CRC 990 - EFForTS

NEWSLETTER

Highlights Phase 3
2020–2022

Issue 8 / July 2022

Photo Cover:
Ellena Yusti explaining her work to two children during the *Landscape Assessment* field campaign in 2021 (left).
Melky Susandro measuring tree diameter and tagging trees during the *Landscape Assessment* field campaign in 2021 (middle).
Vegetation team entering a flooded shrubland plot in the Harapan landscape during the *Landscape Assessment* field campaign (right).

Content

Acknowledgement from the Management

LANDSCAPE ASSESSMENT – SUCCESSFUL REALIZATION OF THE FIELD EXPERIMENT IN 2021 AND 2022

The global coronavirus crisis has challenged *EFForTS* in many new and unexpected ways, especially as we could not carry out the research program as anticipated (and as outlined in the proposal). Besides the planned field activities of the respective subprojects (see pages 18/A01, 23/A03, 27/A07, 30/B04, 35/B09, 39/B14, 45/C02, 47/C06, 49/C07, 52/C08, 53/C10, 56/C12, 62/Z02, 69/BEE), above all this concerned the integrative *Landscape Assessment*, one of the central research platforms of *EFForTS* of Phase 3. As you all know the *Landscape Assessment* campaign was planned for 2020.

However, we have faced the challenges and in the course of the pandemic we have developed new ways and opportunities to run our field research campaigns. Given the situation we decided to conduct the *Landscape Assessment* campaign "remotely" in 2021 – meaning that the research staff in Göttingen would organize and oversee fieldwork activities from abroad relying entirely on their team of local research assistants. We had several meetings with the *Landscape Assessment* planning group (see below) and a final conclusion meeting with PIs, Postdocs and group speakers of the Indonesian counterparts on December 3, 2020:

- The field work campaign would be done between May (start on May 24, 2021 after Idul Fitri) and October 2021
- On-site field work would be conducted primarily by local assistants under the supervision of the head coordination in Indonesia (see below), counterparts and Göttingen PIs and Postdocs.

To this end, the initial plan was to train field assistants in Göttingen before the start of the field work campaign, potentially accompanied by counterparts. However, due to the severity of the pandemic and the impossibility to travel, the plan had to be scrapped. Instead, teaching material and learning videos were developed for training purposes of the field assistants by postdocs in Göttingen:

- Prepared field protocols and created illustrated teaching material
- Set up a Covid protocol with the help of the company doctor of the University of Göttingen (in English and Bahasa Indonesia): The protocol entailed Covid vaccinations, regular tests of all our field assistants (– roughly 1.500 tests, PCR & Antigen rapid tests –) and how to behave in case of an infection
- Employed modern data collection tools – data management via KoBoToolbox: The app 'KoboCollect' was used to collect field data via android devices; the data were synchronized with a virtual server specially set up and hosted in Göttingen by the GWDG
- Provided sufficient accommodation: Besides the permanent field hubs, additional houses were rented: two in Muara Bulian, two in Pematang Kabau and one in PT REKI
- Grouped four field teams, guided by experienced field assistants: station team for stationary measures (A01, A03, B06 LiDAR, B08), vegetation team for vegetation sampling (A02, A07, B04, B06, B14), fogging team for canopy fogging (Z02) and household team (C-groups) for household surveys (see page 74, *Landscape Assessment*)

Thanks to the relentless efforts of the local coordination team, the *Landscape Assessment* field campaign went smoothly (transportation, housing, access to plots – permits, Covid testing, storage of samples …):

- ➤ Aiyen (overall coordination), Yuking, Mega, Shara.

Thanks to the dedicated efforts of the field assistants and the great communication between the teams, all 132 plots located in two landscapes and four areas were sampled:

- ➤ Erick (overall field coordination); Reza, Bayu, Basri, Alifian, Wisda, Bambang, Nico, Leonarda, Elena, Ilham, Patrick, Erick, Nando (station team); Iqbal, Vais, Tiarma, Erwin, Vive, Irham, Melky, Udin, Jamal, Ojan, Adhy, Edo, Ihsan, Wulandari, Mei, Nadia, Widia (vegetation team); Toni, Naufal, Fajar, Mario, Adi, Yudhi (fogging team); Amsalia, Rizki and Wildan (household team).

Thanks to the scientific coordination of the campaign by our postdoctoral and doctoral researchers (bi-weekly meetings for mutual updates, planning and discussions), the decision for a remotely managed field campaign has paid off:

- Arne (overall coordination, B09), Svea (A01), Pallavi & Medha (A02), Christian (A03), Ashehad, (A07), Martyna (B04), Fabian (B06), Valentyna & Anton (B08), Kevin (B09), Carina (B14), Kibrom (C07), Jochen & Nicolo (Z02).

Below are impressions from the *Landscape Assessment* (LA) campaign:

Pictures 1 a + b. Meeting of Aiyen with all field assistants of the Landscape Assessment campaign on May 4, 2021 in the guest house 'Jelutung' in Jambi city: Management of the LA – safety issues, logistics, introduction of field coordinators.

Pictures 1 c + d. Mega and Shara taking care of the regular testings of our field assistants.

Pictures 2 a–d. A02 field campaign – Tiarma (a) and Vais (b) measuring leaf area index, Iqbal determining the temperature and humidity with a thermo-hygrometer (c), and Iqbal and Vais transporting equipment to the plots (d).

Pictures 3 a–c. A03 field campaign – Alifian and Basri collecting data from the meteo station (a), Basri downloading data from a datalogger (b), and Wisda, Basri and Bayu installing a meteo station in the field (c).

Pictures 4 a–c. A07 field campaign – Viverani (a), Erwin and Basri (b), and Erwin and Irham (c) carrying out leaf-gas exchange measurements on cut branches in oil palm and rubber land-use plots.

Pictures 5 a–d. B04 field campaign – Jamalludin measuring the canopy cover with a densitometer (a) and wood density using a pilodyn (b), Melky cutting twig samples (c), and the vegetation team colleting understory biomass in a forest plot (d).

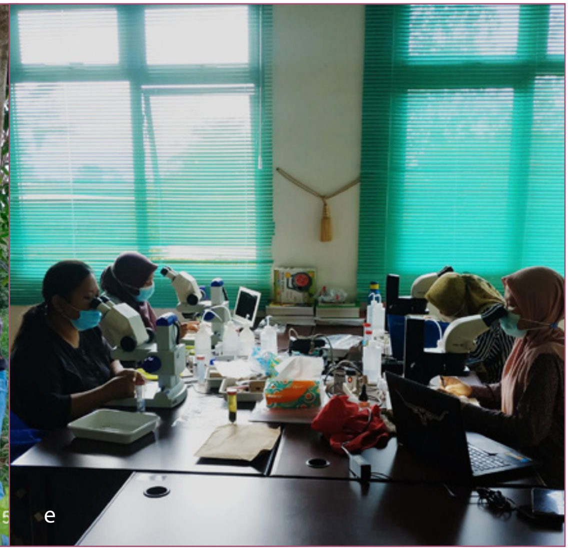
Pictures 6 a–c. B06 field campaign – Ihsan documenting leaf samples (a), Widia determing tree directions using a compass (b), and Adhy and Dian sorting leaf samples for herbarium (c).

Pictures 7 a–c. B08 field campaign – Bambang taking soil and litter samples (a), B08 & B14 team in the field: Leonarda, Nando, Fransiscus, Nico and Bambag (b), and Bambang & Nando & Nico sorting soil samples in the field to sort roots and soil fauna (c).

Pictures 8 a–d. B09 field campaign – Ilham during the set-up of a sound recorder in the field to record bats and birds (a), to make sure the sound recorders were setup correctly Ellena is checking a test recording in the field (b), Patrick with the terrestrial lidar scanner, shortly before scanning the first plot (c), and the B09 team after installation of one recorder at the very beginning of the field campaign (d).

Pictures 9a–d. B14 field campaign – Widia and Nadia measuring twig length (a) and scanning leaf samples (b), Nando taking soil samples (c) and B14 & B08 team in the field: Nando, Bambang, driver, Nico (d).

Pictures 10a–c. Vegetation team in the field: Fajar, Widia, Ihsan, Udin, Melky, Edo, Dian, Fauzan, Adhy, Nadia (a), scanning samples (b) and taking photos and processing herbarium (c).



Pictures 11 a–f. Z02 field campaign: field and lab team: Toni, Yudhi, Naufal, Mario, Fajar, Adi Lubis, Rizky, Kasmiatun, Febriani, Handriani (a), Toni fogging an oil palm plot (b), insect trap installation training: Mario, Naufal, Adi Lubis (c), trap check at dawn (d), lab team sorting fogged insects: Juwita, Febriani, Rizky N, Kasmiatun (e), collected insect samples (f).

Pictures 12a–c. C07 household survey during the *Landscape Assessment* (@ Amsalia Pasila)

Z01 – Central tasks

MANAGEMENT

The Joint Management Board (JMB) Indonesia designated new members:

- Tadulako University (UNTAD)
  - ➤ Dr. Lukman Nadjamuddin (counterpart affairs), replacing Dr. Muhammad Rusydi

The Management Board Göttingen & the members of *EFForTS* appointed new members:

- Prof. Dr. Heiko Faust as new member of the management board, replacing Prof. Dr. Matin Qaim
- Prof. Dr. Meike Wollni as new member of the extended management board, succeeding Prof. Faust

The Management Board Göttingen assigned new group speakers and foci representatives:

- Prof. Dr. Oliver Mußhoff, deputy speaker group C
- Prof. Dr. Holger Kreft, representative focus 2
- Prof. Dr. Meike Wollni & Prof. Dr. Carola Paul, representatives focus 4

Picture 13. Management coordination meeting at UNJA on November 8, 2021. From left to right: Dr. Syamsurizal (Head of Quality Assurance, UNJA), Dr. Aiyen Tjoa (JMB UNTAD, head coordination), Prof. I Nengah (IPB University), Prof. Rayandra Asyhar (Vice Rector for Planning, Collaboration and Information system, UNJA), Prof. Dodik R Nurrochmat (Spokesperson of the Indonesian University Consortium), Prof. Sutrisno (Rector of UNJA), Dr. Kamid (Vice Rector for Academic Affair, UNJA).

COORDINATION OFFICES IN INDONESIA:

The management of the coordination offices at IPB University and UNJA has been restructured:

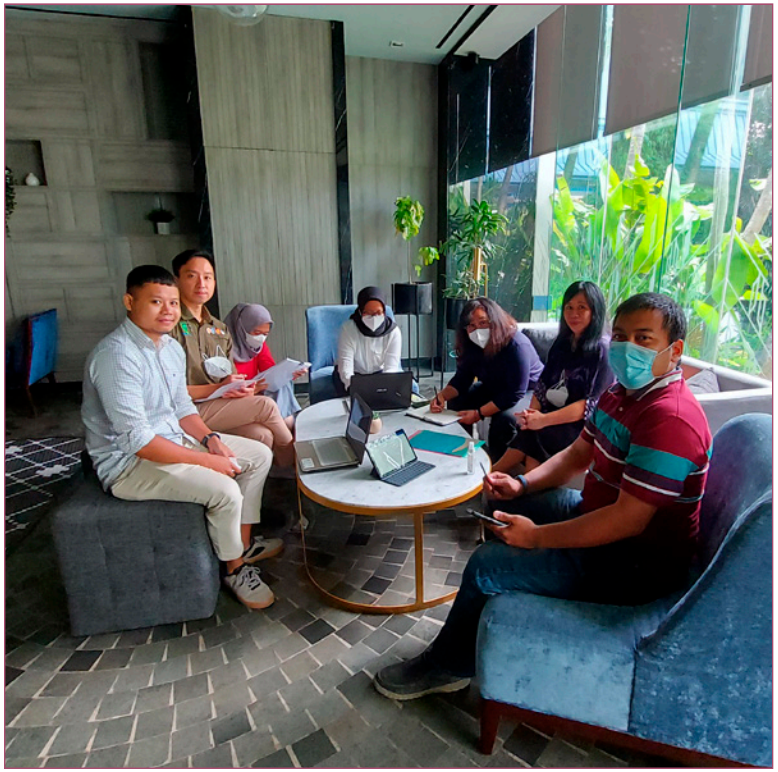
- From 2022, Dr. Aiyen Tjoa, – member of the JMB Indonesia & counterpart of A05 and C11 – is head coordinator of Bogor and Jambi offices.
- Dr. Randi Pratama mainly will manage the financial affairs at IPB University.
- Pujiono joined the *EFForTS* team at Bogor office in December 2020, succeeding / replacing Jean Siswitasari Mulyana & Mira Kartikasari.

