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Reducing uncertainty in greenhouse gas emissions from Indonesian peatfire

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1 Executive summary

The main goal of this project is to improve the knowledge base of parameters for calculating GHG emissions from peat fires in a sequence of increasingly degraded peat forests. To address this aim we amassed and analysed a comprehensive dataset of peat forest parameters for aboveground biomass, peat bulk density and peat carbon content as they are affected by fires. Using a chrono sequence of increasingly degraded peat forests we documented a new method to scale peat combustion factors according to the depth of peat burning, to accurately represent heterogeneric conditions of peat moisture across a landscape.

The success of this project is that Indonesia is currently revising its FREL using the new updated data derived from our activities.

The dataset amassed in this project also allowed for investigation of the recovery of species diversity of peat swamp forests following repeated fires. We observed that the richness and diversity of tree species recovers to about 80% of relatively undisturbed forests about 16-22 years after peat fires, as does the aboveground biomass. In contrast the structural composition of regenerating peat forests requires multiple decades for recovery. Management interventions, such as enrichment planting, will be required to increase the number and diversity of species which are not able to naturally recover over the first three decades after fires.

The capacity building aspect of this project resulted in new skills acquired by both Indonesian and Australian researchers – we worked effectively as a team, achieving several peer-reviewed publications with the prospect of more to follow.

2 Background

This Small Research Activity aims at reducing uncertainties in emissions estimates from peat fires for Indonesian Government reporting to the UNFCCC. Regional droughts in 1997-98, 2005, 2015-16, and 2019 resulted in an unprecedented increase in peat fires in Indonesia affecting both natural forests and those subject to conversion to plantations. Smoke and air pollution from those fires affected not only Indonesia but all south-eastern Asia (Hayasaka et al., 2014; Marlier et al., 2015; Tham et al., 2019; Wiggins et al., 2018). Reducing smoke and greenhouse gas (GHG) emissions from peat fires is important for regional health and air quality, it is also gaining national and international significance as a mechanism for addressing climate change (UNFCCC, 2015). Current emissions from drained and burnt peatlands are claimed to be in the range of 2 billion t CO₂ per year, accounting for about five per cent of all emissions caused by human activity (UN, 2017), yet there is limited transparency in these estimates. For these reasons the Food and Agriculture Organisation (FAO) of the United Nations (UN) has recently declared that improving the assessment of GHG emissions from peatland is a global strategic priority (FAO and Wetlands International, 2012).

In its first Nationally Determined Contributions (NDC), Indonesia committed to reduce its GHG emissions by 26% relative to a business-as-usual scenario by 2020, and by 41% with international support. For the period 2020 to 2030 these reduction targets are 29% (unconditional) and 41% (conditional) (Republic of Indonesia, 2016). Due to a high level of uncertainty in peat fire emissions parameters, the Government of Indonesia (GoI) excluded emissions from peat fires in its first Forest Reference Emission Level (FREL) submitted to the UNFCCC (MoEF, 2016), preventing it from subsequently claiming emission reduction from reduced peat fires.

The need to improve GHG emissions estimates from peat fires was identified as a priority area and a major knowledge gap by the Indonesian stakeholders in the Gambut Kita project (meeting in Jakarta in September 2019). Additionally, GoI is under increasing international pressure to include and report emissions from peat fires if the international donors (such as the Government of Norway) are to support Indonesian efforts to meet its NDC commitments.

The main goal of this project is to improve the knowledge base of parameters for calculating GHG emissions from peat fires in a sequence of increasingly degraded peat forests that will enable the GoI to include peat fire emissions in their international reporting and subsequently to claim emission reduction benefits over time.

