(B1) Year of drainage	Determines the onset of conversion from initial stratum to drained stratum and sets all the drainage related parameters/variables accordingly, such as initial consolidations, bulk density changes, etc. This does not take effect if the initial stratum of the parcel is already a drained stratum. Together with B2 this is used to determine the correct Emission Factor for the corresponding parcel
(B2) Year of deforestation/ planting of the baseline land cover	Determines the onset of conversion of initial stratum to deforested/planted stratum. Together with B1 this is used to determine the correct Emission Factor for the corresponding parcel

Variables	Description
(B3) PDT	The PDT is the period of time that it takes to deplete the remaining peat layer by microbial decomposition and burning (conservatively will be assumed that PDT is reached once the remaining peat layer has reached 20 cm). Once the PDT is reached in a given stratum all GHG emissions in that stratum are set to zero.
(B4) Year tag for burning	Determines whether the corresponding parcel has been marked to catch peat burning for the corresponding year, and counting the number of burn scars (and any repetitions) of the parcel since year 1. This is used to set the correct burn scar depth and other related burning parameters for the corresponding parcel accordingly.
(B5) Burning restriction	If the corresponding parcel has been marked for burning in the corresponding year (as being checked in B4), this restriction further checks whether GHG emissions from burning would still be possible based on variables: B1 (Year of drainage), B2 (Year of deforestation/planting) and B3 (Remaining peat thickness available for microbial decomposition and burning). Only drained-deforested parcels with >20 cm peat is categorized as available and would emit GHGs from burning.

4.1.7.2 Emissions calculations

Taking into account the spatial and temporal variability described in Section 5.3.4.1 and Appendix 7of the PD, the net CO_2-equivalent emissions from the peat (microbial decomposition and burning) and water bodies were estimated following equation 18 from module BL-PEAT (7):

$$GHG_{BSL\text{-}WRC}=\sum_{t=1}^{t^*}\sum_{i=1}^{M}\left(E_{peatsoil\text{-}BSL,i,t}+E_{peatditch\text{-}BSL,i,t}+E_{peatburn\text{-}BSL,i,t}\right) \quad (7)$$

Where:

$GHG_{BSL\text{-}WRC}$	Net GHG emissions in the CUPP baseline scenario up to year t* (t CO_2e)
$E_{peatsoil\text{-}BSL,i,t}$	GHG emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})
$E_{peatditch\text{-}BSL,i,t}$	GHG emissions from water bodies in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})
$E_{peatburn\text{-}BSL,i,t}$	GHG emissions from burning of peat in the base line scenario in stratum i at year t (t CO_2-e yr^{-1})
i	1, 2, 3 …M strata in the baseline scenario (unitless)
t	1, 2, 3, … t* times elapsed since the project start (yr)

For all strata i where the project duration exceeds the peat depletion time (PDT or t_{PDT}), for t > $t_{PDT\text{-}BSL,I}$ the following equations 8, 9, and 10 apply:

$E_{peatsoil-BSL,i,t} = 0$ (8)

$E_{peatditch-BSL,i,t} = 0$ (9)

$E_{peatburn-BSL,i,t} = 0$ (10)

Where:

$t_{PDT-BSL,i}$	Peat Depletion Time in the baseline scenario in stratum i in years elapsed since the project start (yr)
$E_{peatsoil-BSL,i,t}$	GHG emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})
$E_{peatditch-BSL,i,t}$	GHG emissions from water bodies at year t (t CO_2e yr^{-1})
$E_{peatburn-BSL,i,t}$	GHG emissions from burning of peat in the base line scenario in stratum i at year t (t CO_2e yr^{-1})
i	1, 2, 3 …M_{BSL} strata in the baseline scenario (unitless)
t	1, 2, 3, … t* time elapsed since the project start (yr)

GHG emissions from peat soils comprise GHG emission as CO_2 and CH_4. Were calculated using the following equation 11:

$$E_{peatsoil-BSL,i,t}=E_{CO2-BSL,i,t}+E_{CH4-BSL,i,t} \quad (11)$$

Where:

$E_{CO2-BSL,i,t}$	CO_2 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})
$E_{CH4-BSL,i,t}$	CH_4 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

4.1.7.3 Subsidence related to initial compression, microbial decomposition and burning of peat

The initial peat thickness in the baseline scenario is assumed equal to the initial peat thickness as mapped at the project start date minus the initial thickness loss due to compression resulting from initial drainage (see Annex 6 of the PD). GHG emissions from peat soils comprise GHG emission as CO_2 and CH_4. Were calculated using the following equation 12:

$$E_{peatsoil-BSL,i,t}=E_{CO2-BSL,i,t}+E_{CH4-BSL,i,t} \quad (12)$$

Where:

$E_{CO2-BSL,i,t}$	CO_2 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})
$E_{CH4-BSL,i,t}$	CH_4 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

On peatlands that were undrained and which would remain undrained during the project period (stratum P1L1D0CF) and peatlands that are already drained at the project start date (strata P1L1D1, P1L0D1) the compression is assumed to be absent, therefore $Depth_{peatloss\text{-}BSL\text{-}comp} = 0$.

As a result of the initial compression, the bulk density of peat increases proportionally with associated thickness loss. This is taken into account when quantifying peat carbon stock dynamics.

To maintain consistency between annual net CO_2-equivalent emissions and remaining peat carbon stock, annual rates of peat and carbon stock loss in the baseline scenario were quantified annually based on the rate of emissions from microbial decompositions of peat (CO_2 and CH_4 decomposition), burn scar depths (for areas where peat burning was projected to occur), bulk density of peat above water table, and a conservative carbon content value (48 $kg.kg^{-1}$ dry mass) as calculated using equation 13 as follows:

$$Rate_{peatloss\text{-}BSL,i,t}=D_{peatburn\text{-}BSL,i,t}+\left(\frac{12}{44}\times\frac{EF_{CO2,i,t}}{BD_{BSL,i,t}\times C_c\times 10}\right)+\left(\frac{1}{GWP_{CH4}}\times\frac{12}{16}\times\frac{EF_{CH4,i,t}}{BD_{BSL,i,t}\times C_c\times 10}\right) \quad (13)$$

Where:

$Rate_{peatloss\text{-}BSL,I,t}$	Rate of peatloss due to microbial decompositions and burning in baseline scenario of stratum i at year t ($m.y^{-1}$)
$D_{peatburn\text{-}BSL,i,t}$	Burn scar depth under baseline scenario in stratum i at year t (m)
$BD_{BSL,i,t}$	Bulk density of peat soil above water table in baseline scenario in stratum i at year t* ($kg.m^{-3}$)
$EF_{CO2,i,t}$	CO_2 emissions from microbial decomposition of peat in baseline scenario in stratum i at year t ($tCO_2.ha^{-1}.y^{-1}$). Equals CO_2 emission factor when peat available for decomposition > 20 cm, otherwise zero
$EF_{CH4,i,t}$	CH_4 emissions from microbial microbial decomposition of peat in baseline scenario in stratum i at year t ($tCO_2.ha^{-1}.y^{-1}$). Equals CH_4 emission factor when peat available for decomposition > 20 cm, otherwise zero
GWP_{CH4}	Global Warming Potential of CH_4
Cc	Carbon content of peat soil ($kg.kg^{-1}$)

Remaining peat thickness was assessed annually for the project crediting period based on the rate of peat loss due to microbial decompositions of and burning incidents using equation 14 as follow:

$$Depth_{peat\text{-}BSL,i,t}=Depth_{peat\text{-}BSL,i,t0}-\sum_{t=1}^{t=t^*}Rate_{peatloss\text{-}BSL,i,t} \quad (14)$$

Where:

$Depth_{peat\text{-}BSL,i,t}$	Remaining peat thickness in the baseline scenario in stratum i at year t* (m)
$Depth_{peat\text{-}BSL,i,t0}$	Peat thickness at the baseline scenario in stratum i at year t0 = project start date (initial peat thickness) (m)
$Rate_{peatloss\text{-}BSL,i,t}$	Rate of peat loss due (subsidence) due to microbial decomposition of peat and peat burning in the baseline scenario in stratum i in year t ($m\ yr^{-1}$)
i	Strata

Peat carbon stock and its annual changes were calculated using equation 15 following annual peat carbon loss due to microbial decompositions and burning.

$$C_{stock\text{-}BSL,i,t}=C_{stock\text{-}BSL,i,t-1}-C_{loss\text{-}BSL,i,t-1} \quad (15)$$

Where:

$C_{stock-BSL,i,t}$ Remaining peat carbon stock in baseline scenario in stratum i at year t (t $C.ha^{-1}$)

$C_{stock-BSL,i,t-1}$ Remaining peat carbon stock in baseline scenario in stratum i at previous year (t $C.ha^{-1}$)

$C_{loss-BSL,i,t-1}$ Equivalent carbon stock loss from microbial decomposition of peat and peat burning in baseline scenario in stratum i at previous year (t $C.ha^{-1}$)

By tracking annual peat carbon stock and peat thickness in the baseline scenario it has been assured that there is no GHG emissions has been accounted for within any parcel of each stratum once available carbon stock/peat has been depleted. Conservatively, peat is assumed depleted once peat thickness available for decompositions and burning has been reduced to 20 cm.

A summary of the quantified GHG emissions from peat microbial decomposition, uncontrolled peat burning and water bodies under the baseline scenario are presented in Table 16, and the next Sub-subsections describe how Table 16 has been calculated.

Table 16. A summary of the annual GHG emissions from peat microbial decomposition, uncontrolled peat burning and water bodies in the Project area under the baseline scenario ($tCO_2e.y^{-1}$) since the start of the project in 2010

Year	CO_2 from peat microbial decomp.	CH_4 from peat microbial decomp.	CO_2 from peat burning	CH_4 from peat burning	CO_2 from DOC	Total
2011	872,262	80,618	113,627	13,693	2,779	1,082,979
2012	966,973	80,528	127,390	15,351	2,779	1,193,020
2013	2,292,138	49,284	205,515	24,766	6,052	2,577,755
2014	2,588,966	48,998	251,623	30,322	6,052	2,925,961
2015	2,910,708	47,418	244,700	29,488	6,314	3,238,629
2016	3,204,660	47,144	269,703	32,501	6,314	3,560,321
2017	3,628,150	42,686	313,518	37,781	7,012	4,029,146
2018	3,932,268	42,398	338,149	40,749	7,012	4,360,576
2019	4,307,185	39,805	349,520	42,119	7,370	4,746,000
2020	4,584,724	39,541	404,301	48,721	7,370	5,084,656
2021	4,973,666	36,356	382,934	46,146	7,965	5,447,067
2022	5,268,302	36,073	386,441	46,569	7,965	5,745,349
2023	5,631,354	34,002	403,044	48,569	8,275	6,125,244
2024	5,923,395	33,720	379,011	45,673	8,275	6,390,075
2025	6,308,103	29,970	388,991	46,876	8,890	6,782,830
2026	6,585,466	29,681	373,954	45,064	8,890	7,043,055
2027	6,906,267	28,391	411,579	49,598	9,127	7,404,961
2028	7,189,341	28,092	417,025	50,254	9,127	7,693,839
2029	7,614,737	23,607	423,444	51,028	9,821	8,122,636

Year	CO_2 from peat microbial decomp.	CH_4 from peat microbial decomp.	CO_2 from peat burning	CH_4 from peat burning	CO_2 from DOC	Total
2030	7,894,864	23,301	400,032	48,206	9,821	8,376,224
2031	8,081,433	23,087	379,649	45,750	9,821	8,539,740
2032	8,286,789	22,849	390,765	47,090	9,821	8,757,313
2033	8,278,593	22,832	387,157	46,655	9,821	8,745,058
2034	8,268,410	22,812	346,079	41,705	9,821	8,688,826
2035	8,262,373	22,797	309,556	37,303	9,821	8,641,850
2036	8,255,644	22,783	310,482	37,415	9,821	8,636,144
2037	8,248,377	22,766	310,670	37,438	9,821	8,629,072
2038	8,241,859	22,752	255,033	30,733	9,821	8,560,198
2039	8,234,741	22,737	288,620	34,781	9,821	8,590,699
2040	8,225,122	22,720	274,839	33,120	9,821	8,565,622
2041	8,217,806	22,704	276,610	33,333	9,821	8,560,273
2042	8,209,559	22,682	216,776	26,123	9,821	8,484,961
2043	8,202,803	22,667	228,318	27,514	9,821	8,491,122
2044	8,193,613	22,650	232,271	27,990	9,821	8,486,345
2045	8,185,905	22,633	214,734	25,877	9,821	8,458,970
2046	8,178,125	22,617	196,918	23,730	9,821	8,431,210
2047	8,170,001	22,598	202,848	24,444	9,821	8,429,712
2048	8,161,601	22,583	190,877	23,002	9,821	8,407,884
2049	8,154,522	22,567	176,446	21,263	9,821	8,384,618
2050	8,145,756	22,550	190,277	22,930	9,821	8,391,334
2051	8,138,962	22,537	183,798	22,149	9,821	8,377,267
2052	8,131,369	22,520	171,602	20,679	9,821	8,355,991
2053	8,123,480	22,506	170,305	20,523	9,821	8,346,635
2054	8,113,478	22,490	167,613	20,198	9,821	8,333,601
2055	8,105,756	22,477	149,992	18,075	9,821	8,306,120
2056	8,096,914	22,461	159,279	19,194	9,821	8,307,668
2057	8,086,643	22,444	150,819	18,175	9,821	8,287,901
2058	8,079,669	22,431	160,835	19,382	9,821	8,292,137
2059	8,069,217	22,414	150,511	18,137	9,821	8,270,101
2060	8,053,640	22,384	151,922	18,308	9,821	8,256,074
2061	8,041,789	22,367	154,261	18,589	9,821	8,246,826
2062	8,030,326	22,348	149,805	18,052	9,821	8,230,353