To this end, a management coordination meeting was held in UNJA on November 8, 2021 (Picture 13). Agenda items were the personnel structuring of the coordination offices in Indonesia, handling of finances in Indonesia and spokesperson function of the consortium – the last two functions remain with IPB University.

Following this, the offices in Indonesia met from January 11 to 17, 2022 in Bogor (including the financial department of IPB University) and Yogyakarta to consolidate and restructure work portfolios and responsibilities (Pictures 14a and b).

COORDINATION OFFICE IN GÖTTINGEN

- Cornelia Reinhardt took over the secretariat in August 2020, following Ivonne Hein
- Dr. Garvin Schulz joined the coordination in May 2022.



Picture 14a. Consolidation meeting of offices in Indonesia. From left to right: Jion, Yuking, Mira, Shara, Indri, Aiyen, and Randi.

Picture 14b. Consolidation meeting of offices in Indonesia – here: excursion to 'Obelix Hills', Yogyakarta. From left to right: Yuking, Shara, Aiyen, Indri, Mira, Jion, and Randi.

AGREEMENTS:

Memorandum of Agreement (MoA) – University of Göttingen and University Consortium Indonesia has been extended:

- Extension Agreement No. 2 to the MoA between the Consortium of IPB University, University of Jambi and Tadulako University, and the University of Göttingen has been signed in April 2021 (until December 2023).

Memorandum of Understanding (MoU) with PTPN 6 has been extended:

- The MoU between the Indonesian University Consortium and PTPN 6 has been signed on February 25, 2021 at PTPN 6 by the director of PTPN 6, Pak M. Iswan Achir and by Prof. Sutrisno, Rector of UNJA (Pictures 15a and b).

Furthermore, plot compensation payments were completed for 2021 & 2022:

- The contract extension for 2022 with farmers of the *Landscape Assessment* were signed in January 2022 (Pictures 16a and b).

Picture 15a. Signing of the MoU between the University Consortium Indonesia and PTPN 6 in the main office of PTPN 6 on February 25, 2021. From left to right: Pak M. Iswan Achir (Director of PTPN 6, signing the MoU), Prof. Sutrisno (Rector of UNJA) and Prof. Rayandra Asyhar (Vice rector of UNJA).

Picture 15b. Signing ceremony of MoU of the University Consortium and PTPN 6 on February 25, 2022. Third from left to right: Pak M. Iswan Achir (Director of PTPN 6), Prof. Sutrisno (Rector UNJA), Prof. Rayandra Asyhar (Vice rector UNJA), Ade Octavia (former JMB member), Heri Junedi (former coordinator UNJA).

Picture 16a and b. Contract extension with owners of *Landscape Assessment* plots in January 2022. Left: Bapak Samin, owner of O19, right: Bapak Indra Gunawan, owner of S18.

SCIENTIFIC & SOCIAL NETWORKING AND COLLABORATION WITH PARTNERS AND STAKEHOLDERS

Monitoring and Evaluation Meeting with the Head of the National Park Bukit Duabelas (TNBD)

- Following the statutes of the MoA of the University Consortium with TNBD, the annual 'Monitoring and Evaluation' meeting (MoA/Perjanjian Kerjasama – MoA/Cooperation Agreement) of the partners took place on September 21, 2021 at the head office of TNBD.
- Central points of discussion during the meeting of Ibu Aiyen with Pak Haidir S. Hut, head of TNBD and his staff (Pak Saeful and Bu Asri Buliyansik, Pak Wawan) were ongoing research activities at the site and capacity building measures of *EFForTS* for TNBD (Picture 17).

Picture 17. Annual 'Monitoring and Evaluation' Meeting with the head of the National Park Bukit Duabelas on September 21, 2021 at the head office of TNBD. From left to right: Yuking, Shara and Rizky (*EFFoTS-UNJA*), Ibu Asri (TNBD), Ibu Aiyen (JMB and head coordination), Pak Haidir (Head TNBD), Wawan and Saeful (TNBD).

Kementerian Perdagangan – The Ministry of Trade in Indonesia
Strategy meeting – Export of soil samples in international research partnership Projects

- On March 15, 2022, Aiyen Tjoa and Iskandar Siregar met the director of export of the Ministry of Trade to explore possibilities for the export of soil & sediment samples for research purposes within *EFForTS* – as of 2020, the export of soil is subject to strict export regulations and is not permitted (regulation by the Ministries of Trade and Energy and Mineral Resosources).
- The meeting was constructive and an exemption can be granted. In conclusion: A letter of recommendation from the Ministry of Mineral and Natural Resources shall be submitted to the Ministry

Picture 18a. Meeting with the Ministry of Trade concerning the export of soil samples for research purposes. From left to right: Iskandar Siregar (JMB *EFForTS*), Aiyen Tjoa (JMB *EFForTS*), Pak M. Suaib Sulaiman (Director of Export, Ministry of Trade), Ibu Yessi Fadila (Staff of Pak M. Suaib), Pak Kasan Muhri (Head of Trade Analysis and Development Agency of the Ministry of Trade)

of Trade for a final recommendation and exemption (Pictures 18a and b).

To this end, the JMB members of IPB University met on March 11, 2022 to prepare and consolidate the practical approach (Picture 18c).

Workshop "Socialization of foreign research permits" – Sosialisasi perizinan peneutian asing

- On August 12, 2020, the Department of Research Strengthening and Development of RISTEK/BRIN organized a one-day virtual national workshop about the management of foreign research permits within international research collaborations.
- Dr. Aiyen Tjoa was invited as keynote speaker; Aiyen took *EFForTS* as an example and presented the management structures and benefits of the collaborative partnership (Picture 19).

Workshop "International Research Partnership Forum" – Workshop Forum Kemitraan Riset Internasional

- A one-day workshop on "*Counterpart relations in an International Research Partnership*" was hosted by the non-profit & non-governmental Forum Mitra Riset Internasional / International Research Partner Forum on August 18, 2020. The meeting was organized by Aiyen in her capacity as Secretary General of the forum and by Iskandar as head of the forum.
- The forum meets on a regular basis to share experiences, build capacities & strengthen networks, and to exchange with the government on

Picture 18b: Meeting with the Ministry of Trade concerning the export of soil samples for research purposes. From left to right: Immanuel Alfonsus (Staff Ministry of Trade & team member C08), Majidu (Staff of Pak Iskandar), Prof Iskandar Siregar (*JMB EFForTS*), Pak Kasan Muhri (Head of Trade Analysis and Development Agency of the Ministry of Trade), Dr. Aiyen Tjoa (*JMB EFForTS*), Pak M. Suaib Sulaiman (Director of Export of the Ministry of Trade), Ibu Yessi Fadila (Staff of Pak M. Suaib).

Picture 18c. Meeting of the JMB members of IPB University on March 11, 2022. From left to right: Ibu Damayanti Buchori, Pak Anas Fauzi, Pak Iskandar Siregar, Ibu Aiyen Tjoa, Pak Dodik R Nurrochmat.

Picture 19. Outline of virtual national workshop on research permits organized by RISTEK/BRIN

Picture 20. Outline of annual meeting of the Forum Mitra Riset Internasional on August 18, 2020.

the implementation of transparent and supportive international research partnerships.

- Pak Bambang Irawan, Pak Anas Fauzi, Ibu Rosyani and Ibu Leti Sundawati – counterparts of *EFForTS* – participated at this year's meeting (Picture 20).

Enjoy reading!

Prof. Dr. Stefan Scheu
(Speaker of EFForTS)

Prof. Dr. Dodik Ridho Nurrochmat
(Speaker of the Indonesian University Consortium)

I. Mid-term project & research progress – Highlights 2020–2022

1. Research acivities of groups A, B, C, Z02, Public Relation, INF, and associated projects

Group A

FIELDS OF RESEARCH

- Environmental processes

GROUP COORDINATORS

- Dirk Hölscher, Marife Core (University of Göttingen, UGoe);
- Suria Darma Tarigan (IPB University);
- Muhammad Damris (University of Jambi, UNJA)

A01

TITLE: **Long-term vegetation dynamics, plant phenology and plant-pollinator interactions in rainforest and rainforest transformations in central Sumatra**

TEAM: Principal Investigators: Hermann Behling (UGoe); Supiandi Sabiham, Rika Raffiudin, Nina Djuita (IPB University); Asmadi Saad (UNJA).
Scientific Staff: Svea Lina Jahnk (Doctoral Researcher).
Associated Scientists: Kartika Anggi Hapsari (Postdoctoral Researcher), Chung Nguyen (Doctoral Researcher).

RESEARCH SUMMARY:

Apprehending long-term vegetation dynamics is essential to understand ecological functioning and resilience of ecosystems under disturbance such as the rapidly transformed Sumatran rainforest. Information on phenological responses to anthropogenic and natural alterations at different time scales, as provided by paleoecological and modern palynological approaches helps us to reveal some of the mechanisms behind ecosystem dynamics.

In Phase 3, we continued the paleoenvironmental investigations of key ecosystems in Sumatra with special focus on anthropogenic influences. E.g., the study of Danau

Kecil revealed details on the land use history in Sumatran highlands, including the transition from shifting cultivation to permanent agroforestry. Results show intensive human activities since 200 AD with indicators of dipterocarp agroforestry and forest-like gardening. Meta-barcoding to assess more detailed diversity patterns, is currently implemented (in cooperation with B14). Modern pollen rain studies on the other hand, resulted in significant correlations between vegetation and pollen and spore rain (Fig. 1) and indicate a sound representation of plant diversity in modern pollen rain on a regional scale. Thus, palynological diversity is not only a suitable tool for paleoecological reconstructions, but also to access regional phenological diversity patterns in tropical rainforest and transformation

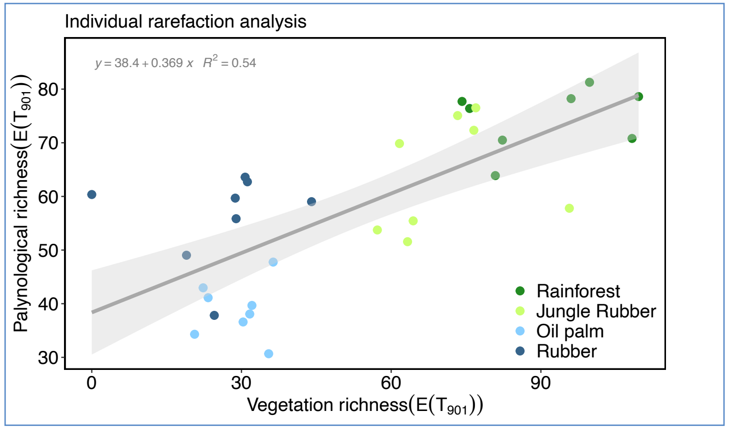


Figure 1. Correlations between vegetation and palynological diversity alongside a land use gradient (rainforest, jungle rubber, rubber, oil palm). Linear regression plot, of plot level (*EFForTS Core Plots*) palynological (y-axis) and vegetation (x-axis) richness, interpolated for a minimum individual count of n=901 (E(T901)).