3 Objectives

The main goal of this project is to improve the knowledge base of GHG emissions from peat fires so that the GoI can use a refined Tier 2 approach in their international reporting. Specifically, the objectives are to:

1. Build a comprehensive dataset of aboveground and peat biomass parameters that are required to improve emissions estimates by using a Tier 2 approach (Eq 1 and Eq 2) through literature review, data mining, meta-analysis and targeted field sampling, including:
 - a. Data derived from the APFNet/DISER project (field sampling in 2019-2020)
 - b. Data provided by the Indonesian researchers
 - c. Data derived from field sampling in this SRA including laboratory analysis (such as peat bulk density, peat carbon content, combustion factor for the aboveground mass and production of pyrogenic carbon)
2. Develop a baseline of GHG emissions from peat swamp forests at different stages of forest degradation (such as after one or more fires after initial drainage and timber extraction)
3. Identify the major biomass sources of emissions from peat fires at different stages of degradation that also includes stages in recovery from fire
4. Develop recovery functions of live and dead biomass for inclusion in Tier 2 reporting
5. Conduct trade-off analysis to understand the consequences of moving to a higher Tier in reporting emissions from peat fires
6. Conduct capacity building workshops and training with the Indonesian researchers for data analysis techniques and support them to lead publications arising from the activities of this SRA
7. Collaborate with the Australian Government experts on emissions reporting to the UNFCCC to ensure that revised parameters comply with international requirements
8. Engage in-person or via online workshops with colleagues in the GoI for discussion and improvements in the emission parameters.

3.1 Activities

Scientific publications and grey literature (e.g. unpublished research reports) related to fire emission measurements from peat fires will be reviewed to add to the database. Data relevant to the emissions estimates and biomass/fuel recovery will be reviewed to update methods and reduce uncertainties in emission estimates.

Activity output – Publications on Tier 2 updated parameters, recovery functions and uncertainty analysis of the GHG emissions estimates using current approach and a refined Tier 2 method (please note that the publication process may not be completed within the life of the project). All of the activities will be conducted in close partnership with Indonesian researchers and the GoI representatives.

The main activities are to:

1. Compile a comprehensive dataset from various sources and targeted field work on the parameters required for the Tier 2 emissions estimates.

Outcome – a dataset of parameters and a scientific peer reviewed publication summarizing the results for easier adaptation by the GoI.

2. Develop recovery functions for dead organic matter and live biomass for inclusion of CO₂ uptake for Tier 2 reporting.
Outcome – modeled recovery functions and a scientific peer reviewed publication.
3. Conduct a trade-off analysis of current Tier 1 approach vs refined Tier 2 method – for changes in emission magnitude and developing a set of recommendations for the Gol.
Outcome – results of trade-off analysis of Tier 1 to Tier 2, uncertainty analysis as a part of a publication in Activities 1-2 or a separate publication.
4. Evaluate possible emission reduction outcomes for a range of forest recovery scenarios.
Outcome – a set of recommendations for discussion and review with the Gol via webinars and workshops.
5. Document the methodology to enable this research to be adopted in GHG Inventory processes, and future improvement cycles.
Outcome – a documented methodology in English and Indonesian.
6. Build capacity. We aim for the majority of the publications arising from this SRA to be led by our Indonesian partners. Our main activity will be developing scripts in R or other program languages, workshop trainings and editing of the writing.
Outcome – improved capacity of Indonesian researchers, increased records in international peer-reviewed publications.

4 Methodology

A detailed implementation and operational plan will be agreed by all funding and delivery partners within three weeks of contracting. This SRA project will utilise expertise in greenhouse gas science and international reporting policy and practice, degraded peat forest management and land use change, and data synthesis, analysis and interpretation from Australia and Indonesia to achieve the project objectives. The project involves data synthesis, analysis and interpretation and the acquisition of novel field data. These tasks will be staged as outlined above.