Year	CO_2 from peat microbial decomp.	CH_4 from peat microbial decomp.	CO_2 from peat burning	CH_4 from peat burning	CO_2 from DOC	Total
2063	8,017,565	22,326	152,702	18,402	9,821	8,220,815
2064	8,005,012	22,307	145,495	17,533	9,821	8,200,168
2065	7,993,522	22,289	134,659	16,227	9,821	8,176,517
2066	7,980,530	22,269	143,981	17,351	9,821	8,173,951
2067	7,965,650	22,246	130,055	15,672	9,821	8,143,443
2068	7,949,145	22,218	131,385	15,833	9,821	8,128,402
2069	7,936,436	22,197	133,213	16,053	9,821	8,117,720
2070	7,922,493	22,175	128,773	15,518	9,821	8,098,779

4.1.7.4 Emissions from peat microbial decomposition

It is assumed that the rate of conversion of undrained peatland to drained peatland in the baseline scenario is based on the rate of conversion of the forest by the deforestation agents as outlined in Sub-subsection 5.3.4 and Appendix 6 of the PD. The temporal variability of the emissions from peat microbial decompositions are therefore directly related to the land use and land use changes in the baseline. Table 17 below and Table 8 above provide details on the WRC related baseline stratification that is used and the area (ha) per stratum. Based on this data, the baseline GHG emissions for the different 'emission strata' were calculated using conservative and scientifically robust (TIER 1) IPCC default emission factors for each stratum i and processed using equations 16, 17, and 18 defined by the VCS methodology VM0007 module BL-PEAT:

$$E_{peatsoil\text{-}BSL,i,t} = E_{peatsoil\text{-}BSL,CO2,i,t} + E_{peatsoil\text{-}BSL,CH4,i,t} \quad (16)$$

Where:

$E_{peatsoil\text{-}BSL,i,t}$ GHG emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

$E_{peatsoil\text{-}BSL,CO2,i,t}$ CO_2 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

$E_{peatsoil\text{-}BSL,CH4,i,t}$ CH_4 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

i 1, 2, 3 …M_{BSL} strata in the baseline scenario (unitless)

t 1, 2, 3, … t* time elapsed since the project start (yr)

For each stratum, the CO_2 emissions from microbial decomposition of the peat within the project boundary were estimated as follows:

$$E_{peatsoil\text{-}BSL,CO2,i,t} = A_{i,t} \times EF_{CO2,i,t} \quad (17)$$

Where:

$E_{peatsoil\text{-}BSL,CO2,i,t}$ CO_2 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

$EF_{CO2,i,t}$ Emission factor for CO2 emissions corresponds to each stratum i, as provided by IPCC (t CO_2e ha^{-1} yr^{-1})

$A_{,i,t}$ Area of stratum i at time t (ha)

i 1, 2, 3 …M_{BSL} strata in the baseline scenario (unitless)

t 1, 2, 3, … t* time elapsed since the project start (yr)

For each stratum, the CH_4 emission from the peat soil within the project boundary were estimated as follows:

$$E_{peatsoil\text{-}BSL,CH4,i,t} = A_{i,t} \times GWP_{CH4} \times EF_{CH4,i,t} \quad (18)$$

Where:

$E_{peatsoil\text{-}BSL,CH4,i,t}$ CH_4 emissions from the peat soil within the project boundary in the baseline scenario in stratum i at year t (t CO_2e yr^{-1})

$EF_{CH4,t,t}$ Emission factor for CH_4 emissions corresponds to each stratum i, as provided by IPCC (t CO_2e ha^{-1} yr^{-1})

$A_{,i,t}$ Area of stratum i at time t (ha)

GWP_{CH4} Global Warming Potential for CH_4

i 1, 2, 3 …M_{BSL} strata in the baseline scenario (unitless)

t 1, 2, 3, … t* time elapsed since the project start (yr)

Table 17. The stratification used for the calculation of GHG emissions per stratum, the area (ha) per each stratum and the CO_2 and CH_4 default factors used for the specific land use

Strata	Description	Area (ha)	IPCC default emission factor for CO_2 (t CO_2-eq ha-1 yr-1)	IPCC default emission factor for CH_4 (t CO_2-eq ha-1 yr-1)	IPCC default emission factor for ∆ DOC (t CO_2-eq ha-1 yr-1)
Initial					
P1L0D0	Undrained deforested peatland	3,172	1.5	0.20	
P1L0D1	Drained deforested peatland	987	19.43	0.14	
P1L1D0	Undrained forested peatland	141,910	0	0.72	
P1L1D1	Drained deforested peatland	354	19.43	0.14	
WB	Water bodies (rivers and canals) present at the project start date	216			2.09
After conversion					
P1L0D1AC	*Acacia* on drained peatland	102,257	73.33	0.08	

P1L1D0CF	Conservation area (undrained peatland forest)	13,451	0	0.72	
P1L0D1CA	Community crops on drained peatland	11,028	51.33	0.20	
P1L0D1IF	Ground facilities on drained peatland	290	19.43	0.14	
P1L1D1IS	Indigenous species area and river buffer (drained peatland forest)	16,286	19.43	0.14	
WB	Water bodies (rivers and canals)	3,327			3.01

Note: Appendix 6 of the PD provides more details on the emission factors used and the references.

Calculated annual GHG emissions from microbial decompositions of peat in the baseline scenario is presented in Table 18.

Table 18. GHG emissions from microbial decompositions of peat in the baseline scenario in tCO_2-e.y^{-1}

Year	CO_2 from peat microbial decomposition	CH_4 from peat microbial decomposition	Total
2011	872,262	80,618	952,880
2012	966,973	80,528	1,047,500
2013	2,292,138	49,284	2,341,422
2014	2,588,966	48,998	2,637,964
2015	2,910,708	47,418	2,958,127
2016	3,204,660	47,144	3,251,804
2017	3,628,150	42,686	3,670,836
2018	3,932,268	42,398	3,974,666
2019	4,307,185	39,805	4,346,990
2020	4,584,724	39,541	4,624,265
2021	4,973,666	36,356	5,010,022
2022	5,268,302	36,073	5,304,374
2023	5,631,354	34,002	5,665,356
2024	5,923,395	33,720	5,957,115
2025	6,308,103	29,970	6,338,073
2026	6,585,466	29,681	6,615,147
2027	6,906,267	28,391	6,934,658
2028	7,189,341	28,092	7,217,433
2029	7,614,737	23,607	7,638,344
2030	7,894,864	23,301	7,918,165
2031	8,081,433	23,087	8,104,520

Year	CO_2 from peat microbial decomposition	CH_4 from peat microbial decomposition	Total
2032	8,286,789	22,849	8,309,637
2033	8,278,593	22,832	8,301,426
2034	8,268,410	22,812	8,291,222
2035	8,262,373	22,797	8,285,170
2036	8,255,644	22,783	8,278,427
2037	8,248,377	22,766	8,271,143
2038	8,241,859	22,752	8,264,611
2039	8,234,741	22,737	8,257,478
2040	8,225,122	22,720	8,247,843
2041	8,217,806	22,704	8,240,510
2042	8,209,559	22,682	8,232,242
2043	8,202,803	22,667	8,225,470
2044	8,193,613	22,650	8,216,263
2045	8,185,905	22,633	8,208,538
2046	8,178,125	22,617	8,200,742
2047	8,170,001	22,598	8,192,599
2048	8,161,601	22,583	8,184,185
2049	8,154,522	22,567	8,177,089
2050	8,145,756	22,550	8,168,306
2051	8,138,962	22,537	8,161,499
2052	8,131,369	22,520	8,153,889
2053	8,123,480	22,506	8,145,987
2054	8,113,478	22,490	8,135,968
2055	8,105,756	22,477	8,128,233
2056	8,096,914	22,461	8,119,375
2057	8,086,643	22,444	8,109,087
2058	8,079,669	22,431	8,102,100
2059	8,069,217	22,414	8,091,632
2060	8,053,640	22,384	8,076,024
2061	8,041,789	22,367	8,064,155
2062	8,030,326	22,348	8,052,674
2063	8,017,565	22,326	8,039,891
2064	8,005,012	22,307	8,027,319
2065	7,993,522	22,289	8,015,810

Year	CO_2 from peat microbial decomposition	CH_4 from peat microbial decomposition	Total
2066	7,980,530	22,269	8,002,798
2067	7,965,650	22,246	7,987,896
2068	7,949,145	22,218	7,971,363
2069	7,936,436	22,197	7,958,633
2070	7,922,493	22,175	7,944,667

4.1.7.5 Emissions from peat burning

This section explains in more detail how the numbers for peat burning in the Project area in Table 19 have been calculated.

Peatland fires in Indonesia are widely known as human induced events. Based on this fact it can be inferred that the probability of peat burning events increases according to the decrease in distance to human activity (roads, rivers, agriculture area, etc.). It is common in Kalimantan that local communities use rivers and canals extensively as transportation means. Observations in the project area showed that most burnings occur along the Hantipan canal where human activity is high. Burnt area in this location extended to about 1 km from the canal sides.

Per module E-BPB, GHG emissions from biomass burning can result from:

- Conversion of forest land to non-forest land using fire
- Periodical burning of grassland or agricultural land after deforestation
- Controlled burning in forest land remaining forest land
- Uncontrolled fire in drained peat swamp forest
- Uncontrolled peat burning in (abandoned) drained peat sites

Since it is illegal to clear forests on Acacia plantation it is assumed that the deforestation agents do not perform controlled peat burning during site preparation or (rotational) clearance for plantation/crop establishment. Therefore, only emissions from unintentional/uncontrolled burnings are accounted for in the baseline scenario. Furthermore, above ground biomass lost by combustion is conservatively omitted.

Procedures for quantification of GHG emissions from uncontrolled peat burnings follow the VCS methodology VM0007 module E-BPB using the following equation 19:

$$E_{peatburn-BSL,i,t} = \sum_{g=1}^{G} \left(\left(\left(A_{peatburn-BSL,i,t} \times P_{BSL,i,t} \times G_{g,i} \right) \times 10^{-3} \right) \times GWP_g \right) \quad (19)$$

Where:

$E_{peatburn-BSLi,t}$	Greenhouse emissions due to peat burning under baseline scenario in stratum i in year t of each GHG (CO_2, CH_4, N_2O) (t CO_2e)
$A_{peatburn-BSL,i,t}$	Area peat burnt under baseline scenario in stratum i in year t (ha)
$P_{BSL,i,t}$	Average mass of peat burnt under baseline scenario in stratum i, year t (t d.m. ha^{-1})
$G_{g,i}$	Emission factor in stratum i for gas g (kg t^{-1} d.m. burnt)
GWP_g	Global warming potential for gas g (t CO_2/t g)
g	1, 2, 3 ... G greenhouse gases including carbon dioxide, methane and nitrous oxide (unitless)

i	1, 2, 3 …M strata (unitless)
t	1, 2, 3, … t time elapsed since the start of the project activity (year)

The average mass of peat burnt for a particular stratum is estimated using the equation 20:

$$P_{BSL,i,t} = D_{peatburn\text{-}BSL,i,t} \times BD_{upper} \times 10^{-4} \quad (20)$$