Picture 21. Installed pollen trap in a rubber plantation core plot.

systems on a spatial and temporal scale. Moreover, preliminary results of the first six years of pollen rain imply interannual phenological phases, following the climatic El Niño Southern Oscillation (ENSO) phenomenon.

We now hope to further approach palynological composition and diversity on a landscape scale, by our contribution to the *Landscape Assessment* project. The study of modern pollen rain and pollen collected by stingless bees (in cooperation with B09 and B14) will help to investigate patterns of landscape heterogeneity in different land use systems (forest, shrubland, rubber, oil palm). We furthermore continue our studies on pollen material from the Oil palm Biodiversity Enrichment Experiment – *EFForTS-BEE* (B11) on intra-annual pollen production and reproductive success.

Moreover, we aim to "upscale" the paleoecological and -environmental approach by conflating the results of analysed sediment cores. Our study on modern pollen rain highlights several taxa, suitable to record and compare environmental changes between cores and alongside a landscape heterogeneity gradient. Consequently, we may be able to access past landscape transformation through time and space.

Challenges of the coronavirus pandemic:

The ongoing Covid-19 pandemic significantly delayed our fieldwork activities and thus obtaining research material such as sediment cores and pollen traps transpired to be difficult. Especially the reinstallation of pollen traps for the *Landscape Assessment* project was challenging.

The two additional cores from Sumatran peat swamp forest could not yet be gathered, thus previously retrieved cores from the submontane area have been chosen to be analysed in the meantime. Fortunately, the capable and autonomous work of our fieldwork assistant, Reza Mardhony, allowed us to retrieve most of the annual and intra-annual pollen trap material. His active support in the installation of traps on new study plots in 2021 allowed our group to participate successfully in the still ongoing *Landscape Assessment* fieldwork. His engagement and the support of all participating subgroups and their fieldwork assistants made this project at all possible. The new integration of the KoBo App, moreover, gave us the possibility to manage and supervise the fieldwork digitally.

A02

TITLE: **Tree and palm water use**

TEAM: Principal Investigators: Dirk Hölscher (UGoe); Herdhata Agusta, Hendrayanto (IPB University).
Scientific Staff: Medha Bulusu (Doctoral Researcher).
Associated Scientists: Alexander Röll (Postdoctoral Researcher), Afik Hardanto (Postdoctoral Researcher, Jenderal Soedirman University), Pallavi (Doctoral Researcher).

RESEARCH SUMMARY:

We study evapotranspiration (ET), which is a central flux in hydrological cycles. It is an important process in climate regulation, and may strongly be affected by land-use change. Established methods for ET assessments include ground-based and space-borne approaches, which can be limited in spatial or temporal resolution, or due to cloud cover. Near-surface operating drones equipped with adequate sensors and a modelling framework may help to bridge gaps. We tested drone-based thermography with subsequent energy balance modelling against well-established ground-based methods, and derived ET characteristics in the mosaic landscape of lowland Sumatra. Comparing the results of the drone-based approach with eddy-covariance measurements (A03) for an oil palm plantation, we observed a very high agreement between the two methods yielding statistical interchangeability. The coverage of spatial heterogeneity was tested using sap flux methods as a reference in forests and oil palm agroforests and likewise yielded convincing results. ET rates predicted by the drone-based approach were similar for oil palm plantations and the rainforest. In a more detailed study in the rainforest (Fig. 2), we found that ET is mediated by site characteristics and season (Fig. 3). In the heterogenous mosaic landscape, we found only minor edge effects between oil palm and forest, and quantified how exposed soil in oil palm plantations and logged forest reduced ET. We contributed to the joint landscape assessment by measuring canopy leaf area index and below-canopy surface tem-

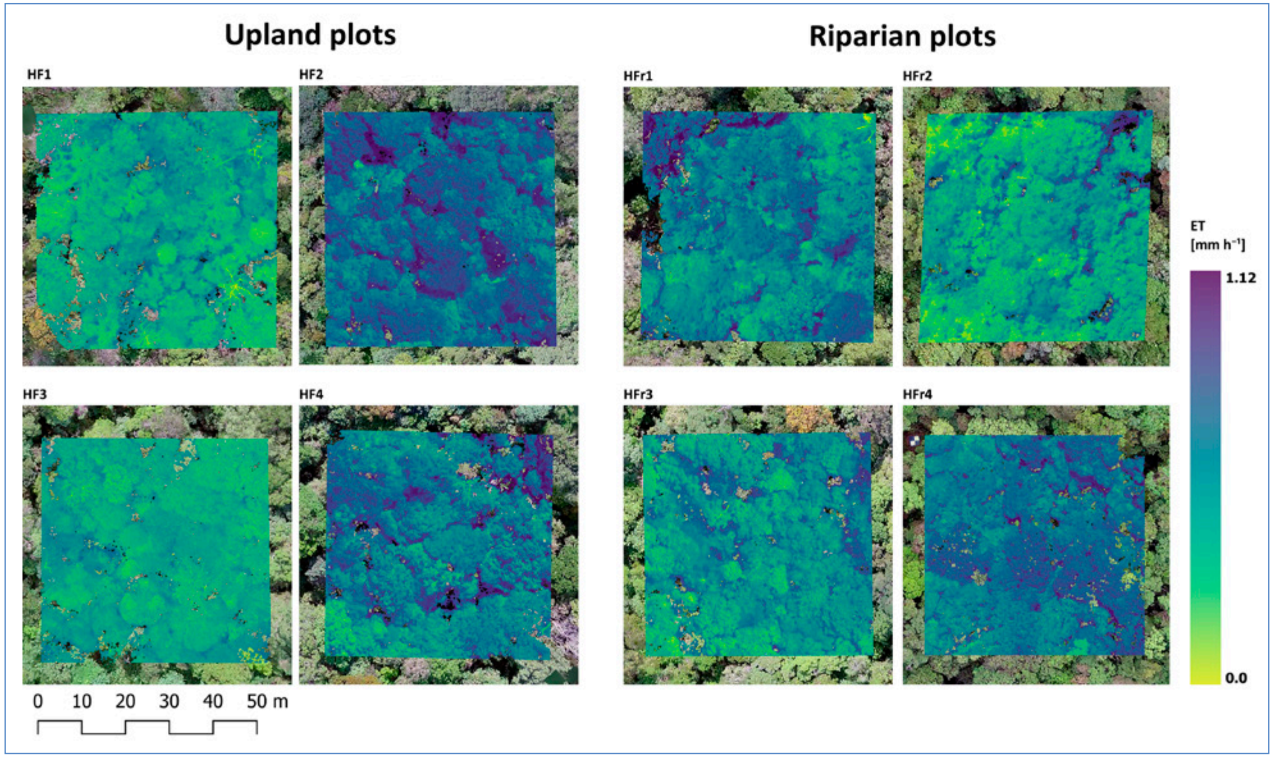


Figure 2. Evapotranspiration (ET) from rainforest canopies derived with a drone-based approach (shortwave irradiance ≥ 700 W m^{-2}; spatial resolution 10 cm per pixel).

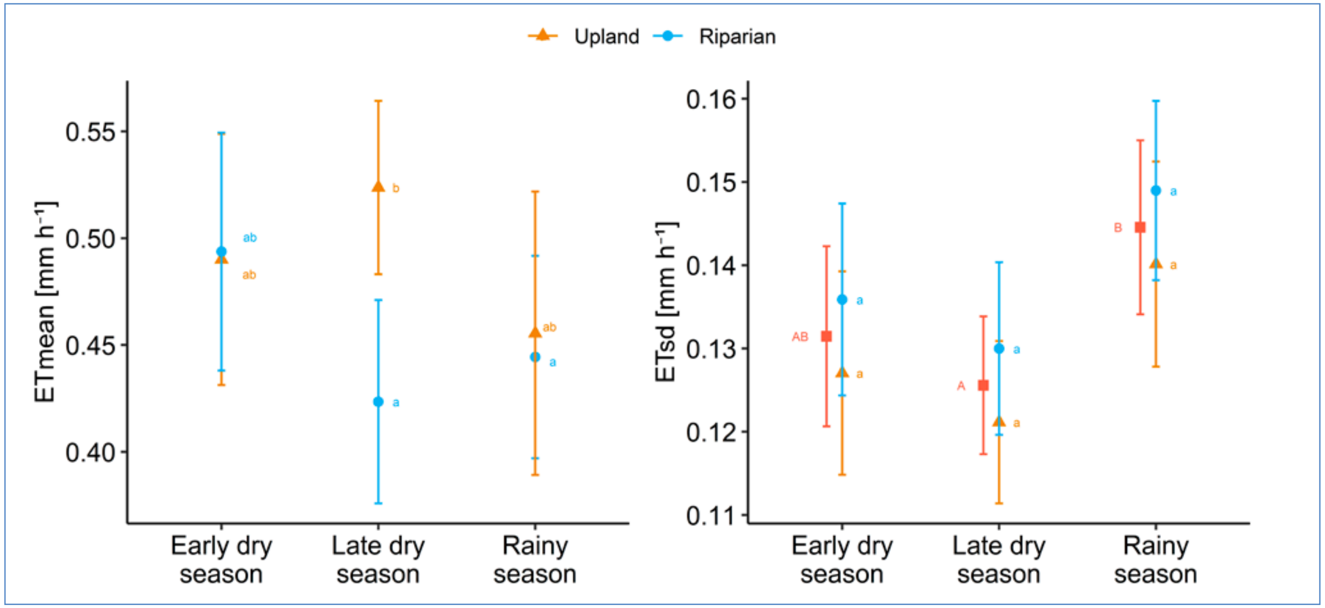


Figure 3. Linear mixed effects models (LMMs) were used to analyse the among-site (ETmean model; left image) and the within-site ET variability (ETsd model; right image) with site location (riparian, upland), season and solar irradiance as predictors. Dots and error bars represent estimated marginal means and the ± 95% confidence based on the LMMs. The dots of the ETmean model represent interaction effects between season and site. For the ETsd model, seasons as well as sites within each season are compared. Means not sharing any letter are significantly different by the Tukey-test at the 5% level of significance.

peratures (vegetation, soil, black-and-white chessboard, hijab and cap). We are planning to continue our work by (a) extending these studies to *EFForTS-BEE* and *EFForTS-OPMX* and (b) to analyse surface temperatures and ET at the landscape scale. Thereby, our studies shall contribute to syntheses addressing trade-offs between land-use change and ecosystem services.

A03

TITLE: **Understanding land-atmosphere exchange processes in land-use transformation systems**

TEAM: Principal Investigators: Alexander Knohl, (UGoe), Tania June (IPB University), Dodo Gunawan (Badan Meteorologi Klimatologi dan Geofisika, Indonesia, BMKG), Abdul Rauf (University of Tadulako, UNTAD).
Scientific Staff: Christian Stiegler (Postdoctoral Researcher).
Associated Scientists: Jonathan Jürgensen (Doctoral Researcher)
Technical Staff: Marek Peksa, Edgar Tunsch.