5 Achievements against activities and outputs/milestones

No.	Activity	Outputs/ milestones	Completion date	Comments
1	Compile a comprehensive dataset from various sources and targeted field work on the parameters required for the Tier 2 emissions estimates	A dataset of parameters and a scientific peer reviewed publication summarizing the results for easier adaptation by the GoI	August 2021	Dataset is completed and a publication with improved combustion factors for peat and aboveground biomass is published in the Science of the Total Environment
2	Develop recovery functions for dead organic matter and live biomass for inclusion of CO ₂ uptake for Tier 2 reporting	Modelled recovery functions and a scientific peer reviewed publication	August 2021	The carbon recovery functions are developed for the aboveground live and litter components. This publication is led by the Indonesian collaborator -this led to extended delay in producing a publication; submission is anticipated in January-February 2022. Draft of the manuscript can be presented on request
3	Conduct a trade-off analysis of current Tier 1 approach vs refined Tier 2 method – for changes in emission magnitude and developing a set of recommendations for the GoI	Results of trade-off analysis of Tier 1 to Tier 2, uncertainty analysis as a part of a publication in Activities 1-2 or a separate publication	October 2021	We conducted a trade-off analysis of estimating peat emissions using the IPCC default method, method developed by the GoI and method used by the Australian Government, those estimates were compared. We conducted several round table discussions with MoEF on the selection of the most appropriate method for reporting emissions. GoI agreed to include aboveground component in its emission reporting; using newly published data derived from this project GoI is in the process of resubmitting FREL to the UNFCCC. We are working on a joint publication with anticipated submission late January

4	Evaluate possible emission reduction outcomes for a range of forest recovery scenarios	A set of recommendations for discussion and review with the GoI via webinars and workshops	October 2021 and January 2022	<p>Our study in degraded peatlands revealed that using a traditional approach of estimating peat fire released emissions (based on peat depth consumption) will significantly overestimate the emissions. This is because in degraded peatlands, the major fuels contributing to smoke are a combination of roots, ferns, grasses, shrubs, and top peat layer. We also estimated that recovery of carbon will be achieved within 3 years after peat fires.</p> <p>A workshop discussing emission reduction outcome is planned for late January.</p>
5	Document the methodology to enable this research to be adopted in GHG Inventory processes, and future improvement cycles	A documented methodology in English and Indonesian	May 2021	<p>A sampling design has been developed in both English and Bahasa.</p> <p>An excel file showing different emission estimates methods has been shared with the MoEF.</p>
6	Build capacity. We aim for most of the publications arising from this SRA to be led by our Indonesian partners. Our main activity will be developing scripts in R or other program languages, workshop trainings and editing of the writing	Improved capacity of Indonesian researchers, increased records in international peer-reviewed publications	Ongoing	<p>So far we have published three peer-reviewed publications in ISI journals in co-authorship with our Indonesian collaborators. Three more publications are in the progress and will be submitted for publication early next year.</p> <p>We have conducted numerous workshops discussing scientific writing; data presentations, code development (R).</p> <p>We shared concept note approach for writing scientific publications and have been guiding two of Indonesian collaborators to lead publications</p>

6 Key results and discussion

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7 Impacts

7.1 Scientific impacts

New revised parameters of peat emission factors have been developed and are shaking old grounds of oversimplified emissions estimates coming from Indonesian peatlands. We also developed new functions to estimate the recovery of peat swamp forests carbon and tree diversity after fires. Our findings indicate that aboveground carbon will be recovered within 10 years after fire and species richness and diversity will recover 16-22 years after fires. In degraded peatlands, subjected to frequent and repeated burns recovery of carbon is anticipated within 3 years after peat fire.

7.2 Capacity impacts

A number of joint publications led to career advancement of our Indonesian colleagues and their greater international recognition. Inclusiveness of Indonesian colleagues into manuscript preparation, submission to the journal, revision and addressing reviewer's comments (sometimes very harsh and unfair) have shown Indonesian colleagues how to deal with sometimes very difficult and challenging criticism.

Our Indonesian project partner Dr Haruni Krisnawati has been promoted to the position of Professor becoming one of a few women professors in Indonesia. Because of her leading role in the peat combustion factor publication, she received several invitations to the round tables and seminar presentations at COP26 in Glasgow.