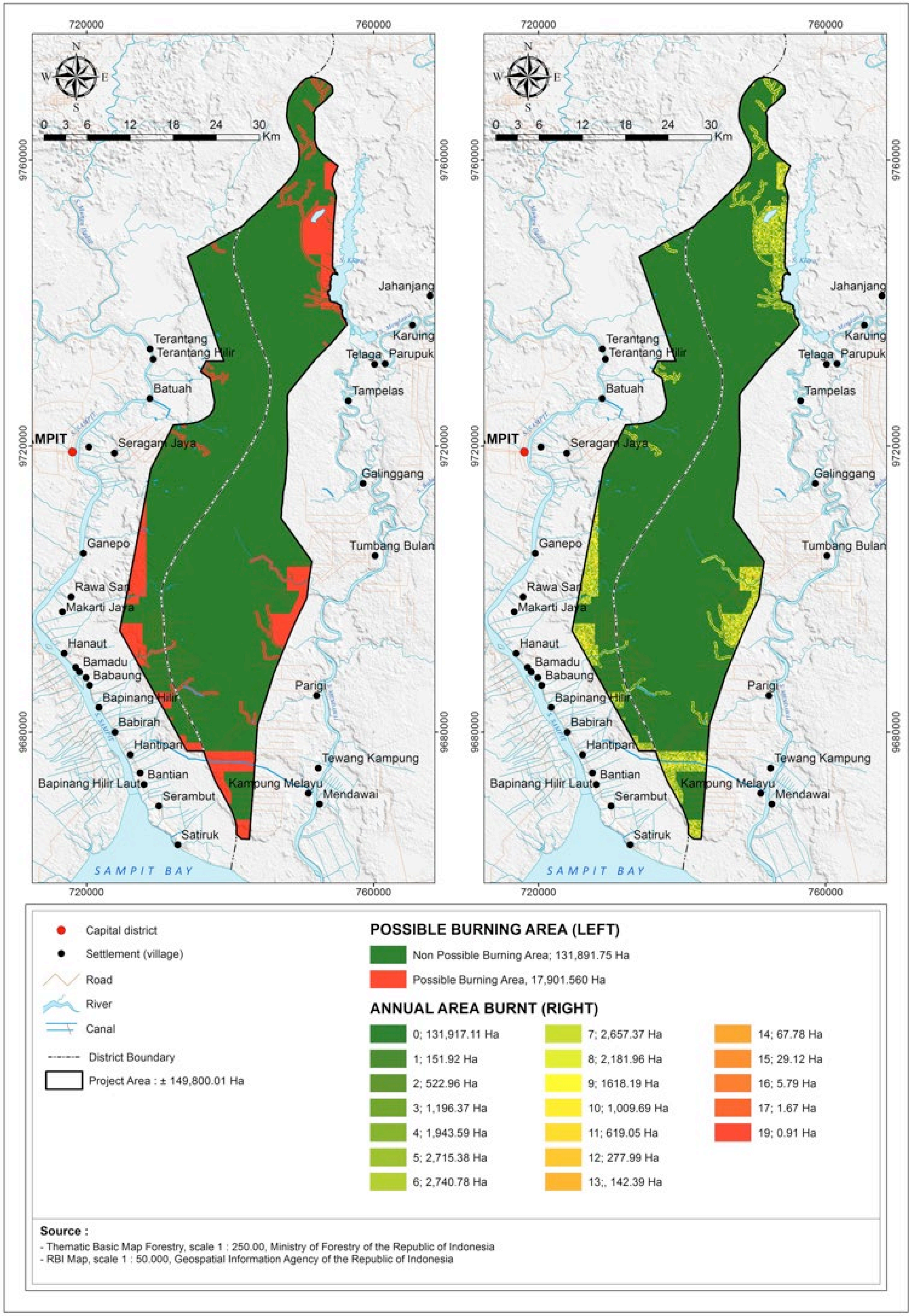
Where:

$P_{BSL,i,t}$	Average mass of peat burnt under baseline scenario in stratum i, year t (t d.m. ha^{-1})
$D_{peatburn\text{-}BSL,i,t}$	Average burn scar depth under baseline scenario in stratum i in year t (m)
$BD_{upper,i}$	Bulk density of the upper peat in stratum i (g cm^{-3})
i	1, 2, 3 …M strata
t	1, 2, 3, … t time elapsed since the start of the project activity (years)

Emissions from peat burning in the baseline are thus calculated from the mass of peat lost by combustion and emission factors from scientific literature (see Appendix 6 of the PD for the default values that were used for the calculations of baseline carbon losses and emissions from burning).

Uncontrolled burnings in peatlands were assumed to repeat randomly on places that are ‘high risk’ areas. To determine where the ‘high risk areas’ are in the baseline of the project area, a hotspot intensity analysis was performed, and the spatial position of burning within the project boundary in the baseline scenario was simulated (details provided in Annex 12 of the PD). A water body network map from BIG 2008 (rivers and canals) was used to represent human activity variable. NOAA and NASA MODIS Fire hotspot data from 1997-2010 for Kalimantan were plotted on ArcGIS 10.1 and the distances to the nearest human activities (using rivers and canals as proxy) were calculated. Histogram analysis showed that the closer an area is to human activity the higher the probability is for a peat fire. Plotting percentages of hotspot numbers against distances to human activity resulted in a Burning Probability Density (BPD) model with an $R^2 > 0.9$ (Annex 12 of the PD). The resulted BPD model was used in creating a proportionally scaled down “Possible Burning Area” (PBA_{BSL}) map (Map 12) that shows the area with the highest burning probability (95 percent probability threshold) in the project baseline. This map does not show the “actual area burnt” in the baseline scenario, rather showing possible locations where peat burning can be expected to occur randomly.

Map 12. Map of possible burning area (left) and annual area burnt (right) in the baseline scenario



To assess the frequency and extent of uncontrolled peat fires in the baseline scenario, remote sensing data of the proxy areas was used, per VCS methodology VM0007 module BL-PEAT (see Annex 12 of the PD). MODIS fire pixels, which are recorded daily, were downloaded for the seven proxy areas and filtered as to only include the pixels with 100% confidence of the presence of a fire. To identify fires that occurred on bare soil all available Landsat data was subsequently downloaded for the 2000-2010 period, only selected data collected after the individual concession grant dates. When no cloud-free data was available within 2 months prior to the fire pixel acquisition date it was conservatively excluded. Each fire occurring on bare soil was conservatively assumed to have burnt 0.49 km^2 (Giglio, L., et al, 2006). Based on this data the average percentage of burnt area per proxy area was determined to be 1.44% per year. This value was used as a parameter in estimating “Annual Area Burnt Threshold” in the baseline scenario ($AABT_{BSL}$), according to the following equation 21:

$$AABT_{BSL} = 1.44\%.y^{-1} \times A_{Project} = 2{,}157\ ha.y^{-1} \quad (21)$$

Where:

$A_{project}$ Project area size (149,800 hectares)

The coverage of the Annual Area Burnt for each baseline stratum ($AAB_{BSL,i,t}$) was simulated as a subset of PBA_{BSL} by randomly selecting parcels in PBA_{BSL} annually over 100 years in such a way that the annual average area of the selected parcels approximately equals (but does not exceed) the area of $AABT_{BSL}$. Once a parcel was selected randomly in the first year the parcel is marked as “catching the 1st burning”. If it was randomly selected again for the second year it is marked as “catching the 2nd burning”, and so forth.

Given the random nature of the $AAB_{BSL,i,t}$ selection, and due to gradual land use change in the baseline scenario, $AAB_{BSL,i,t}$ varies by strata and year with increasing trend following land use change (Figure 10, Table 19). The project has assured that not every burning event would result in peat GHG emissions. At every burning event during the calculation, for the GHG emissions from peat burning to take effect, the corresponding “burnt parcel” must have been drained and deforested first, and that available peat for decomposition and burning exceed 20 cm. By applying these restrictions, net annual area burnt with positive net GHG emissions from peat burning has been calculated as given in Figure 10.

Figure 10. Annual area burnt in baseline scenario

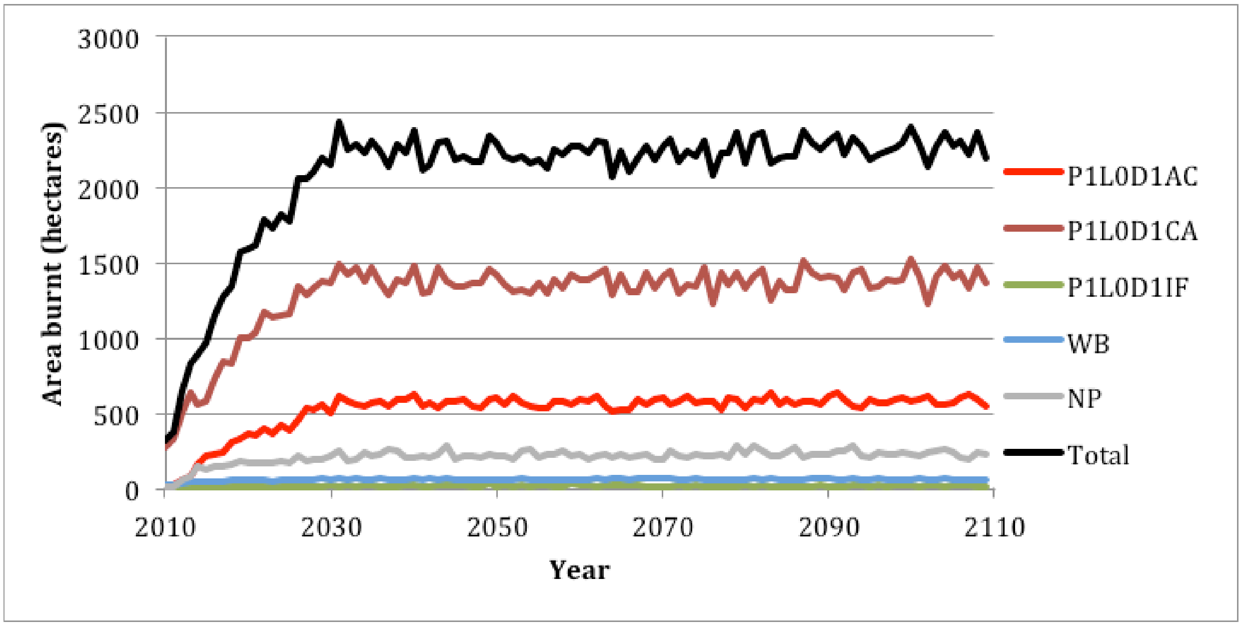


Figure 11. Annual area burnt with positive net GHG emissions from peat burning in baseline scenario

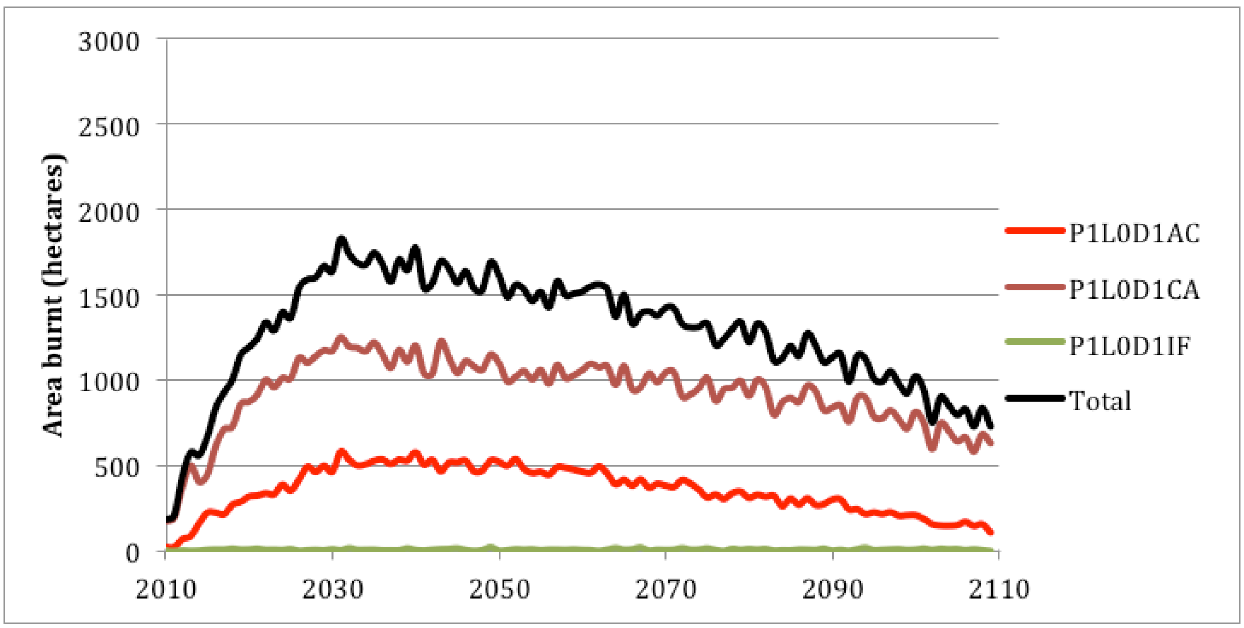


Table 19. GHG emissions from peat burning per stratum and per (repeated) burning

Strata	Strata Area	Total Area Burnt in 60 years	Average Burnt area in 60 years	GHG Emissions from peat burning in 60 years (tCO_2e)			
	(ha)	(ha)	($ha.y^{-1}$)	1st burning	2nd burning	≥3rd burning	Total
P1L0D1AC	102,257	28,631	477.2	1,865,786	1,101,649	1,600,247	4,567,683
P1L0D1CA	11,028	73,039	1,217.3	4,242,612	2,484,608	3,946,775	10,673,995
P1L0D1IF	290	626	10.4	40,996	24,101	36,479	101,575.4
P1L1D0CF	13,451	-	-	-	-	-	-
P1L1D1IS	16,286	-	-	-	-	-	-
WB	3,327	3,205	53.4	-	-	-	-
NP	3,162	11,321	188.7	-	-	-	-
Total	149,800	116,821	1,947	6,149,395	3,610,358	5,583,501	15,343,253

*See Appendix 6 of the PD for the defaults used.

Given the fact that there is a difference in burn scar depths between 1st, 2nd and 3rd burnings, calculations took into account the repetition of burnings. Burn scar depths of 18, 11 and 4 cm were assumed for the first, 2nd and 3rd burning respectively [9](see Appendix 12 of the PD for more details).