RESEARCH SUMMARY:

We performed a rapid assessment of microclimate and meteorological conditions across 120 plot locations in the tropical lowlands of Jambi province to study land-use intensity gradients and spatial small-scale climate variability between lowland tropical rainforest, oil palm monoculture, rubber monoculture and agroforestry systems, and fallow shrublands. During the period June to November 2021, we used mini-meteorological stations to monitor the microclimate of each plot location. Preliminary results show that forests and fallow shrublands are generally cooler, wetter and receive lower below-canopy radiation compared to agricultural systems and open land (Fig. 4).

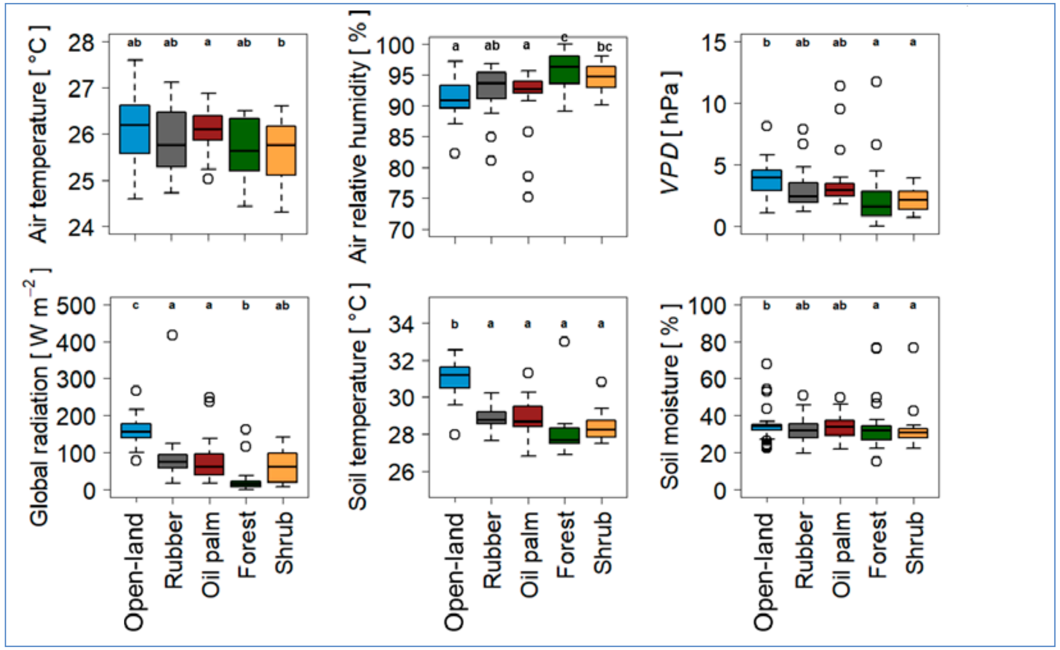


Figure 4. Boxplots of meteorological and environmental parameters at the different land-use systems. Different lower-case letters indicate a significant difference of the respective parameter among the different land-use systems (Tukey's HSD test).

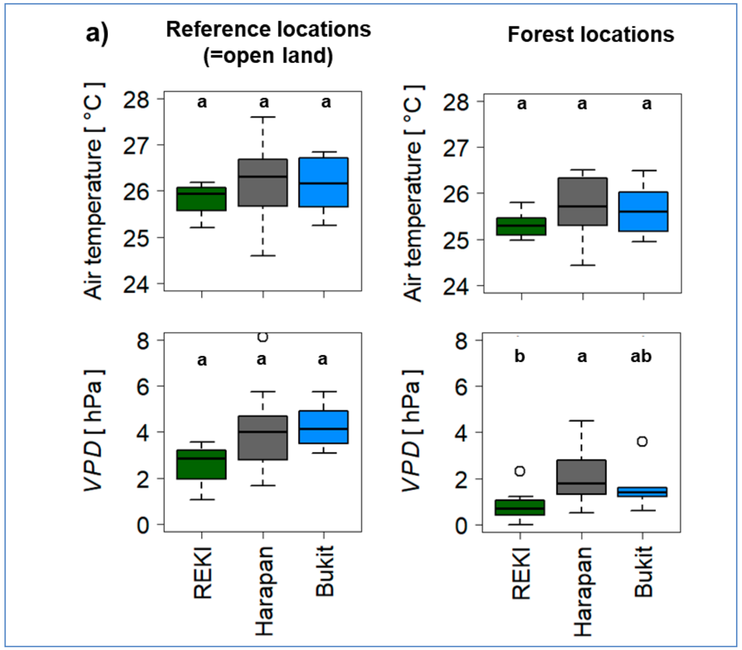
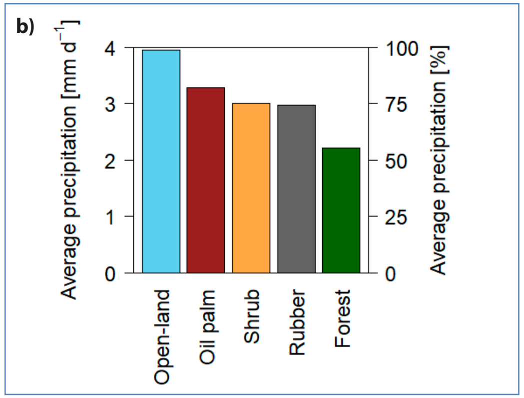


Figure 5. a) Boxplots of air temperature and vapour pressure deficit (VPD) of open land and forest locations in forest-dominated (REKI) and mixed-land (Harapan and Bukit) systems. Different lower-case letters indicate a significant difference of the respective parameter among the different land-use systems (Tukey's HSD test). b) Average below-canopy precipitation among the different land-use systems.

Forests show a strong capacity to buffer high levels of open-land air temperature and atmospheric vapour pressure deficit (VPD) variability by, on average, 1.7 °C and 6.4 hPa, respectively, while oil palm showed very little buffering capacities (0.2 °C and 2.2 hPa). At a regional scale, mixed land-use systems that consist of plantations, forests and agroforestry systems, tend to be slightly warmer (+ 0.36 ± 0.18 °C) and drier (+ 1.47 ± 0.52 hPa VPD) compared to forest-dominated land-use systems (Fig. 5a). Within the mixed land-use systems, forests tend to be drier (+ 1.05 ± 0.41 hPa VPD) while below-canopy temperature remains similar (+ 0.38 ± 0.34 °C) compared to forests in the forest-dominated land-use systems. Interception is an important component in the hydrology of the studied forest locations, with approx. 66 % of precipitation being intercepted, while at fallow shrubland, rubber and oil palm locations, only 24, 25 and 17 %, respectively, of



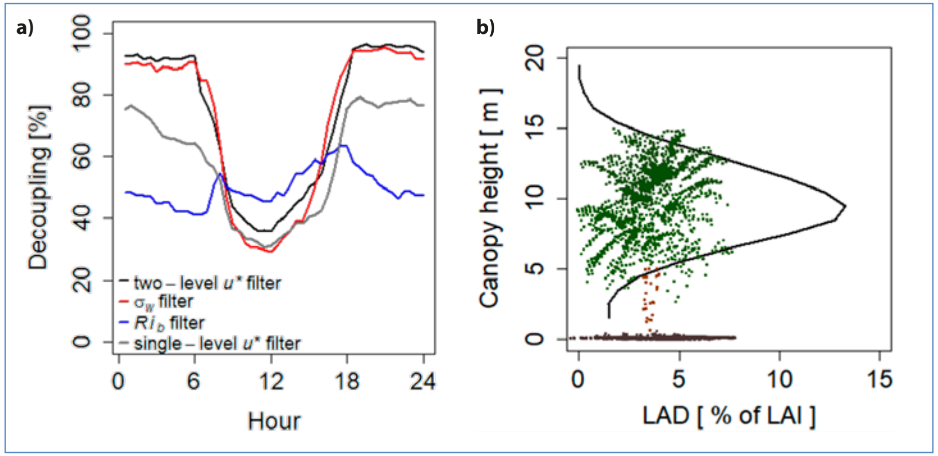


Figure 6. a) Diel percentage of decoupling events according to the respective filtering approach. b) LiDAR-derived leaf area density (LAD, % of leaf area index) and 2D point cloud representation of an oil palm.

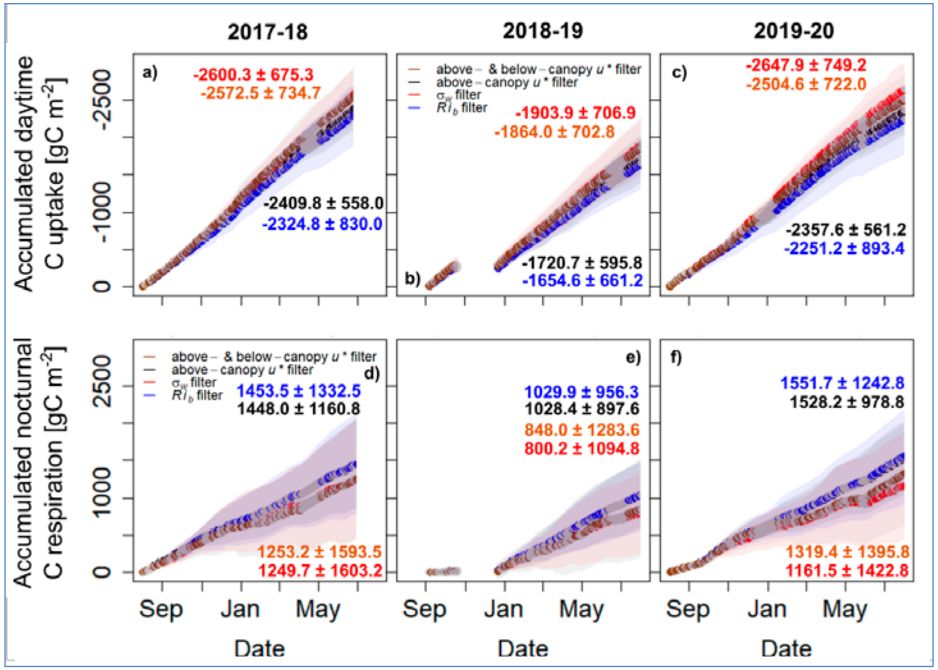


Figure 7. Daytime (06:30-18:00 h local time) accumulated carbon ± uncertainty and nocturnal accumulated carbon respiration ± uncertainty during a), d) the first year of study (August 2017-July 2018), b), e) the second year of study (August 2018-July 2019), and c), f) the third year of study (August 2019-July 2020). Due to power failure, no data is available for August 2018 and from November to late December 2018. Grey lines show gap-filled data. Shaded areas represent the uncertainty of the respective gap-filling method. The red colour represents σ_w filter, brown colour represents two-level u* filter, black colour represents single-level u* filter, and blue colour represents Ri_b filter.

precipitation was intercepted (Fig. 5b). Overall, our preliminary results show that there is high variability in meteorological conditions, even within the same micro-region or land-use type.