Project Leader Dr Volkova has presented findings of this project at the University of Melbourne seminar, as a keynote speaker at INAFOR 2021, and to our colleagues at ACIAR - this broader communication of the results led to greater awareness of situation in Indonesia. Dr Volkova has received numerous acknowledgements about capacity building component of our project during INAFOR talk.

7.3 Community impacts

7.3.1 Economic impacts

The economic impact of this project will be observed in years to come – when the solid baseline of Indonesian peat fire emissions, that is required so that a country (or participating communities) can later claim emissions reduction benefits, allows for benefits to be realized.

7.3.2 Social impacts

Inclusiveness of Indonesian colleagues into publication process increased their social status and gave them opportunity to have secured (and even further advance) their professional positions.

7.3.3 Environmental impacts

Our work indicates relatively short time of biomass recovery recognizing and estimating the re-absorbance of CO₂ by new growth, effectively restoring aboveground C lost to the atmosphere during peat fire. The work on carbon recovery will have long lasting positive consequences on Indonesian environmental policies and highlights the need for targeted recovery actions (such as with peat species diversity) or increasing water table to reduce peat carbon oxidation.

7.4 Communication and dissemination activities

We communicated the results of project activities in consultation sessions with the Ministry of Environment and Forestry. We discussed the selection of the method to use in the peat fire emission reporting. Because the results of this project influence Indonesian reporting to the UNFCCC and are a subject of technical revision – we focus on writing scientific peer-reviewed publications in recognised journals, to make sure that our results will stand up to scrutiny.

8 Conclusions and recommendations

8.1 Conclusions

This Small Research Activity aimed to reduce uncertainty in emission estimates from peat swamp forest (PSF) fires. The project results were directly implemented by the Government of Indonesia (GoI) in their UNFCCC reporting, with revisions to its forest reference emission level (FREL) using data generated by the project.

The project developed new functions to estimate the recovery of PSF aboveground carbon storage capacity, forest structure, and tree diversity after fire/s in Central Kalimantan area. We discovered that not much of a scientific basis exists for the selection of species for peat forest restoration – often fire adapted, easily growing species are selected, which in practice do not require artificial revegetation.

Capacity building was at the core of this project, with activities such as the recent *Results Integration workshop*, held in March 2022. This workshop identified that in adopting a simplistic method for emission reporting for FREL#1, emissions were overestimated by the GoI, with the selected method also restricted to emissions from peat layer, and not allowing for estimation of other greenhouse gases.

Our ongoing capacity building and communication with the GoI and researchers allowed us to influence the method used for the revised FREL#2. This demonstrates the projects' reach to the GoI to further develop understanding of emissions reporting and the evidence base required to support improvements. The GoI emissions reporting team is now able to readily see the advantages in distinguishing the difference between emission parameters such as the Combustion Factor (CF) – an amount of organic matter combusted, from the Modified Combustion Efficiency (MCE), the ratio of CO₂ released to the sum of CO and CO₂.

While results of our project were quickly adopted by the GoI, there are lingering concerns that only one area of peatlands was studied (Central Kalimantan), with more geographically representative results from Indonesian peatlands sought to better extrapolate to the whole.

8.2 Recommendations

Our main recommendations from this project:

- Continue building capacity at the highest Governmental and research level.
- Direct future research at establishing a national resource by building the database of forest recovery sites – for monitoring, research and demonstration (recovery versus development for other land uses);
 - e.g. include case studies from peat domes in Sumatra and Papua to support national reporting (C loss and recovery, biodiversity and forest structural recovery).
 - This approach also addresses species richness and diversity thereby identifying appropriate species for peat swamp forest restoration.
- Work up the point in space and time estimates of emissions to the landscape level, including a visual demonstration tool to assist with policy development (scenario testing).

- This step could be based on the activity data over the last few decades.
- Linking recovery of carbon and ecosystem services (such as biodiversity) with livelihood development via REDD+ and voluntary carbon credits

9 References

9.1 References cited in report

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9.2 List of publications produced by project

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10 Appendixes

10.1 Appendix 1:

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