The peat burning baseline will be re-assessed every 10 years based on observations of burning frequency and extent in reference region and/or based on the latest scientific findings of ‘repeated burnings’ pattern.

Calculated annual GHG emissions from uncontrolled peat burning are presented in Table 20.

Table 20. GHG emissions from peat burning in the baseline scenario in tCO_2-$e.y^{-1}$

Year	CO_2 from peat burning	CH_4 from peat burning	Total
2011	113,627	13,693	127,320
2012	127,390	15,351	142,741
2013	205,515	24,766	230,281
2014	251,623	30,322	281,945
2015	244,700	29,488	274,188
2016	269,703	32,501	302,204
2017	313,518	37,781	351,299
2018	338,149	40,749	378,898
2019	349,520	42,119	391,640
2020	404,301	48,721	453,021
2021	382,934	46,146	429,080
2022	386,441	46,569	433,009
2023	403,044	48,569	451,613
2024	379,011	45,673	424,685

[9] Page, S., K. Tansey, P. Navratil, A. Hooijer, and N. Mawdsley. 2014. Measuring emissions from peat fire: Commentary on a proposed methodology for Indonesia. Report for the Indonesia-Australia Forest Carbon Partnership, IACP, Jakarta.

Year	CO_2 from peat burning	CH_4 from peat burning	Total
2025	388,991	46,876	435,867
2026	373,954	45,064	419,018
2027	411,579	49,598	461,177
2028	417,025	50,254	467,279
2029	423,444	51,028	474,472
2030	400,032	48,206	448,239
2031	379,649	45,750	425,399
2032	390,765	47,090	437,855
2033	387,157	46,655	433,812
2034	346,079	41,705	387,784
2035	309,556	37,303	346,859
2036	310,482	37,415	347,897
2037	310,670	37,438	348,108
2038	255,033	30,733	285,767
2039	288,620	34,781	323,400
2040	274,839	33,120	307,959
2041	276,610	33,333	309,943
2042	216,776	26,123	242,898
2043	228,318	27,514	255,831
2044	232,271	27,990	260,261
2045	214,734	25,877	240,611
2046	196,918	23,730	220,648
2047	202,848	24,444	227,292
2048	190,877	23,002	213,879
2049	176,446	21,263	197,709
2050	190,277	22,930	213,207
2051	183,798	22,149	205,947
2052	171,602	20,679	192,281
2053	170,305	20,523	190,828
2054	167,613	20,198	187,812
2055	149,992	18,075	168,067
2056	159,279	19,194	178,473
2057	150,819	18,175	168,994
2058	160,835	19,382	180,216
2059	150,511	18,137	168,648
2060	151,922	18,308	170,229
2061	154,261	18,589	172,850
2062	149,805	18,052	167,858
2063	152,702	18,402	171,103
2064	145,495	17,533	163,028
2065	134,659	16,227	150,886
2066	143,981	17,351	161,332

Year	CO_2 from peat burning	CH_4 from peat burning	Total
2067	130,055	15,672	145,727
2068	131,385	15,833	147,218
2069	133,213	16,053	149,266
2070	128,773	15,518	144,291

4.1.7.6 Emissions from water bodies in peatlands

This section explains in more detail how the numbers for emissions from water bodies in the project area in Table 21 have been calculated.

Except for drainage canals, it is assumed that the baseline agents do not create open water such as ponds and lakes. Hence the only type of open water body present in the baseline scenario are rivers and drainage canals. The area of canals in the baseline scenario is determined based on the rate of conversion, topography characteristics and common practice. In the baseline stratification, all area that is, or would be, water body during the project-life falls into the WB stratum.

Temporal stratification is being applied to this stratum by separating water bodies present at the project start date and drainage canals that would be constructed in later phases by the baseline agents during the project period. Therefore, part of the WB stratum would remain land before the conversion is completed. This situation has been taken into account by using a spatially and temporally explicit quantification approach. In total 3,327 ha of the peatland area falls into the stratum WB in the baseline scenario. Details on area and sequence of changes from land strata to WB is given in Section 4.1.7.1.

No default emission factors are yet provided by IPCC for CO_2 and CH_4 from water bodies. Therefore, IPCC default values for Dissolved Organic Carbon (Δ DOC) were used to calculate the difference in carbon losses between the project scenario and the baseline scenario.

From DOC values it cannot be explained 'how' this carbon will be lost: either transported to the sea, lost as CO_2 within or outside the project area, or lost as CH_4 in- or outside the area (which will be a considerable part). The 'carbon loss' can be calculated, but not the exact proportion of the GHG species CH_4 and CO_2, and therefore all carbon will be assumed to be lost as CO_2 which makes the approach conservative and any double counting will be avoided. Canals and rivers are treated similarly in the use of DOC values. The TIER 1 (IPCC) default annual values for DOC are 0.57 and 0.82 ton C per hectare, for natural and drained peatland respectively. Conservatively, the Hantipan canal (that presents at the project start date) is treated as of producing the same DOC value as that of a natural river despite being man-made water body. Default values used for calculations are given in Appendix 6 of the PD.

For the quantification procedure, the project used the approach as set out in the VCS methodology VM0007 module BL-PEAT by using the equation 22. ($E_{peatditch-CO2,i,t}$ + $E_{peatditch-CH4,i,t}$) found in the equation 7 in the module BL-PEAT was replace with DOC emission, translated into CO_2-equivalents.

$$E_{peatditch-BSL,i,t} = A_{ditch-BSL,i,t} \times EF_{DOC-BSL} \quad (22)$$

Where:

$E_{peatditch-BSL,i,t}$	GHG emissions from canals and other open water stratum i at year t in the baseline scenario (t CO_2e yr^{-1})
$A_{ditch-BSL,i,t}$	Total area of canals and other open water stratum i at year t in the baseline scenario (ha)
$EF_{DOC-BSL}$	IPCC emission factor of Dissolved Organic Carbon from canal and open in the baseline scenario (t CO_2e ha^{-1}yr^{-1})
i	1, 2, 3 …M_{BSL} strata in the baseline scenario (unitless)
t	1, 2, 3, … t time elapsed since the project start (yr)

Projected annual GHG emissions from Dissolved Organic Carbon in water bodies in baseline scenario is presented in Table 21.

Table 21. GHG emissions from Dissolved Organic Carbon in water bodies in the baseline scenario in tCO2-e.y-1

Year	CO_2 from DOC
2011	2,779
2012	2,779
2013	6,052
2014	6,052
2015	6,314
2016	6,314
2017	7,012
2018	7,012
2019	7,370
2020	7,370
2021	7,965
2022	7,965
2023	8,275
2024	8,275
2025	8,890
2026	8,890
2027	9,127
2028	9,127
2029	9,821
2030	9,821
2031	9,821
2032	9,821
2033	9,821
2034	9,821
2035	9,821
2036	9,821
2037	9,821
2038	9,821
2039	9,821
2040	9,821
2041	9,821
2042	9,821
2043	9,821
2044	9,821
2045	9,821
2046	9,821
2047	9,821
2048	9,821

Year	CO_2 from DOC
2049	9,821
2050	9,821
2051	9,821
2052	9,821
2053	9,821
2054	9,821
2055	9,821
2056	9,821
2057	9,821
2058	9,821
2059	9,821
2060	9,821
2061	9,821
2062	9,821
2063	9,821
2064	9,821
2065	9,821
2066	9,821
2067	9,821
2068	9,821
2069	9,821
2070	9,821

4.1.8 Significant sources of baseline emissions

No significance tests were necessary since all carbon pools not included in the baseline and project have either been shown to increase more or decrease less in the project relative to the baseline scenario, or been conservatively excluded. All mandatory pools have been included and all sources of GHG emissions have either been included or conservatively excluded.

4.2 Project Emissions

4.2.1 General procedures and assumptions

Project emissions and changes in carbon stocks during this reporting period are calculated based on a combination of site-specific data, land-use proxies and (IPCC) default emissions factors. Emissions in the project scenario that were accounted for result from:

1. Above ground biomass stock changes due to REDD
2. Above ground biomass stock changes due to uncontrolled burning
3. Peat microbial decompositions
4. Dissolved Organic Carbon in Water bodies
5. Peat oxidation from uncontrolled burning

Emissions in the project scenario that were not accounted for during this reporting period, but which will be accounted for in future period result from:

1. Above ground biomass stock changes due to ARR activities
2. Above ground biomass stock changes from forest growth

Specific GHG sources included and excluded from project emissions calculations are listed in the PD in Section 5.4.1.

4.2.2 Emissions from REDD activities

4.2.2.1 Emissions from deforestation

Per the monitoring plan, multispectral satellite imagery was used to regularly monitor the project area and detect any land cover changes. Due to the unavailability of ALOS PALSAR 2 data, the deforestation assessment was conducted solely with high resolution PlanetLabs multispectral data, with a 3.125m spatial resolution. Imagery from the 4th of January 2019, 18th of March 2019 and 20th of March 2019 were used to assess the entire site, with all images from a single calendar day first being mosaiced together. Subsequently, unsupervised classification analysis was used to produce a forest and non-forest classification which showed some deforestation as well as false positives. In order to produce more accurate classification results, all resulting non-forest areas were closely inspected and any which corresponded to land cover changes were highlighted. Each such area was then clipped from the mosaic PlanetLabs imagery and a new unsupervised classification was run to more accurately map forest changes. As the high-resolution imagery detects both deforestation and degradation, the resulting classifications were further refined by only selecting non-forest polygons with less than 30% canopy cover across a hectare. A confusion matrix was then used to evaluate the classification accuracy and resulted in an overall accuracy of 97.93% (see Table 22).

Table 22 Unsupervised Classification Accuracy Assessment Confusion Matrix

True land cover	Predicted land cover in classification			Accuracy
	Forest	Non-forest	Total	
Forest	100	0	100	
Non-forest	3	42	45	
Total	103	42	145	
Overall Accuracy				97.93%

In total, this analysis detected 64.28 ha of deforestation across the forest, intensive degradation area and area susceptible to degradation strata (see Table 23).

The net carbon stock change as a result of deforestation (ΔCDefPA,u,I,t) is equal to the area deforested multiplied by the emission per unit area.

$$\Delta C_{DefPA,u,i,t} = A_{DefPA,u,i,t} * \Delta C_{pools,P,Def,u,i,t}$$

Where:

$\Delta C_{DefPA,u,i,t}$ = Net carbon stock change as a result of deforestation in the project case in the project area in stratum *i* at time *t*; t CO2-e

$A_{DefPA,u,i,t}$ = Area of recorded deforestation in the project area stratum *i* converted to land use *u* at time *t*; ha

$C_{poolsP,Def,u,i,t}$ = Net carbon stock changes in all pools in the project case in land use *u* in stratum *i* at time *t*; t CO2-e ha-1

By applying the above equation to each strata, net carbon stock change as a result of deforestation ($\Delta C_{DefPA,u,I,t}$) was determined to be 22,421.73 tCO2-e (see Table 23).

Table 23: Emissions from deforestation in project area within the 2018 monitoring period

Strata before deforestation	$A_{DefPA,I}$ (ha)	$\Delta C_{pools,P,Def,I}$ (tCO2-e/ha)	$\Delta C_{DefPA,i}$(tCO2)
Intensive Degradation Area	0.02	254.32	5.14
Forest	53.14	352.81	18,746.98
Area susceptible to degradation	11.12	329.97	3,669.61

4.2.2.2 Emissions from forest degradation

The project quantified forest degradation using the approach described in VM7-M-MON. As a Participatory Rural Appraisal (PRA) was conducted in 2018, it was not repeated in 2019 (as per M-MON). The PRA will be repeated in 2020 and any forest degradation subsequently detected and assessed by field survey will be retrospectively accounted for during the next monitoring period, as per M-MON.

Due to changes in other strata which affected the forest and non-forest boundary, an additional 9.78 ha of forest were designated as area susceptible to degradation. The emissions resulting from the change detected during this monitoring period will be accounted for when the $C_{DegW,i,t}$ is updated during the next monitoring period.

4.2.2.3 Emissions from uncontrolled biomass burning

A total of 56 NASA FIRMS hotspots were detected in the project area during the monitoring period. Two hotspots were confirmed to be false positives while 54, detected between August 18th and September 16th, were due to a fire in the southern part of the project area. PlanetLabs imagery acquired during and after the fire were used to delineate the burnt area which totalled 330.17 ha (see Table 24).