Further, we investigated eddy covariance (EC)-based CO_2 flux measurements, wind and micrometeorological patterns, and LiDAR-derived terrain and canopy structure in a mature commercial oil palm plantation (canopy height approx. 15 m) in the tropical lowlands of Jambi province, Sumatra, Indonesia (PTPN 6, Batanghari unit). Over 3 years, we assessed the strength of turbulent and thermal mixing and tested four different flux filtering methods to determine decoupling, i. e. (i) above- and (ii) below-canopy friction velocity (u*), (iii) above- and below-canopy standard deviation of the vertical wind (σ_w), and (iv) bulk Richardson number (Ri_b). Our results show that decoupling is a common phenomenon in this plantation, with the two-level filters of σ_w and u* being most sensitive in its determination, showing ~93 % nocturnal decoupling (Fig. 6a). Decoupling is driven by the oil palm canopy structure, which develops a marked blocking layer at ~10 meters above the ground (Fig. 6b), high frequency of calm weather conditions, inverse temperature gradients and a terrain slope of 3° which was enough to create a thermally-induced drainage flow. Filtering CO_2 flux data based on the applied approaches challenged estimations of the plantation's CO_2 balance due to high uncertainties in nocturnal respiration rates which could not be reduced by adding storage components to the measured fluxes (Fig. 7). These results highlight the importance of additional below-canopy CO_2 flux measurements, especially in such a weak-wind and dense-canopy tropical environment.

Challenges of the coronavirus pandemic:

The *Landscape Assessment* (LA) campaign had to be postponed from 2020 to 2021. In 2021, the LA was successfully conducted by our local assistants and local CRC 990 teams. At our main site in PTPN 6 oil palm plantation, we maintained most of our existing measurement infrastructure. However, we were not able to install our planned automatic soil chamber system nor the sun-induced fluorescence (FLOX) system. Since these systems are highly sensitive and need installation through our Göttingen-based trained technician, we were not able to install them due to travel restrictions. These activities had to be postponed until further notice.

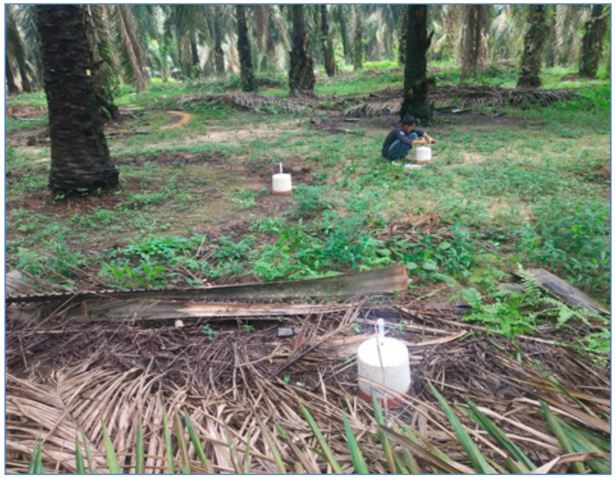
A05

TITLE: **Optimizing nutrient management in oil palm plantations and upscaling greenhouse gas fluxes from plot to a rainforest-transformation landscape**

TEAM: Principal Investigators: Marife D. Corre, Edzo Veldkamp (UGoe); Muhammad Damris (UNJA); Sri Rahayu Utami (University of Brawijaya, UB); Aiyen Tjoa (UNTAD).
Scientific Staff: Najeeb A. Iddris (Postdoctoral Researcher).
Asscociated Scientists: Guantao Chen (Doctoral Researcher).

RESEARCH SUMMARY:

Intensive management practices in large-scale oil palm plantations can slow down nutrient cycling and alter other soil functions. Thus, in Phase 2 of the project, we used a full factorial field experiment of two fertilization levels × two weeding practices to assess the effects of conventional vs. reduced fertilization rates and herbicide vs. mechanical weeding on gross rates of soil N-cycling and soil fertility (Formaglio *et al.*, 2021). We also compared the typical management zones characterizing large-scale plantations: palm circle, inter-row and frond-stacked area. We used the ^{15}N pool dilution technique on intact soil cores with in-situ incubation. Reduced and conventional management showed comparable gross soil N-cycling rates; however, there were stark differences among management zones (Fig. 8). The frond-stacked area had higher soil N-cycling rates and soil fertility than inter-row and palm circle. Microbial biomass was the main driver of the soil N cycle, attested by its high correlation with gross N-cycling rates. The correlations of microbial N with extractable C, extractable organic N, soil organic C and total N suggest that microbial biomass was mainly regulated by the availability of organic matter. Mulching with senesced fronds enhanced soil microbial biomass, which promoted nutrient recycling and thereby can decrease dependency on chemical fertilizers.



Picture 22. The A05 team measuring soil greenhouse gas fluxes in the oil palm plantation

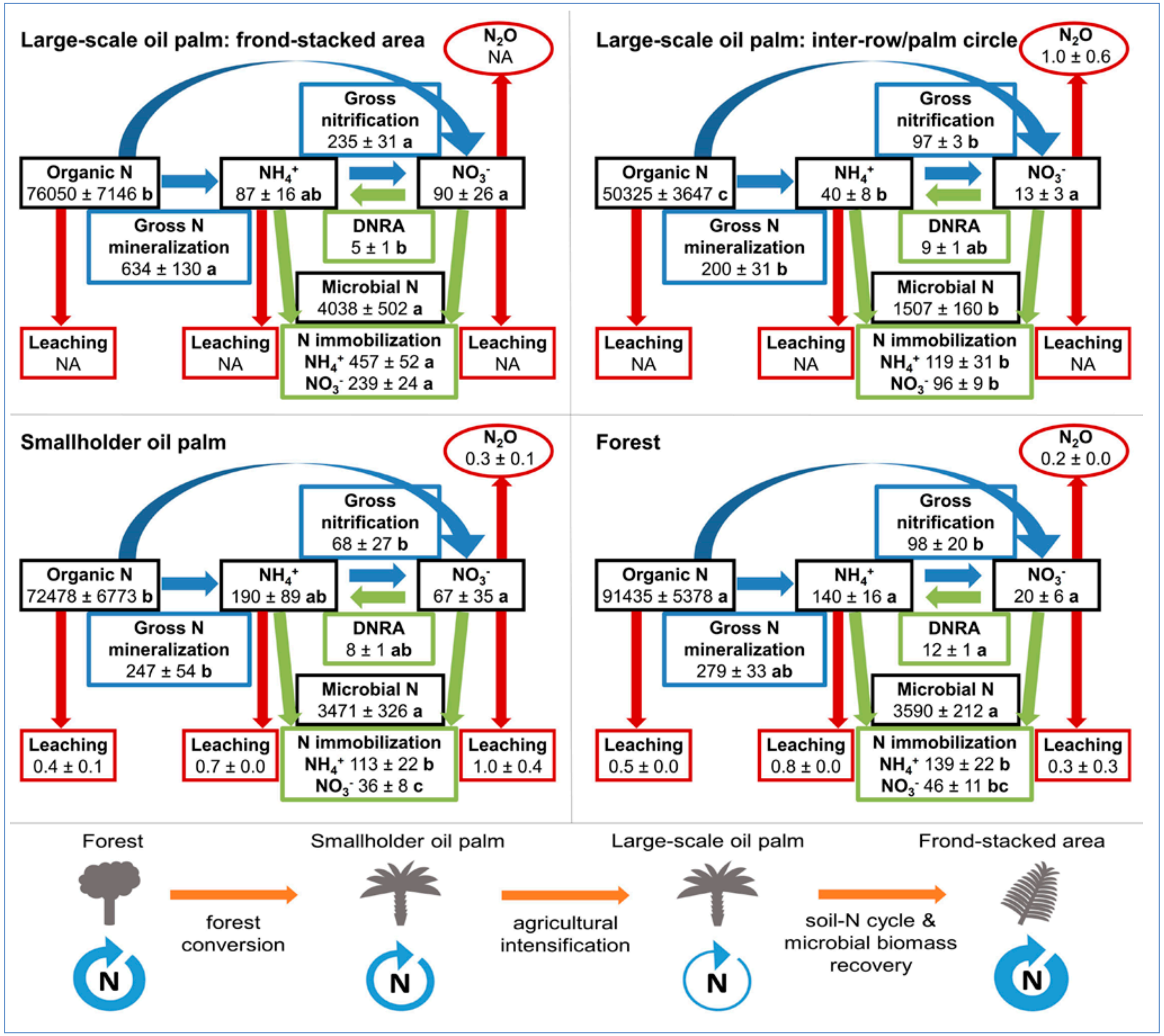


Figure 8. Mean (± SE, n = 4 plots) gross rates of soil N cycling (mg N m^{-2} d^{-1}), and N pools (mg N m^{-2}, in black boxes), measured in the top 5-cm depth, in large-scale and smallholder oil palm plantations and lowland forest, all on loam Acrisol soils in Jambi, Indonesia. Blue arrows represent soil N production processes, green arrows represent soil N retention processes, and red arrows represent soil N losses. For each parameter, different letters indicate significant differences among land uses (one-way ANOVA with Tukey HSD or Kruskal–Wallis H test with multiple comparison extension at $P \leq 0.05$).

In Phase 3, we investigated the effect of management on soil greenhouse gas fluxes. Thus, soil carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) fluxes were measured monthly for a year (2019–2020) in the three management zones in each plot using vented static chambers. The results showed no differences in soil greenhouse gas fluxes between reduced and conventional management but clear differences among management zones (Fig. 9). Frond-stacked area, with high soil organic C and low soil bulk density, had the highest soil CO_2 emission and soil CH_4 uptake. Palm circle, with fertilizer application and high soil bulk density, had the highest soil N_2O emission and lowest soil CH_4 uptake. Inter-row area, with low soil organic C and no direct fertilizer application, had the lowest soil CO_2 and N_2O emission. Our results indicate that the inherent management zones in oil palm plantations should be spatially represented for accurate quantification of soil greenhouse gas fluxes.

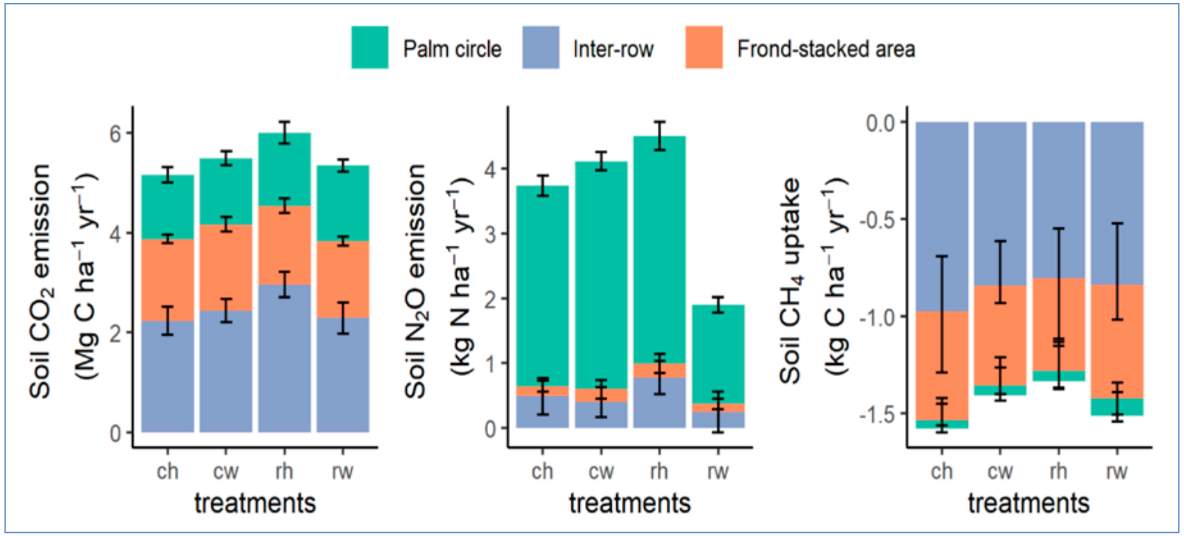


Figure 9. Mean (± SE, $_n$ = 4 plots) soil CO_2, N_2O and CH_4 fluxes weighted by the areal coverages of the palm circle (18%), inter-row (67%), and frond-stacked area (15%) under different fertilization and weeding treatments in an ≥18-year old, large-scale oil palm plantation, Jambi, Indonesia. ch: conventional fertilization – herbicide weeding, cw: conventional fertilization – mechanical weeding, rh: reduced fertilization – herbicide weeding, rw: reduced fertilization – mechanical weeding.