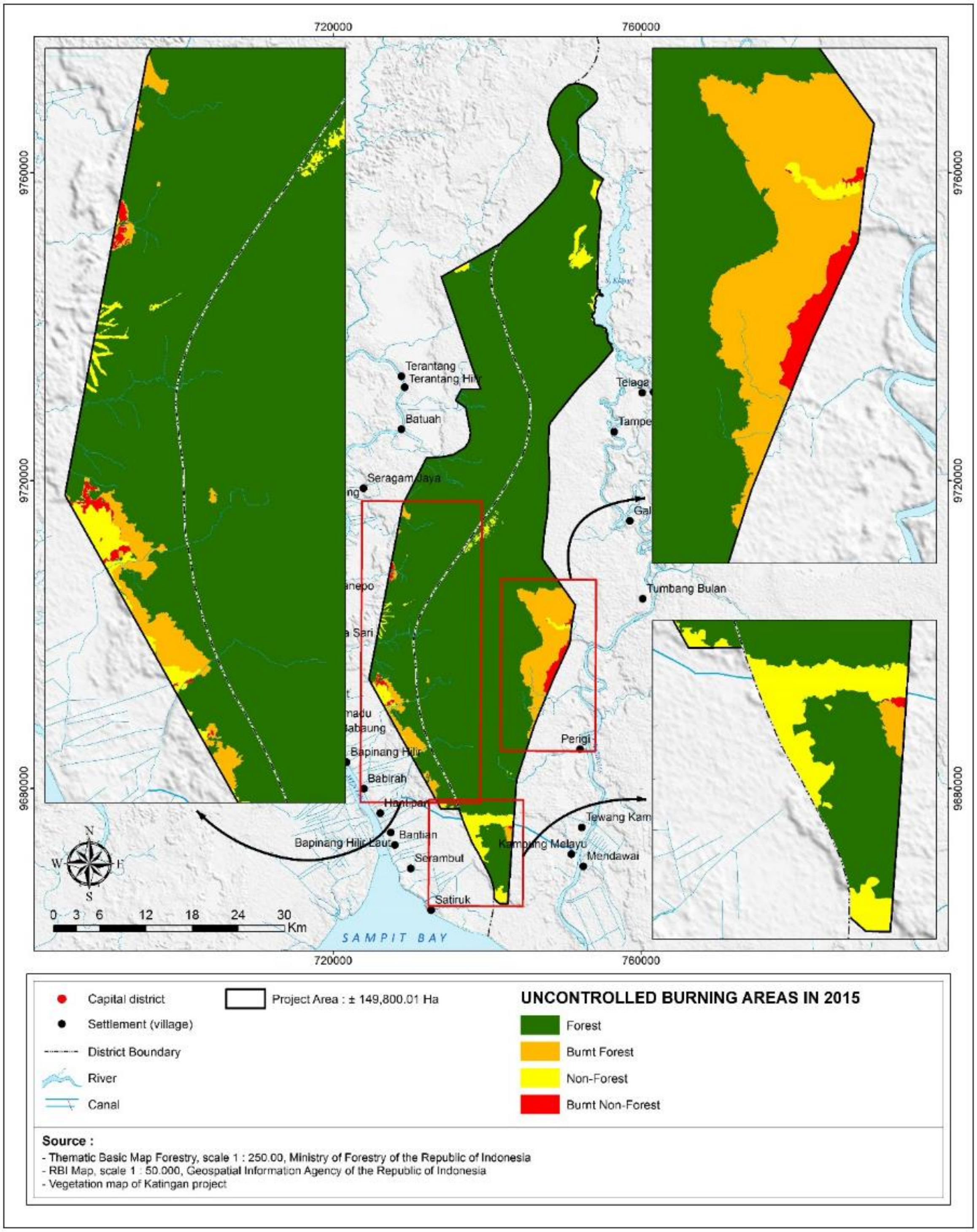
Table 24. Emissions from uncontrolled biomass burning during the 2018 monitoring period

Strata burnt	Extent (Ha)	GHG emission (tCO2-e)			Total GHG emisssion (tCO2-e)
		CO2	CH4	N2O	
Area Susceptible to Degradation	0.07	10.56	1.27	0.35	12.19
Non Forest	71.90	496.00	59.77	16.64	572.41
Burnt Forest	33.65	0.00	0.00	0.00	0.00
Burnt Non-Forest	224.55	0.00	0.00	0.00	0.00
				Total	584.60

Using module E-BPB and assuming instantaneous combustion of carbon, GHG emissions as a result of uncontrolled burning were estimated to be 584.60 tCO_2-e with 12.19 tCO_2-e coming from burnt area susceptible to degradation and 572.41 tCO_2-e from burnt non-forest. Since the burnt forest and burnt non-forest areas previously burnt in 2014 and all its aboveground carbon emissions were accounted for in the MR 2010-2015, it is assumed the GHG emissions from those strata are 0 (see Table 24).

Emissions from the decomposition of biomass previously burnt in 2015 is reported in this monitoring report as dead wood decomposition. As described in MR 2010-2015 (Section 5.1.3.4), a drone survey and field survey was conducted to investigate the condition of forest in areas affected by fires in 2015. Since the UAV surveys from 2015 showed 11.4% of the fire affected area contained live standing trees (Section 5.1.3.4, Table 34 of previous monitoring report) the biomass decomposition emission calculations were applied to 88.6% of the fire affected area.

Map 13. Uncontrolled burnt areas in 2015



Emission from dead wood decomposition are calculated by using the following equation (23):

$$C_{DW_{decay,t}} = \left(EXP\left(-(t-1) \times k_{decay}\right) \times C_{DW,t0}\right) - \left(EXP\left(-t \times k_{decay}\right) \times C_{DW,t0}\right) \quad (23)$$

Where:

$C_{DW_{decay},t}$ = Annual carbon leaving the deadwood pool due to the decay in year t (tCO_2)

$C_{DW,t0}$ = Carbon input to the deadwood pool before burnt (t0)

k_{decay} = Rate of decay of the deadwood pool

t = Year of monitoring period elapsed from fire incident (1,2,3,..)

By applying the equation above, deadwood decomposition GHG in this monitoring period were 158,259.10 tCO2-e. (see Table 25)

Table 25. Decomposition of burnt tree biomass during the 2018 monitoring period

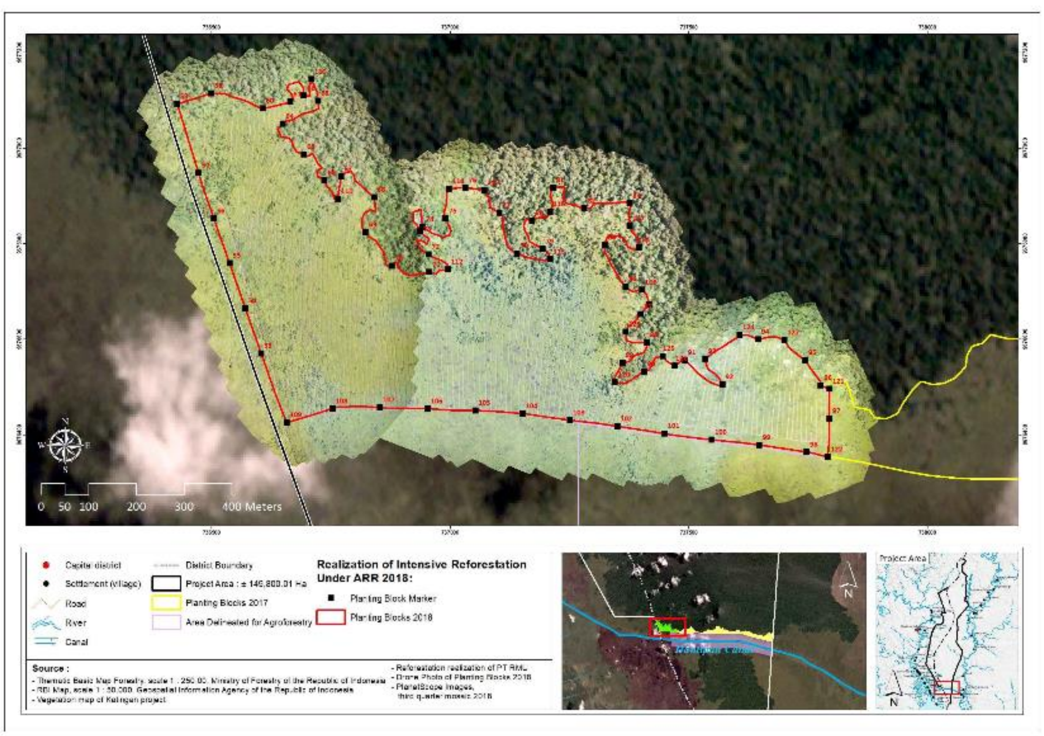
Year		F_burnt	F_dw	tC_remain	C_emmited	
					tC	tCO2-e
2015	0	8,368.93	1.000	364,737.55	-	-
2016	1	0	0.827	301,623.05	63,114.50	231,419.84
2017	2	0	0.684	249,429.94	52,193.11	191,374.75
2018	3	0	0.566	206,268.36	46,161.57	158,259.10

4.2.3 Project emissions from ARR activities

4.2.3.1 Intensive reforestation

Intensive reforestation continued throughout 2018. To date 192.68 ha have been replanted, of which 42.68 ha were planted in 2018. The demarcation of planting site was carried out in February- March 2018, while the planting was done in November 2018. The planting site arranged into three planting blocks as shown by Map 14.

Map 14. The area of intensive reforestation 2018



In total 6,800 saplings of 18 native tree species were planted in this program. Planting stock (seed and wildling) were collected within and surrounding project area, and the seedlings were prepared in the nursery. Among those species, Dyospyros aerolata was the biggest proportion (12,21%) followed by Dyera polyphylla (8.24%) and Ctenolophon parvifolius (8.24 %). The detailed information on species planted in the reforestation program are provided in Table 26.

Table 26. List of species planted in intensive reforestation

No	Local name	Species	n planted	%
1	Jelutung	*Dyera polyphylla*	560	8.24%
2	Balangiran	*Shorea balangeran*	490	7.21%
3	Pulai	*Alstonia* spp	420	6.18%
4	Malam-malam	*Dyospyros aerolata*	830	12.21%
5	Bintan	*Ctenolophon parvifolius*	560	8.24%
6	Jambu-jambu	*Syzygium* sp	525	7.72%
7	Rambutan hutan	*Nephelium spp.*	350	5.15%
8	Tabaras	*Stemonurus scorpiodes*	525	7.72%
9	Hangkang	*Palaquium leiocarpum*	595	8.75%
10	Pampaning	*Lithocarpus* sp	210	3.09%
11	Mangkinang	*Elaeocarpus mastersii*	175	2.57%
12	Papung	*Sandoricum beccarianum*	420	6.18%
13	Kajalaki	*Aglaia rubiginosa*	245	3.60%
14	Kapur naga	*Calophyllum sclerophyllum*	315	4.63%
15	Tumih	*Combretocarpus rotundatus*	105	1.54%
16	Bintangur	*Calophyllum hosei*	105	1.54%
17	Gemor	*Nothaphoebe coriacea*	80	1.18%
18	Parupuk	*Lophopetalum* sp	290	4.26%
Total			6,800	100%

The project intentionally involved local communities to implement reforestation. Three groups were formed for this purpose, in which each group was responsible for one planting block. The planting applied the spacing line of 5 m x 10 m; 10 m is the distance between line/strip planting and 5 is the distance between saplings.

Figure 12. Seedling transferred from nursery (left); planting strip (centre); seedlings planted in field (right)

Figure 13. Planting strips observed by drone

4.2.3.2 Fire break plantation

There was no new planting activity in this monitoring period. As reported in the previous monitoring reports, the project has established fire break plantation in the area of 6.91 ha; 5.68 ha established in 2017 and 1.23 ha established within 2010-2015. The local species planted were Kahui Shorea belangeran, Tumih Combretocarpus rotundatus, Pulai Alstonia spp, Gelam Melaleuca cajuputi.

4.2.3.3 Agroforestry program

After pre condition and preparation completed within 2015-2017, project eventually initiated agroforestry program in this reporting period. In collaboration with forest farmer group “Gambut Lestari”, the project planted 7,600 seedlings over 38 Ha of agroforestry system. Based on agreement with community, jelutong Dyera polyphylla was chosen and planted. Besides CO2 offsetting reason, project and communities expect to utilize latex production produced by this species for potential income. Jelutung latex is mainly used for cosmetic, chewing gum, and various souvenir.

The 38 ha of agroforestry area divided into 19 blocks, each sizing 50 m x 400 m (2 Ha). The planting was carried out from 2 to 7 November 2018 by members of forest farmer group. Map 15 shows the agroforestry area developed by project in this reporting period.