References:

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Formaglio G, Veldkamp E, Damris M, Tjoa A, Corre MD (2021) Mulching with pruned fronds promotes the internal soil N cycling and soil fertility in a large-scale oil palm plantation. Biogeochemistry 154: 63–80. *https://doi.org/10.1007/s10533-021-00798-4*

A07

TITLE: **Spatio-temporal scaling of the impacts of land-use and climate change in land transformation systems in Indonesia**

TEAM: Principal Investigators: Alexander Knohl, Edzo Veldkamp (UGoe); Tania June, Surya Tarigan (IPB University).
Scientific Staff: Ashehad Ali (Postdoctoral Researcher).
Asscociated Scientists: Yuanchao Fan, Fernando Moyano (Postdoctoral Researcher), Rahmi Ariani (Doctoral Researcher, UGoe), Ummu Ma'rufah (IPB University).

RESEARCH SUMMARY:

Plant physiological responses could alter in the lowland areas of the tropics if there are significant changes in the environment, e.g., those that are due to El Niño-Southern Oscillation (ENSO). ENSO brings warm, dry, and sunny conditions to Indonesia. During dry seasons leaf-fall and seed production increase, and under warming, plants have more fruiting than leafing. Therefore, in the first part of Phase 3, we investigated how forests, oil palm, and rubber plant functional types (PFTs) in the Community Land Model (CLM) respond to inter-annual variation in climate (local-scale) that included the 2015 ENSO year. CLM predicted a clear dif-

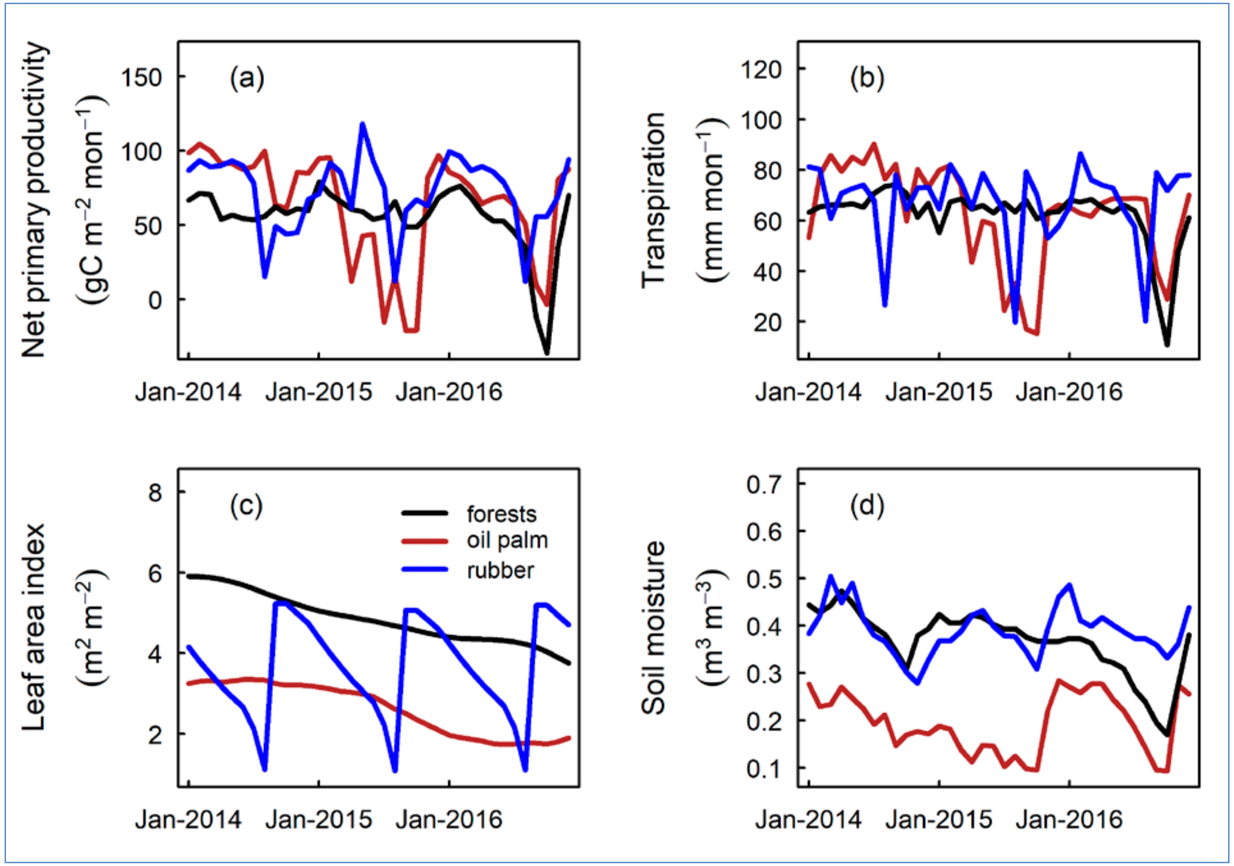

Figure 10. Monthly trends of net primary productivity (a), transpiration (b), leaf area index (c), and soil moisture (d) of tropical evergreen forests, oil palm and rubber plants simulated by the CLM. Figure is taken from Ali *et al.* (unpublished data).

ference in monthly net primary productivity, transpiration, leaf area index, and soil moisture for forests, oil palm, and rubber PFTs (Fig. 10a-d). When the downscaled climate data (CRUN-CEPv7; NCEP reanalysis and Climate Research Unit (CRU TS Version 4.04) climatology at 0.5 resolution) drove CLM, the magnitude and dynamics of its predictions for net primary productivity, transpiration, leaf area index, and soil moisture for forests, oil palm, and rubber PFTs matched very well (results not shown here) with the CLM outputs that was driven by the local-scale climate. This gives us high confidence that the downscaled climate data can be used for more extensive spatial simulations such as those beyond the village level (5 km x 5 km) and cover greater landscapes within the Jambi province's lowland areas. CLM also predicted a sizeable year-to-year variation for the same variables for oil palm and rubber but little for forests (Fig. 10a-d).

Tropical plants hold enormous plant functional diversity, including diversity in leaf-photosynthetic capacity (Leaf traits). Leaf trait data can investigate how leaf photosynthetic capacity scales with leaf N, P, and leaf mass per area. It can also determine potential leaf strategies and parameterize land surface models. As part of the landscape assessment, we measured leaf photosynthetic capacity (in-situ) on leaves from the upper part of the canopy of 46 plant species from the forest, oil palm, rubber, and shrub land-uses. We found that within a land-use type, light- and CO_2- saturated photosynthetic capacity varied more than light-saturated photosynthetic capacity (Fig. 11c vs. a). We also found that species have a similar carboxylation capacity and electron transport rate within a land-use type (Fig. 11 b vs. d); this suggests considerable natural variation within as well as among species.

In the next part of Phase 3, we will (a) quantify the impacts of the land-use change and climate change on biogeochemical cycles of oil palm and rubber plantations on village-level and landscape-level scales by using the newly developed modules for oil palm and rubber in the latest version of CLM (CLM5.0), and b) investigate the influence of species composition, soil fertility and plantation age on the photosynthetic capacity and foliar nutrient concentrations on large spatial scale. CLM simulations will also be informed by the land-use change data (predicted by the *EFForTS-ABM* model) because CLM cannot predict land-use change, e.g., CLM cannot predict which forests pixels will be converted to oil palm in the future. LiDAR data will be used to drive CLM and evaluate CLM. In the context of land-use change, our study will provide, for the first time, the estimated fluxes and stocks of carbon, water, and nitrogen at the village scale that integrated socio-economic and LiDAR data. The downscaled climate data will allow CLM to better predict the yield of oil palm and rubber plantations under future climatic conditions at the landscape level. From the photosynthetic capacity data-sets, we will gain insights into how realistic the physiological parameters are within a plant functional type, how stacking of carbon in leaves varies among coexisting species, and use this information to constrain CLM.

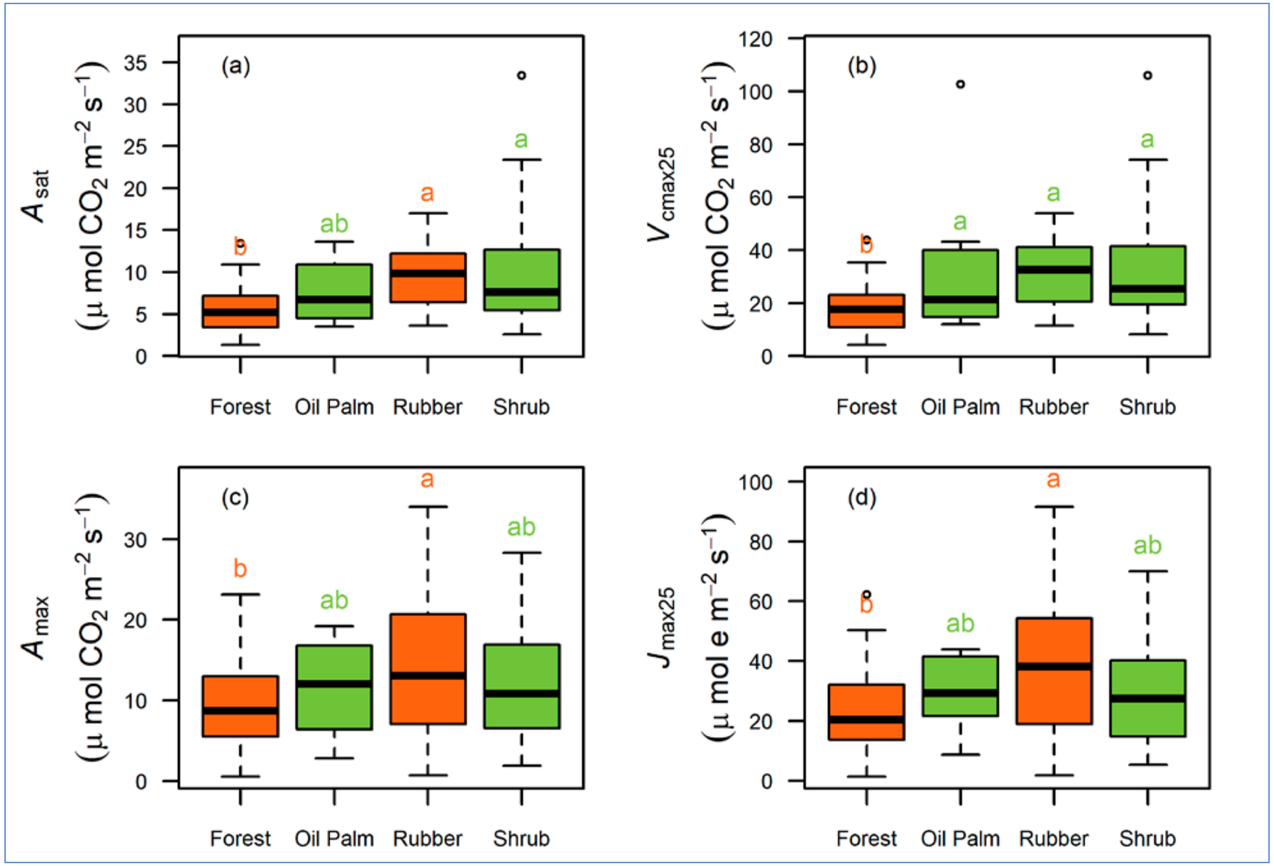

Figure 11. Light saturated (a) and light- and CO_2-saturated (c) photosynthetic rates of plant species from forests, oil palm, rubber and shrub land-uses. Maximum carboxylation capacity (b) and maximum electron transport rates (d) of plant species from the same land-uses are also shown. Different letters indicate significant differences between groups (Tukey test, $P < 0.05$). Figure is taken from Ali *et al.* (unpublished data).