Map 15. The areas developed for agroforestry in project area

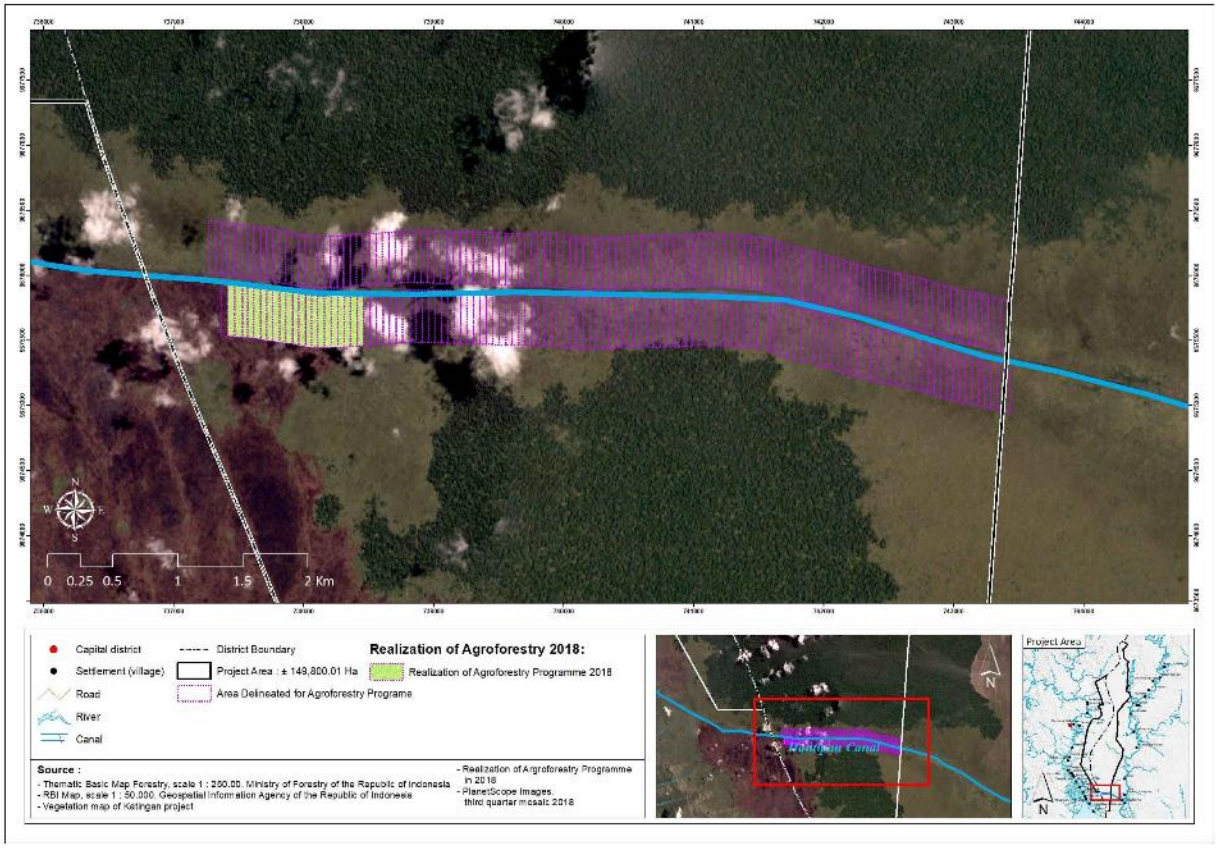


Figure 14. Group members clearing planting line (left), digging planting hole (centre), planting seedlings (right)

The GHG removal from ARR (intensive reforestation, fire break plantation and agroforestry) are not reported and claimed in this reporting period. As planned, biomass growth and GHG removals from ARR will be monitored and claimed in 2020.

4.2.4 Carbon enhancement from forest growth

Forests that are protected from planned conversion to timber plantations have significant potential for regrowth and hence are expected to accumulate biomass by removing CO2 from the atmosphere. However, in this reporting period the carbon enhancement was not monitored as the carbon plots were not re-measured. The carbon stock of unchanged strata were therefore conservatively assumed to have remained constant during the monitoring period. As scheduled, carbon enhancement from forest growth will be monitored and claimed in 2020.

4.2.5 Summary of stratification changes

Due to uncontrolled burning and illegal logging activities during the monitoring period, as described in sections 4.2.2.1, 4.2.2.2 and 4.2.2.3, the forest, non-forest, intensive degradation, burnt forest and burn non-forest strata were updated. As a result of the changes to these strata and the forest's access points, the area susceptible to degradation buffer was also updated (see Table 27 and Map 16).

Map 16. Stratification at the end of the monitoring period ending on the 31st December 2018

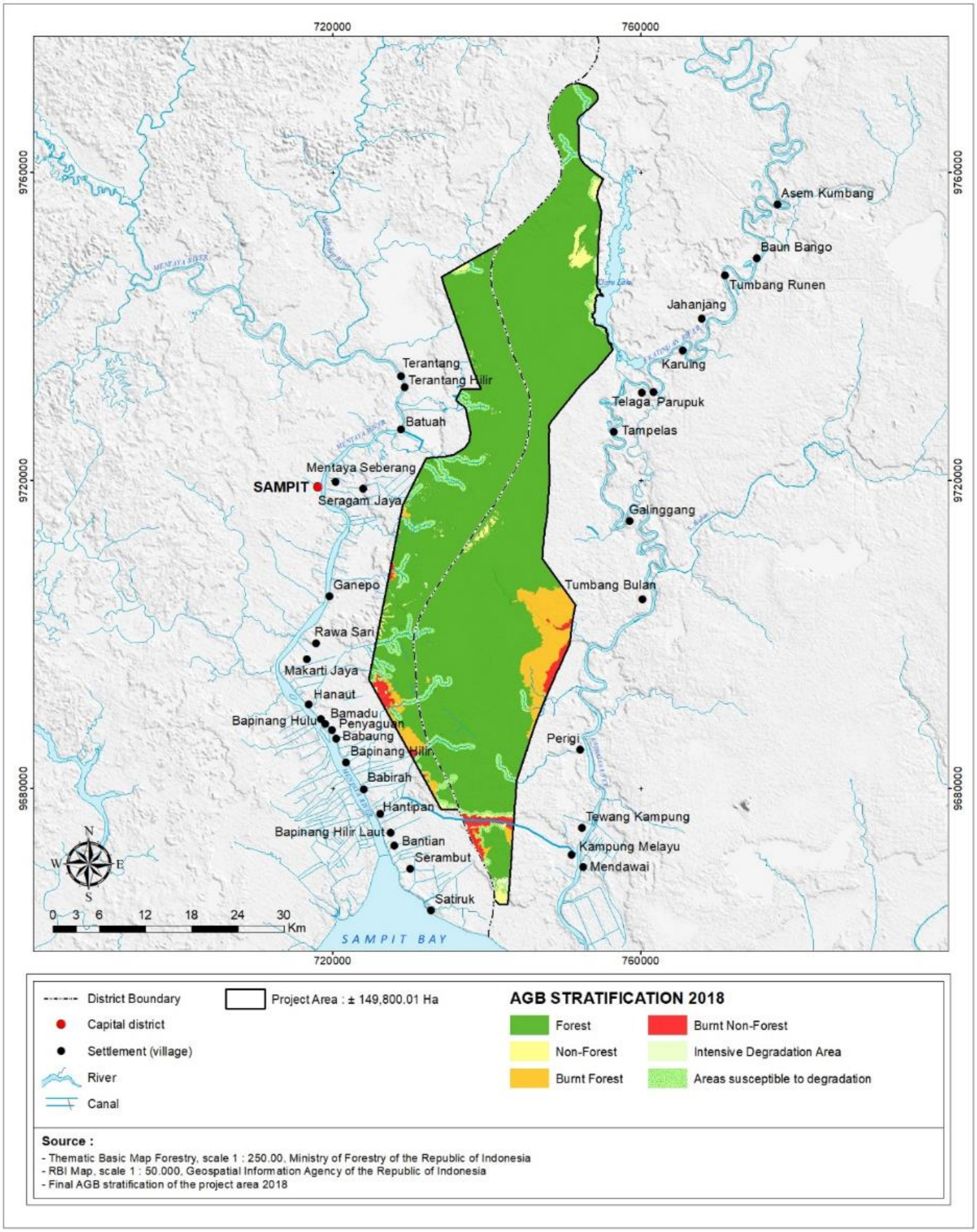


Table 27. 2018 Stratification classes and areas

2016 Stratification classes	Area (ha)
Forest	126,310.00
Non-Forest	2,566.99
Burnt Forest	8,565.30
Burnt Non-Forest	2,567.76
Intensive Degradation Area	406.74
Susceptible Areas to Degradation	9,382.87
Total	149,800.00

4.2.6 Project emissions from peat and water body

Relevant stratification for WRC activities are given in the PD (Section 4.4.1). The strata that are distinguished in the project scenario for the purposes of the calculation of emissions from peat and water bodies are as follows:

- Drained forested peatland (P1L1D1)
- Undrained forested peatland (P1L1D0)
- Drained non-forested peatland (P1L0D1)
- Undrained non-forested peatland (P1L0D0), and
- Water bodies (WB)

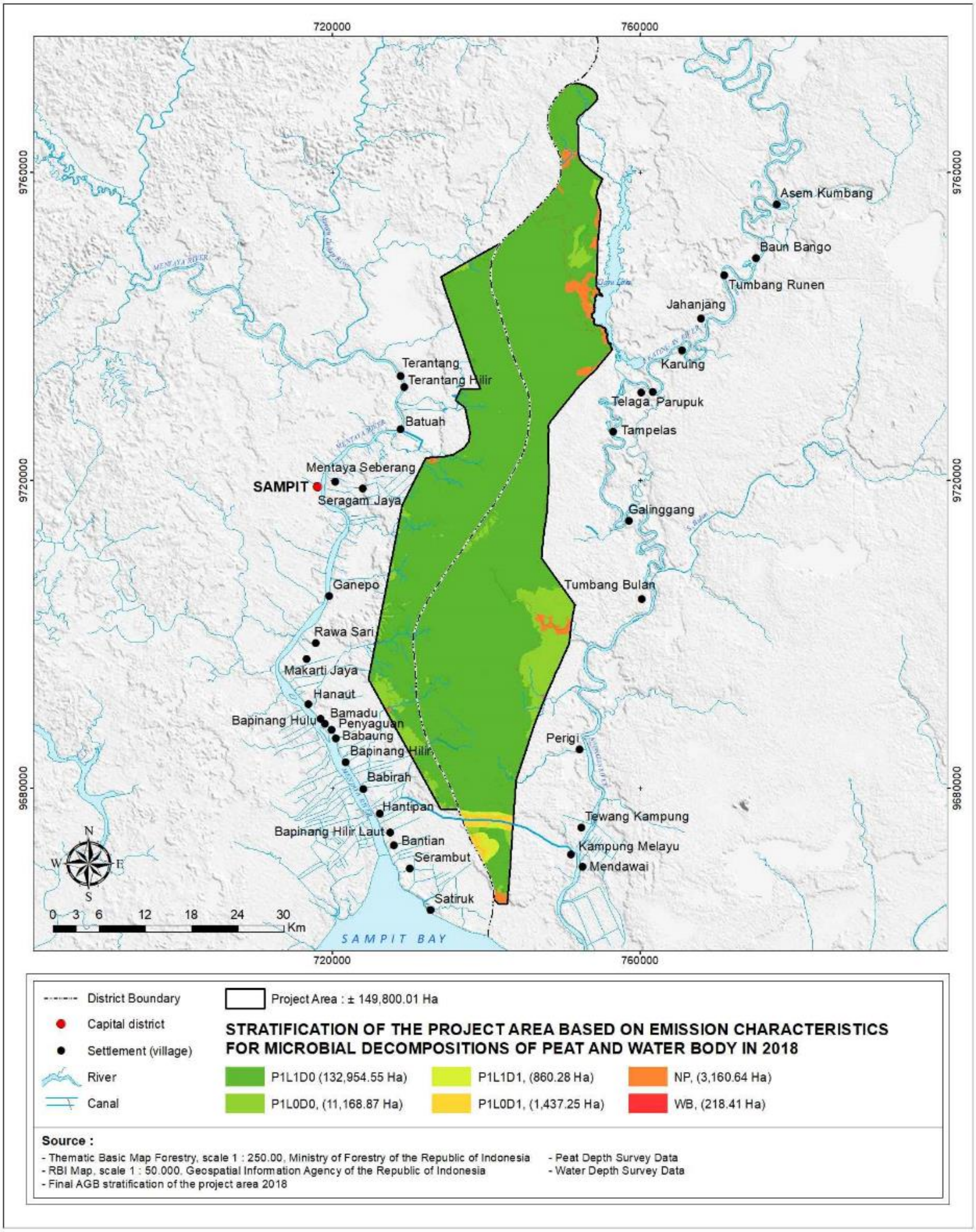
As stated in Section 3.3.3.1 GHG emissions from microbial decomposition of peat were quantified by monitoring land use change in combination with the corresponding IPCC default GHG emission factors. As described in Section 3.3.3.3, GHG emissions from water bodies were monitored by using visual remote sensing analysis, coupled with ground surveys, to detect new canals or water bodies.

The analysis revealed no new canals but did detect 64.28 ha of new deforestation, leading to changes in both the AGB and below ground stratifications (Table 28).