As for capacity building, A07 Knohl/Veldkamp contributes to educating an Indonesian doctoral researcher (Rahmi Ariana) funded by Indonesia Endowment Fund for Education (LPDP) in Göttingen from 2016 to 2020, with the counterpart Tania June acting as external supervisor. The PI Alexander Knohl also co-supervises an Indonesian Master's student (Ummu Ma'rufah) at IPB University, supervised by counterpart Tania June. Ummu has visited Göttingen for modeling training with the support of ABS funds.

Challenges of the coronavirus pandemic:

A master's thesis that quantifies leaf-gas exchange rates of oil palms under different nitrogen fertilizer management regimes (reduced herbicide and fertilizer application) had to be cancelled. The master student then measured instantaneous photosynthesis on various leaves on a branch at a Leinefelde site in Germany and tested it with a leaf photosynthesis model based on Farquhar, von Caemmerer & Berry.

The *Landscape Assessment* (LA) campaign was postponed from 2020 to 2021. So in 2021, part of the LA was successfully conducted by our local assistants in collaboration with other subgroups in LA. A07 hopes to finish the LA campaigns by the end of 2022.

Group B

FIELDS OF RESEARCH

- Biota and ecosystem services

GROUP COORDINATORS

- Holger Kreft, Martyna Kotowska (UGoe);
- Leti Sundawati (IPB University);
- Upik Yelianti (UNJA)

B04

TITLE: **Plant productivity and belowground resource partitioning in gradients of tropical land-use intensity and tree species diversity**

TEAM: Principal Investigators: Christoph Leuschner, Martyna Kotowska (UGoe); Triadiati Antono (IPB University).
Scientific Staff: Sasya Samhita (Doctoral Researcher).
Field Assistants: Jamaluddinsyah, Melky Susandro; Fajar Septiawan; Amanatun Nisa, Syahbarudin

RESEARCH SUMMARY:

Tropical rainforest conversion is associated with severe losses in species and functional diversity. We aim on linking belowground and aboveground functional trait diversity and assess the importance of functional diversity for plant productivity across different land-use systems namely forest, shrubland, oil palm and rubber plantations. Working in a joined vegetation team the *Landscape Assessment* campaign was conducted together with B06 and B14 and was successfully completely yielding a total of 102 sampled plots (Picture 23c). Focusing on aboveground plant biomass and functional trait diversity at the landscape scale, we have conducted tree structural measurement, canopy cover and light spectrum determination and calculated aboveground biomass (Fig. 12).

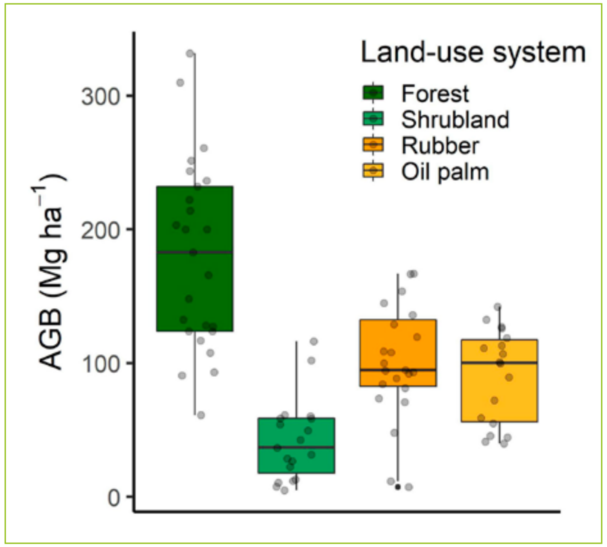

Figure 12. Preliminary results of the *Landscape Assessment*: Aboveground biomass (Mg ha^{-1}) of four tropical land-use systems namely forest, shrubland, rubber and oil palm plantations.

To investigate fine root functional traits, we started to conduct a species-specific root campaign in the biodiversity enrichment experiment (*EFForTS-BEE*) which will be continued in the core plots of different land-use systems. To estimate the fine root production and to determine patterns of coexistence, competition, and drivers of species interactions in belowground assemblages, we have installed 162 ingrowth cores in the *EFForTS-BEE* which will be re-sampled in next six month (Pictures 23 a and b). Additionally, we have installed

90 mini-rhizotrons to determine root birth, death and turnover rates and compare the results to the outcomes of the ingrowth core study. To estimate fine root biomass, we will be conducting fine root inventory. We will also investigate spatial resource partitioning in the plantation to understand the resource uptake and potential asymmetry of root competition between palms and dicot trees using stable isotope technique. Regarding root water uptake we plan to study the root competition intensity and the degree of asymmetry between oil palms and studied dicot trees. The method includes sap flux techniques using miniature sap flow gauges on exposed roots of competing oil palms and different dicot tree species in moist and drier periods. The study may thus lead to a better understanding of below-ground functioning and resource acquisition.

Challenges of the coronavirus pandemic:

Due to pandemic related restrictions in traveling our planned fieldwork had to be restructured substantially and our PhD candidate, Sasya Samhita, could not yet travel to Indonesia in person. The *Landscape Assessment* could be successfully completed with the involvement of a local fieldwork team, which was trained and prepared by detailed tutorials and video material and conducted the fieldwork in constant exchange with the researchers in Germany using online-based platforms (KOBO-Tool, Slack). Furthermore, the preparation of the campaigns for fine root productions, biomass and species-specific traits could be completed, the material was installed in the field and all the equipment and sensors for sap flux measurements are prepared and calibrated in the Göttingen labs.

Picture 23. a) Minirhizotrons and fine root ingrowth cores installed in the *EFForTS-BEE* plots. b) Field assistants installing ingrowth cores and minirhizotrons. c) *Landscape Assessment* vegetation team (f.l.t.r. Ojan, Melky, Edo, Ihsan, Wulandari, Sari, Nadia, Jamal, Udin).

B06

TITLE: **Taxonomic, functional, phylogenetic, and biogeographical diversity of vascular plants in rainforest transformation systems on Sumatra (Indonesia)**

TEAM: Principal Investigators: Holger Kreft (UGoe); Sri Sudarmiyati Tjitrosoedirdjo (IPB University, SEAMEO-BIOTROP).
Scientific Staff: Fabian Brambach (Postdoctoral Researcher).
Associated Scientists: Nathaly Rokssana Guerrero Ramírez (Postdoctoral Researcher), Wendy A. Mustaqim (Universitas Samudra, Langsa, Aceh)
Field and lab assistants: Edo Mauliarta, M. Ihsan, Dian Muh Fauzan, Mei Linda Mardalena, Adhy Widya Setiawan, Wulandari

RESEARCH SUMMARY:

Plants as main primary producers and structural components are essential for resilient terrestrial ecosystems while providing manifold contributions to humans. Subproject B06 Kreft continues to investigate changes in different dimensions of plant diversity from local to landscape scales. Results will contribute to solid assessments of economic-ecological trade-offs and the development of science-based solutions for sustainable land-use and biodiversity conservation.

Our main activities in the past two years were related to the *EFForTS Landscape Assessment* (LA), the comprehensive landscape-scale assessment of ecological and socioeconomic functions of tropical lowland rainforest and main agricultural land-use types. Fabian Brambach was part of the general coordination team of the LA. Together with Martyna Kotowska (B04) and Carina C. M. Moura (B14), he planned and supervised the fieldwork of the fully integrated LA vegetation team, consisting of field assistants of all three SPs. The vegetation team collected data on different facets – taxonomic, functional, and phylogenetic – of tree and understorey plant diversity. A special focus was given to the presence of alien plant species, whose biomass increased with stronger human influence as predicted by former smaller-scale studies (Fig. 13a). Furthermore, we used a mobile LiDAR device to record 3D laser scans (Picture 24) of all LA plots to infer parameters of vegetation structure and their relation to multi-taxon diversity. The LA vegetation fieldwork campaign was finished in April 2022 and data analysis is currently under way. The concept of the interdisciplinary LA, planned and

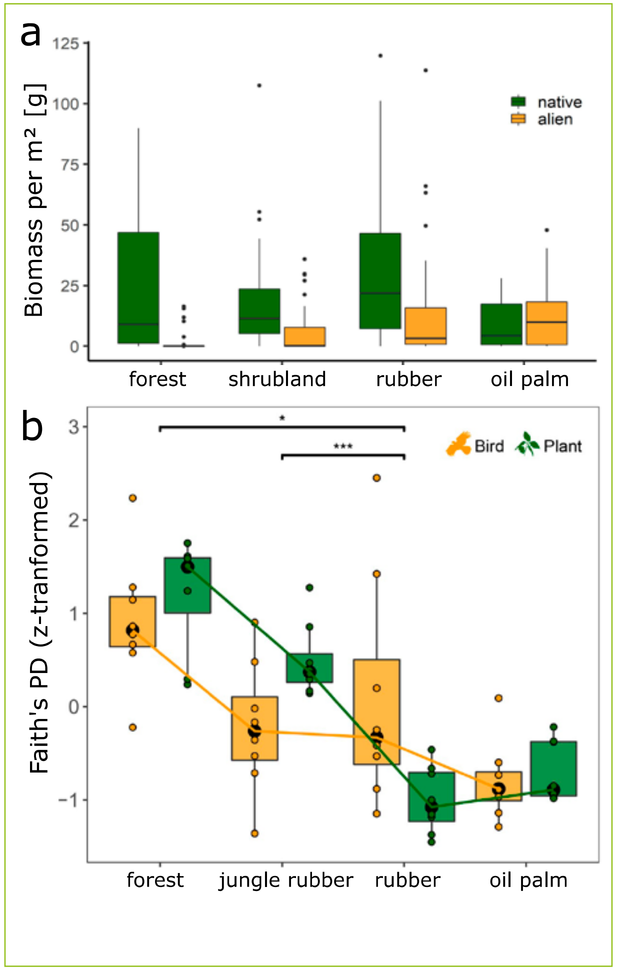

Figure 13. Land-use change leads to higher biomass of alien species (a) and decline in phylogenetic diversity of vascular plants and birds (b). Panel a) shows the harvested biomass per m^2 in 102 Landscape Assessment plots separated into native (green) and alien (orange) plant species. Panel b) shows the z-tranformed Faith's Phylogenetic Diversity for birds (orange) and vascular plants (green) in 32 *Core Plots*.