Table 28. Stratification of the project area based on peat and water body emission characteristics for 2018 monitoring period

Strata	Area (Ha)
NP	3,160.65
P1L0D0 (undrained deforested peatland)	11,168.84
P1L1D0 (undrained peatland forest)	132,955.00
P1L0D1 (drained deforested peatland)	1,437.25
P1L1D1 (drained peatland forest)	860.28
WB (water body)	218.41
Total	146,639.77

Map 17. WRC Stratification of project area at the end of the 2018 monitoring period



Quantification of GHG emissions from peat and water bodies are made up of three elements: microbial decomposition of peat, dissolved organic content (DOC) loss via water bodies, and emissions from peat burning. These emission sources are calculated separately and subsequently combined to produce an overall estimate of peat emissions using the procedures provided in VCS methodology VM0007, modules BL-PEAT and M-PEAT (equation 24):

$$GHG_{WPS-WRC} = \sum_{t=1}^{t*} \sum_{i=1}^{M} (E_{peatsoil-WPS,i,t} + E_{peatditch-WPS,i,t} + E_{peatburn-WPS,i,t}) \quad (24)$$

Where

GHGWPS-WRC	Net CO2 equivalent peat GHG emissions in the project scenario up to year t* (t CO2e)
Epeatsoil-WPS,i,t	GHG emissions from microbial decomposition of the peat soil within the project boundary in the project scenario in stratum i in year t (t CO2e yr^{-1})
Epeatditch-WPS,i,t	GHG emissions from water bodies within the project boundary in the project scenario in stratum i in year t (t CO2e yr^{-1})
Epeatburn-WPS,i,t	GHG emissions from burning of peat within the project boundary in the project scenario in stratum i in year t (t CO2e yr^{-1})). In this project this term equals zero.
I	1, 2, 3 …M strata in the project scenario (unitless)
T	1, 2, 3, … t* time elapsed since the project start (years)

Methods for estimating carbon stock, subsidence, and peat thickness dynamics are described in the PD (Section 6.2.6). Emissions are conservatively assumed to cease when peat has been depleted to a depth of 20cm or less. However, as no area of the project has been depleted to this extent, no corresponding adjustment of the emissions calculations is applied in this monitoring period.

4.2.6.1 Emissions from microbial decomposition of peat

For each land stratum, GHG emissions from microbial decomposition of peat soil was calculated using equation 25:

$$E_{peatsoil-WPS,i,t} = E_{proxy-WPS,i,t} \quad (25)$$

Where

Epeatsoil-WPS,i,t	Greenhouse gas emissions from the peat soil within the project boundary in the project scenario in stratum i in year t (t CO2e yr^{-1})
Eproxy-WPS,i,t	GHG emissions as per the chosen proxy in the project scenario in stratum i in year t, in this project, based on IPCC default values (t CO2e yr^{-1})
i	1, 2, 3 …MWPS strata in the project scenario (unitless)
t	1, 2, 3, … t* time elapsed since the project start (years)

While Eproxy-WPS,i,t in the equation was estimated using equation 26:

$$E_{proxy-WPS,i,t} = A_i \times (E_{proxy-CO2,i,t} + E_{proxy-CH4,i,t}) \quad (26)$$

Where:

Eproxy-WPS,i,t	GHG emissions as per the chosen proxy in the project scenario in stratum i in year t (t CO2e yr^{-1})
Ai	Total area of stratum I (ha)
Eproxy-CO2,i,t	Emission of CO2 as per the chosen proxy in stratum i in year t, for TIER 1 approach this equals default CO2 emission factor for stratum i (t CO2e $ha^{-1}yr^{-1}$)
Eproxy-CH4,i,t	Emission of CH4 as per the chosen proxy in stratum i in year t, for TIER 1 approach this equals default CH4 emission factor for stratum i (t CO2e $ha^{-1}yr^{-1}$)
I	1, 2, 3 …MWPS strata[14] in the project scenario (unitless) t 1, 2, 3, …
t*	time elapsed since the project start (years)

Long-term and site-specific measurements of peat related emissions are not available for the current monitoring period, therefore the GHG emission factors provided in the PD were used as a conservative and scientifically robust alternative (TIER 1 IPCC default emission factors). Emission calculations followed the VCS methodology VM0007 modules BL-PEAT and M-PEAT based on annual strata area (Table 28, above), the resulting annual GHG emissions from microbial decomposition of peat are presented in Table 29.

Table 29. GHG emissions from microbial decomposition of peat by strata for 2018 monitoring period, in tCO2-e.y^{-1}

Strata	CO_2	CH_4
P1L1D0	0.00	95,727.60
P1L1D1	16,715.22	120.44
P1L0D0	16,753.26	2,233.77
P1L0D1	27,925.76	201.21
Total	61,394.24	98,283.02

4.2.6.2 Emissions from water bodies in peatlands

GHG emissions through loss of dissolved organic content (DOC) via water bodies were calculated following procedures set out in the VCS methodology VM0007 module M-PEAT for each water body stratum, using the equation 27, resulting in the estimated annual GHG emissions presented below in Table 30.

$$E_{peatditch-WPS,i,t} = A_{ditch-WPS,i,t} \times EF_{DOC-WPS} \quad (27)$$

Where:

Epeatditch-WPS,i,t	GHG emissions from canals and other open water stratum i in year t in the project scenario (t CO2e yr^{-1})
Aditch-WPS,,i,,t	Total area of canal and other open water stratum i in year t in the project scenario (ha)

EFDOC-WPS IPCC emission factor of Dissolved Organic Carbon from canal and open in the project scenario (t CO2e $ha^{-1}yr^{-1}$)

I 1, 2, 3 …MWPS strata[15] in the project scenario (unitless) t 1, 2, 3, … t* time elapsed since the project start (years)

Table 30. GHG emissions from Dissolved Organic Carbon in water bodies in the project scenario for 2018 monitoring period, in tCO2-e.y^{-1}

Year	CO_2 from DOC
2018	456.47

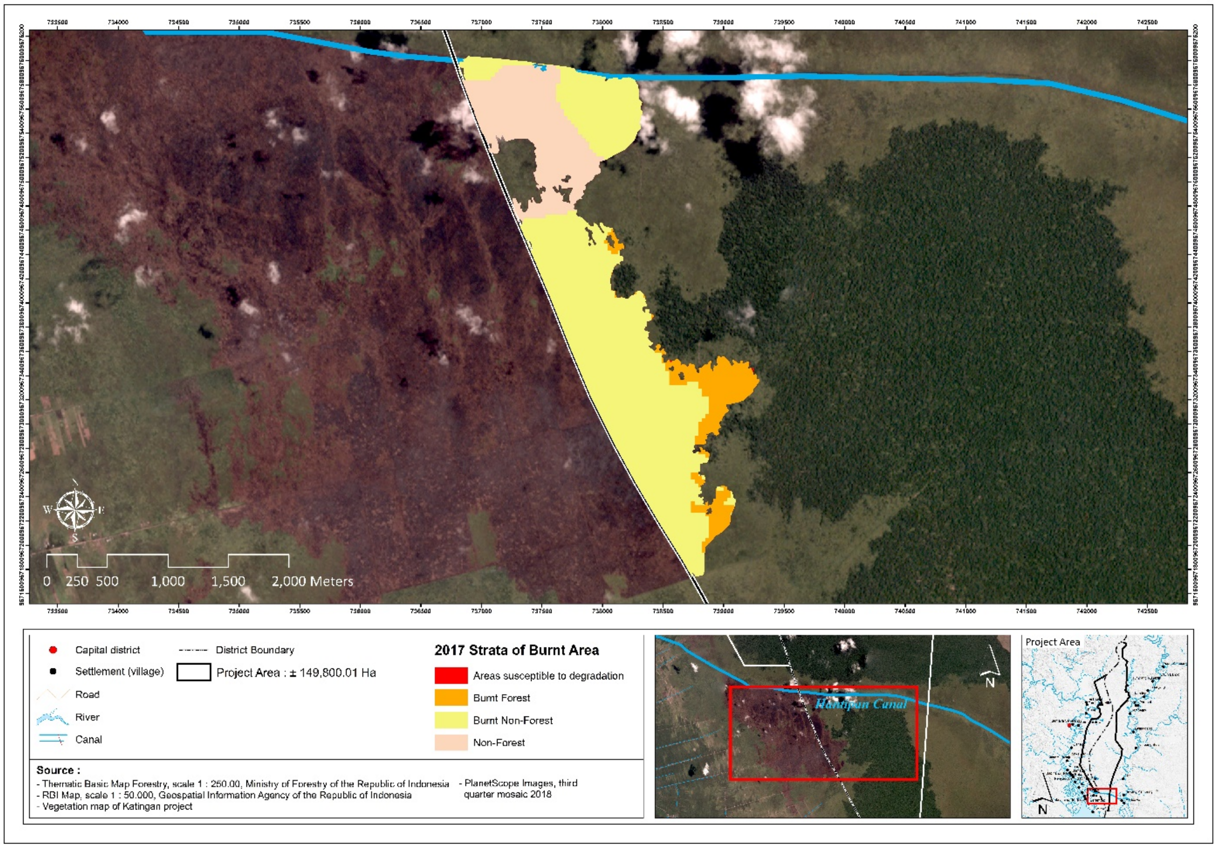
4.2.6.3 Emissions from uncontrolled burning

Fire incidences in the project area were monitored and assessed as described in Section 3.3.3.4. As fire damage was detected during this monitoring period, the burn scar was delineated as described in Section 4.2.2.3. The 2017 AGB stratification was then used to determine which strata were affected. Next, the historical fire incidence mapping, conducted for MR 2010-2015, was used to determine how many times the areas had burnt in the past. Emissions resulting from fire events were then conservatively estimated using IPCC default burn scar depths based on the number of previous incidents of burning (1st, 2nd or 3rd event), bulk density estimates, combustion factors and GHG potential. Further detail of each parameter used is provided in the PD. In total 330.17ha were affected by the fire across 4 strata (see Table 31 and Map 18).

Table 31. Area (in ha) of uncontrolled burning of peat in the project area for the 2018 monitoring period

Strata	Burnt order*		
	1 (BSD = 18 cm)	2 (BSD = 11 cm)	3 (BSD = 4 cm)
P1L0D0	-	1.48	55.73
P1L0D1	0.07	32.17	240.73
P1L1D0	-	-	-
P1L1D1	-	-	-
Total	0.07	33.65	296.46

Map 18. Area burnt, and historical fire incidents, in the project area during 2018 monitoring period



Parameters were combined to estimate GHG emissions from peat burning following the VCS methodology VM 0007 module E-BPB, using equation 28:

$$E_{peatburn-WPS,i,t} = \sum_{g=1}^{G} \left(\left(\left(A_{peatburn-WPS,i,t} \times (P_{WPS,i,t} + B_{WPS,i,t}) \times G_{g,i} \right) \times 10^{-3} \right) \times GWP_g \right) \qquad (1)$$

Where:

$E_{peatburn-WPS,i,t}$	Greenhouse emissions due to peat and biomass burning under project scenario in stratum *i* in year *t* of each GHG (CO_2, CH_4, N_2O) (t CO_2e)
$A_{peatburn-WPS,i,t}$	Area peat burnt under project scenario in stratum *i* in year *t* (ha)
$P_{WPS,i,t}$	Average mass of peat burnt under project scenario in stratum *i*, year *t* (t d.m. ha^{-1})
$B_{WPS,i,t}$	Average biomass burnt under project scenario in stratum *i*, year *t* (t d.m. ha^{-1})
$G_{g,i}$	Emission factor in stratum *i* for gas *g* (kg t^{-1} d.m. burnt)
GWP_g	Global warming potential for gas *g* (t CO_2/t *g)*
g	1, 2, 3 .. *G* greenhouse gases including carbon dioxide, methane and nitrous oxide (unitless)
i	1, 2, 3 …*M* strata (unitless)
t	1, 2, 3, … *t* time elapsed since the start of the project activity (year)

The average mass of peat burnt for a particular stratum is then estimated using the equation as follows (29):

$$P_{WPS,i,t} = D_{peatburn\text{-}WPS,i,t} \times BD_{upper} \times 10^{-4} \quad (2)$$

Where:

$P_{WPS,i,t}$	Average mass of peat burnt under project scenario in stratum *i*, year *t* (t d.m. ha^{-1})
$D_{peatburn\text{-}WPS,i,t}$	Average fire scar depth under project scenario in stratum *i* in year *t* (m)
$BD_{upper,i}$	Bulk density of the upper peat in stratum *I* (g cm^{-3})
i	1, 2, 3 …*M* strata
t	1, 2, 3, … *t* time elapsed since the start of the project activity (years)

Using these equations, the GHG emissions from uncontrolled burning in 2018 were determined to be 35,012.06 t CO_2e (see Table 32).

Table 32. GHG emissions resulting from uncontrolled burning of peat soil in the project area during 2018 monitoring period in $tCO_2e.ha^{-1}.yr^{-1}$

Strata	CO_2	CH_4	Total
P1L1D0	0.00	0.00	0.00
P1L1D1	0.00	0.00	0.00
P1L0D0	4,799.28	578.34	5,377.63
P1L0D1	26,447.36	3,187.07	29,634.43
Total	31,246.64	3,765.42	35,012.06

4.3 Leakage

Applicable leakage modules were determined according to requirements in the VCS methodology VM0007 REDD+ MF. As described in Section 4, the baseline activity is identified as planned deforestation and peatland drainage as a result of conversion to industrial acacia (pulp wood) plantations. The project is therefore categorized as a combination of Avoiding Planned Deforestation (APD) and Reforestation (ARR), in combination with Conservation of Undrained and Partially drained Peatland (CUPP) and Rewetting of Drained Peatland (RDP) activities. As a consequence, potential sources of leakage emissions stem from the displacement of planned deforestation activities and displacement of pre-project agricultural activities on non-forest land, and ecological leakage due to possible alterations of mean annual water table depth in adjacent areas. These potential sources are covered in the VCS Methodology VM0007 Modules **LK-ASP**, **LK-ARR**, and **LK-ECO** respectively, which are therefore identified as the applicable modules for the quantification of total leakage emissions (see Table 33).

Table 33. Applicability of leakage modules

Module	Applicability
Estimation of emissions from activity shifting for avoiding planned deforestation and planned degradation (LK-ASP)	Applicable. The project may cause activity shifting of avoided planned deforestation.
Estimation of emissions from activity shifting for avoiding unplanned deforestation (LK-ASU)	Not applicable. The project is not categorized as avoiding unplanned deforestation.
Estimation of emissions from displacement of fuelwood extraction (LK-DFW)	Not applicable. The project is not categorized as avoiding unsustainable fuelwood extraction.

Estimation of emissions from displacement of pre-project agricultural activities (LK-ARR)	Applicable. The project is categorized as afforestation, reforestation, and revegetation and may cause displacement of pre-project agricultural activities.
Estimation of emissions from market-effects (LK-ME)	Not applicable. The project does not reduce the production of timber, fuelwood, or charcoal.
Estimation of emissions from ecological leakage (LK-ECO)	Applicable. The project is categorized as WRC and may cause ecological leakage.

4.3.1 Estimation of emissions from activity shifting for avoiding planned deforestation and planned degradation

Activity shifting leakage was monitored against the leakage baseline defined in the PD (Section 6). As per the methodology, and the steps defined in the PD, 'area deforested by the baseline class of agents through the years in which planned deforestation was forecast to occur'(AdefLK,i,t) was monitored and compared to the baseline leakage scenario (Step 3, as per Section 6 of the PD), using the following method.

The most up-to-date data on active acacia (pulp wood) concessions in Indonesia, up to and including the current monitoring period, were obtained from Greenpeace since the official government data on such concessions is not publicly accessible (http://www.greenpeace.org/seasia/id/Global/seasia/Indonesia/Code/Forest-Map/en/data.html). The downloaded shapefile contains the spatial delineation of the concessions, the year each concession was granted, and the company that owns it (where known). In some cases the concession date is not listed, so these concessions were conservatively assumed to have been granted prior to 2010 (despite the fact that some may have been issued post-2010) so that any deforestation that occurred within them was included in the calculation of NewRi,t. Prior to analysis, the concession data was reviewed to remove any listed areas that were not attributable to the baseline class of deforestation agent (acacia or other pulp wood plantations). This included the removal of a number of concessions (92) listed in the Greenpeace dataset as "candidate areas" ("Calon Areal") as such areas do not refer to active concessions. Similarly a number of concessions known to not to be associated with acacia or other pulp-wood plantations were removed: these included concessions known to be growing timber for plywood or biomass power generation as well as those growing non-timber crops such as rubber, oil palm, cloves or sagu. In total 166 such non-acacia plantations were removed, leaving a total of 557 known active acacia or other pulp wood plantations. This process was repeated during this monitoring period when an updated version of the Indonesia acacia concessions shapefile became available via the GlobalForestWatch (http://data.globalforestwatch.org/search?q=wood%20fiber). In order to remain conservative, the concessions from the previous greenpeace dataset were added to any new concessions listed in the GlobalForestWatch dataset and all were assumed to remain active during the monitoring period.

Annual area deforested throughout all concessions during the monitoring period was quantified by using satellite imagery. Due to the large area and time-period, the best and most accurate dataset available is the Global Forest Watch data (http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html). The major drawback of this dataset is that it doesn't quantify deforestation specifically; rather it quantifies tree cover loss. This means that any tree cover loss attributed to harvesting operations within the plantation are also included in the tree cover loss data, therefore significantly inflating the forest cover loss results. Despite the considerable drawbacks of the data and its overly conservative nature, the data was extracted for all concessions to quantify the annual deforested area by the class of deforestation agent throughout the monitoring period. In future it may become possible to subtract forest gain data over the same periods to generate a net loss value more closely attributable to actual deforestation, however currently the GFW dataset only includes such data for 2000-2012, and warns against direct comparisons. During this period the same set of concessions gained

1,530,482 ha of tree cover, a large proportion of which will relate to the plantations themselves, and subsequently be lost in harvesting. An alternative approach might be to model harvesting losses based on a set of assumed parameters.

Areas of deforestation and leakage were determined using equation 30. The area of deforestation attributable to peatland and non-peatland plantations was allocated following the approach described in the PD, Section 5.5.1, whereby deforestation was assumed to occur at an equivalent rate within plantations on peat and in non-peat areas so was proportionally allocated based on the corresponding areas (20.5% and 79.5% respectively, see PD Section 5.5.1 for more details). Results are shown in Table 34:

$$LKA_{planned,i,t} = A_{defLK,i,t} - NewR_{i,t} \quad (30)$$

Where:

LKAplanned,i,t	The area of activity shifting leakage in stratum i in year t (ha)
NewRi,t	New calculated forest clearance by the baseline agent of the planned deforestation in stratum i in year t where no leakage is occurring (ha)
AdefLK,i,t	The total area of monitored deforestation by the baseline agent of the planned deforestation in stratum i in year t (ha)
I	1, 2, 3, … M strata (unitless)
T	1, 2, 3, … t^* time elapsed since the start of the project activity (years)

Table 34. Monitored area of deforestation by the class of agent of deforestation (Acacia/other-pulpwood plantations) during the monitoring period

	AdefLK,i,t		NewRi,t		LKAplanned,i,t	
Year	Peatland	Non-Peatland	Peatland	Non-Peatland	Peatland*	Non-Peatland
2011	59,311.46	230,212.33	84,897.33	329,521.67	-25,585.87	-99,309.34
2012	83,297.77	323,313.10	88,254.15	342,550.85	-4,956.38	-19,237.75
2013	39,157.94	151,988.15	90,569.26	351,536.74	-51,411.32	-199,548.59
2014	48,967.20	190,061.94	94,023.17	364,942.83	-45,055.97	-174,880.89
2015	54,448.07	211,152.29	97,255.64	377,489.36	-42,807.57	-166,337.07
2016	75,277.58	291,930.11	100,685.55	390,463.46	-25,407.97	-98,533.35
2017	41,282.36	160,095.00	103,873.92	402,828.14	-62,591.56	242,733.14
2018	33,176.82	128,772.96	106,933.81	414,694.52	-23,636.04	-91,381.42

Since this analysis confirmed there was no leakage throughout the monitoring period (all values of LKAplanned,i,t in Table 34 are negative), Steps 4 through 7 as described in the project description were not required.

4.3.2 Estimation of emissions from displacement of pre-project agricultural activities (LK-ARR)

The VM0007 Module LK-ARR requires the use of the latest version of the CDM tool "Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity” [24]. Step 1 of the CDM tool requires that the area subject to pre-project agricultural activities that is expected to be afforested/reforested (therefore the activities having to be displaced) be identified.

The project area includes only comparatively small areas of non-forest land which will be reforested in the project scenario. The vast majority of these areas are not forested as a result of uncontrolled burning that occurred prior to the project’s start. Only a small fraction of area (< 2 ha) has some existing planted rubber trees, however this will be fully incorporated within a larger (262 ha) area of community-managed rubber/jelutong agroforests which will border the Hantipan canal area. As a result, no pre-project agricultural activities will be displaced by ARR project activities, and hence leakage from the displacement of pre-project agricultural activities did not, and will not, occur (Change_C_LK-ARR = 0).

4.3.3 Estimation of emissions from ecological leakage (LK-ECO)

During this monitoring period, and as per the project’s implementation plan the project did not initiate rewetting activities. Therefore ecological leakage (LK-ECO) is deemed zero.

4.4 Net GHG Emission Reductions and Removals

Net GHG emission reductions from REDD, WRC, and ARR activities are calculated using equation 31. This section provides an overview of total net emission reductions and details activity specific calculations in sub-sections.

$$NER_{REDD+} = NER_{REDD} + NGR_{ARR} + NER_{WRC} \tag{31}$$

Where:

NER_{REDD} Total net GHG emission reductions of the REDD project activity up to year t^*; t CO_2-e

NGR_{ARR} Total net GHG removals of the ARR project activity up to year t^*; t CO_2-e

NER_{WRC} Total net GHG emission reductions of the WRC project activity up to year t^*; t CO_2-e

4.4.1 Uncertainty Analysis

Per module X-UNC, uncertainties were calculated for the project’s REDD and WRC components in both the project and baseline scenarios.

4.4.1.1 REDD Uncertainty

The REDD baseline uncertainty remained unchanged and was calculated per the methods described in the project description. Per the calculations the REDD baseline uncertainty was determined to be 10.61%. For the REDD project uncertainty, the uncertainty was calculated per the methods outlined in module X-UNC and was calculated to be 0.47%.

4.4.1.2 WRC Uncertainty

The WRC baseline uncertainty remained unchanged and was calculated per the methods outlined in the project description. For the WRC project uncertainty the proxyCO_2, proxy CH_4 and peatditchCO_2

uncertainties were also calculated using the same assumptions used in the methods outlined in the project description using the updated areas for the respective strata. The WRC project uncertainty was calculated to be 2.39%.

4.4.1.3 Combined Uncertainty

The total uncertainty error in the project was calculated to be 0.90%. Considering the 15% uncertainty threshold, no VCU deductions were made due to uncertainty. Further detail on all calculations is provided in Annex 17 of the PD.

4.4.2 Total net GHG emission reductions of the REDD project activity

Net GHG emission reductions from REDD project activities are calculated by subtracting project emissions and emissions due to leakage from baseline emissions. (Table 35)

Table 35. Total net GHG emission reductions of the REDD project activity

Years	Estimated baseline emissions or removals (tCO2e)	Estimated project emissions or removals (tCO2e)	Estimated leakage emissions (tCO2e)	Estimated net GHG emission reductions or removals (tCO2e)
2018	1,726,187	22,422	-	1,703,765
Total	1,726,187	22,422	-	1,703,765

4.4.3 Total net GHG emission reductions of the WRC project activity

Net GHG emission reductions from WRC project activities are calculated by subtracting project emissions and emissions due to leakage from baseline emissions (see Table 36).

Table 36. Total net GHG emission reductions of the WRC project activity

Years	Estimated baseline emissions or removals (tCO2e)	Estimated project emissions or removals (tCO2e)	Estimated leakage emissions (tCO2e)	Estimated net GHG emission reductions or removals (tCO2e)
2018	4,360,576	160,134	-	4,200,442
Total	4,360,576	160,134	-	4,200,442

4.4.4 Total net GHG removals of the ARR project activity

In this monitoring period, no estimated project carbon removals from ARR are calculated. Therefore, the net GHG removal of the ARR project activities are calculated by subtracting baseline removals from with project removals, accounting for any leakage (see Table 37).

Table 37. Total net GHG removals of the ARR project activity

Years	Estimated baseline emissions or removals (tCO2e)	Estimated project emissions or removals (tCO2e)	Estimated leakage emissions (tCO2e)	Estimated net GHG emission reductions or removals (tCO2e)
2018	6,664	-	-	(6,664)
Total	6,664	-	-	(6,664)

4.4.5 Total net GHG removals from uncontrolled burning

Net GHG emission reductions from uncontrolled burning are calculated by subtracting estimated project emissions from estimated baseline emissions (see Table 38).

Table 38. Total net GHG removals from uncontrolled burning

Years	Estimated baseline emissions or removals (tCO2e)	Estimated project emissions or removals (tCO2e)	Estimated net GHG emission reductions or removals (tCO2e)
2018	-	193,856	(193,856)
Total	-	193,856	(193,856)

4.4.6 Calculation of the VCS Non-Permanence Risk Buffer Withholding

The combined non-permanence risk buffer for the project was determined as 10% (Section 2.3.1). Per VSC methodology VM0007 modules REDD+ MF, the annual buffer withholding for all activities was determined as a percentage of the total carbon stock benefits including fire which excludes emissions due to leakage (see Table 39). As the project does not account for emissions from fossil fuel combustion, and direct N_2O emissions, these were also omitted from calculations.

Table 39. Annual non-permanence risk buffer withholding

Years	REDD total carbon stock benefits	WRC total carbon stock benefits	ARR total carbon stock benefits	Estimated carbon emission from Fire	Non-Permanence Risk Buffer (10%)
2018	1,703,765	4,200,442	(6,664)	(193,856)	570,369
Total	1,703,765	4,200,442	(6,664)	(193,856)	570,369

4.4.7 Calculation of Verified Carbon Units

VCU are calculated by subtracting the VCS non-permanence risk buffer withholding from the uncertainty adjusted net emission reductions for each project activity (see Table 40).

Table 40. Calculation of estimated verified carbon units

Years	NGR_{ARR}	$NER_{REDD+WRC+Fire}$	Adjusted $NER_{REDD+WRC+FIRE+ARR}$	Non-Permanence Risk Buffer	Estimated VCU
2018	(6,664)	5,710,352	5,703,688	570,368	5,133,319
Total	(6,664)	5,710,352	5,703,688	570,368	5,133,319

APPENDIX 1: NON-PERMANENCE RISK ASSESSMENT

Please see attached document.

APPENDIX 2: CLIMATE MRV TRACKER

Please see attached document.