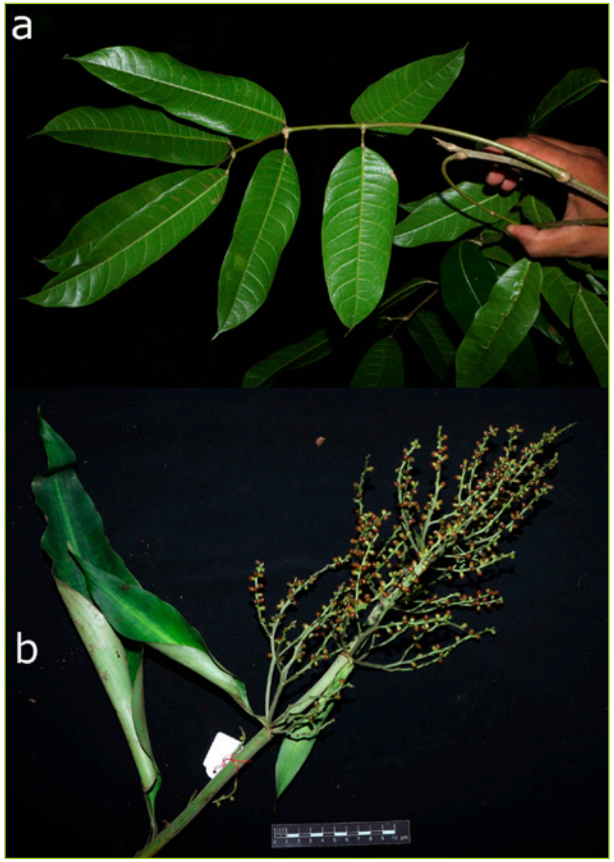

Figure 14. Two undescribed species of vascular plants found in Landscape Assessment plots with forest vegetation: a) *Dacryodes* sp. nov. (*Burseraceae*), a mid-sized to large tree and b) *Hanguana* sp. nov., a large understorey herb of primary forest.

Picture 24. The *Landscape Assessment* vegetation team (SPs B04, B06, and B14) and some plants collected during the Landscape Assessment vegetation team.

coordinated remotely and executed mostly by field assistants due to the Covid-19 pandemic, together with lessons learned and preliminary results will be compiled in a paper project led by Fabian Brambach.

The second main scope of our recent activities was the development of a synthesis analysis on multi-taxon phylogenetic diversity and its relation to land-use change. For this effort, we took a major step forward with the Master thesis of Duc Anh Le, who used plants and birds as example taxa and showed that the phylogenetic diversity of both groups declines with the conversion of tropical rainforest to rubber and oil palm plantations (Fig. 13b).

During the LA fieldwork, we found several plant species, which are most likely unknown to science so far. Together with taxonomists from Indonesia, UK, and Malaysia, we are currently planning the formal description of these species (Fig. 14). All potentially new species were found in forest plots, highlighting the conservation importance of the remaining forest fragments in Jambi province.

B08

TITLE: **Structure and functioning of the decomposer system in tropical lowland rainforest transformation systems**

TEAM: Principal Investigators: Stefan Scheu (UGoe); Rahayu Widyastuti (IPB University).
Scientific Staff: Anton Potapov, Valentyna Krashevska (Postdoctoral Researcher).
Associated Scientists: Simin Wang, Zheng Zhou (Doctoral Researchers), Garvin Schulz, Winda Ika Susanti (Postdoctoral Researchers)

RESEARCH SUMMARY:

Subproject B08 focuses on belowground animal and microbial diversity, interactions in soil food webs, and ecosystem functions associated with belowground biota, such as litter decomposition. Since the beginning of the third phase of the project, we showed among others widespread invasion of earthworms across Jambi province and its consequences for soil communities and food webs (Fig. 15), we quantified changes in trophic niches and functional diversity of soil animals following the conversion of rainforest into plantations, and used testate amoebae for reconstruction of past hydrological regimes in Central Sumatra. Current work in collaboration with Z02 focuses on the link between below- and aboveground food webs. With the help of our Indonesian team (Picture 25), we sampled 132 litter and soil samples for analyzing

Picture 25. The Indonesian Landscape Assessment team of B08. From left to right: Bambang, Leonarda, Nico.

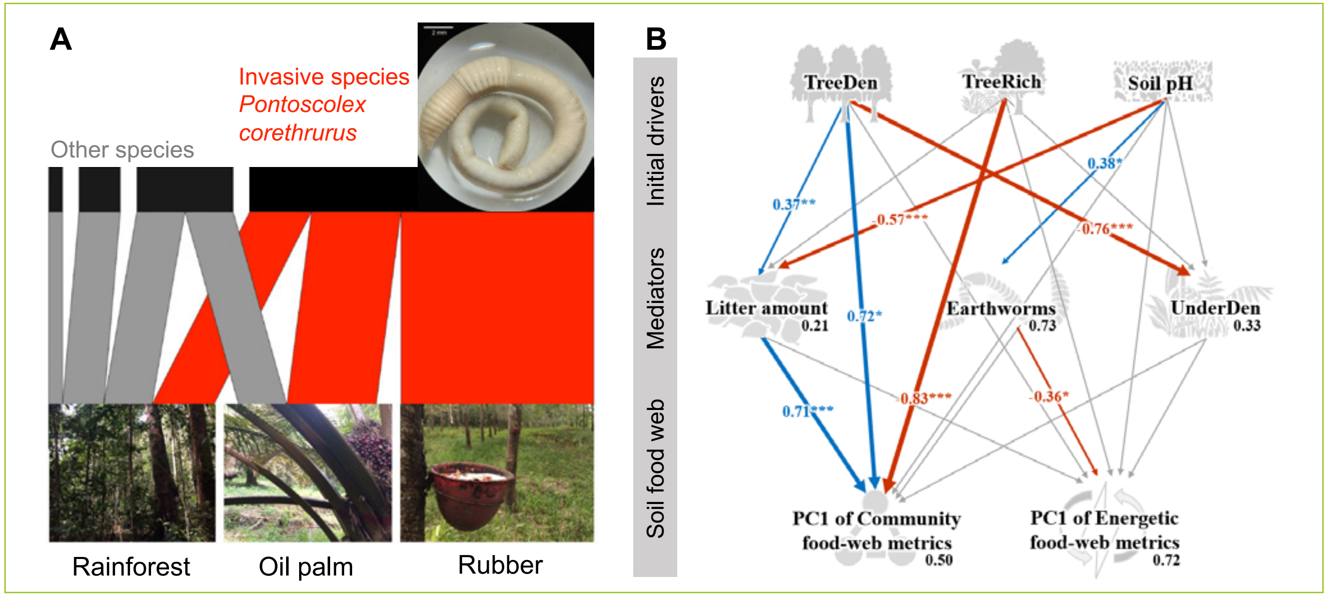

Figure 15. Earthworm invasion associated with the land-use change in Sumatra. Plantations are colonized by the invasive earthworm species *Pontoscolex corethrurus* in lieu with the native earthworm community (A). High abundance of earthworms in plantations and poor leaf litter layer are associated with strong changes in soil food-web structure and energetics; structural equation modelling with blue lines showing positive effects and red lines showing negative effects (B). Based on Potapov *et al.* (2021) and Zhou *et al.* (2022).

microorganisms and fauna in the framework of the *Landscape Assessment*. Further, we installed and retrieved 264 litterbags, with first results showing litter mass loss after 6 months being faster in rainforest and shrubland (ca. 66 % mass loss) than in plantations (ca. 50 %). Currently, we are planning taking samples from the *EFForTS* long-term experiments, *OPMX* and *BEE*. Finally, our Indonesian PhD student, Winda Ika Susanti, has successfully defended her PhD by the end of 2021!

References

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Zhou Z, Krashevska V, Widyastuti R, Scheu S, Potapov A (2022) Tropical land use alters functional diversity of soil food webs and leads to monopolization of the detrital energy channel. eLife 11:e75428. *https://doi.org/10.7554/eLife.75428*

B09

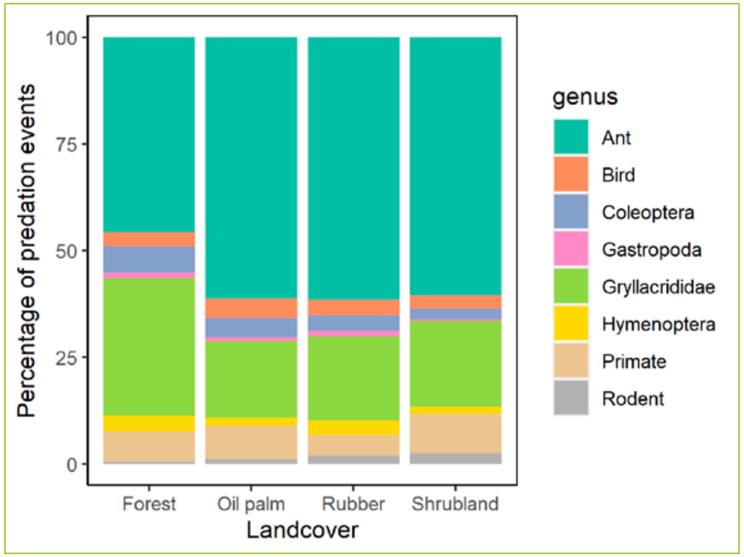
TITLE: **Aboveground biodiversity patterns and processes across rainforest transformation landscapes**

TEAM: Principal Investigators: Catrin Westphal (UGoe); Ingo Grass (University of Hohenheim); Damayanti Buchori, Yeni Mulyani, Windra Priawandiputra, Ellena Yusti (IPB University); Fuad Nurdiansyah (UNJA).

Scientific Staff: Arne Wenzel (Postdoctoral Researcher).

Associated Scientist: Kevin Darras (Postdoctoral Researcher, Westlake University, China)

Field team: Patrick Diaz, Erick Mandelson, Ilham, Sugeng Selviandi, Davig Warisman



RESEARCH SUMMARY:

In subproject B09 we focus on aboveground biodiversity and associated ecosystem functions such as biological control of pest animals.

Research activities in the third phase have so far revolved mainly around the *Landscape Assessment* (*EFForTS-LA*). This large-scale collaborative project, which focused on rapid assessments of many field sites, took place in the Jambi province between May and October 2021. Remotely coordinated by Arne Wenzel (postdoctoral researcher) B09 was heavily involved in organizing the sampling campaign. On the ground, our dedicated field team, led by Ellena Yusti and Patrick Diaz, stayed in the field for many months, recording soundscapes of birds and bats and measuring predation rates and predator diversity by using sentinel prey. The analysis of this data is ongoing, but preliminary results indicate a shift towards more predation by ants in the non-forest systems (Fig. 16). While we will continue working on the data, we will also continue our coordinating efforts with a strong focus on bringing the members and data sets of the *Landscape Assessment* together to tackle multiple synthesis publication projects.

Figure 16. Proportional predator identity between land uses. Predator identity was determined via identification of unique bite-marks left in the plasticine caterpillar after a predation event. Eight different predator groups could be identified, which are indicated by colors.

Picture 26. The B09 field team next to the experimental stingless bee colonies installed underneath a shelter in one of the LA plots (a). The B09 field team on field work in the Bukit Duabelas National Park (b). Construction of one of the beehive shelters (c).

Making use of the *EFForTS-LA* platform, our field team has also recently deployed colonies of the stingless bee Tetragonula laeviceps in a large subset of LA plots (Picture 26 a). We will monitor the performance and foraging behavior of these colonies over a period of 6 months. Data will be analyzed in relation to land use and landscape heterogeneity. This project also involves pollen samples and the assessment of local flower richness (collaboration with A01 and B11). Next to the LA, the B09 team also continued their routine research protocols within the framework of the oil palm experiments of *EFForTS*. In the *EFForTS-OPMX* this involved sound recordings of bird and bats and the collection of flower visiting insects via yellow colored pan traps in March 2020 and 2021. Similarly, in the *EFForTS-BEE* enrichment experiment soundscapes were recorded in November 2020 and 2021 in all sites. Here, we also plan to deploy and monitor stingless bee colonies in the second half of 2022. Furthermore, we plan a detailed assessment of predation potential in the *EFForTS-BEE* sites. Within the framework of at least two Master theses, we aim to measure predation rates via sentinel prey as well as predator diversity using sound recording (birds and bats), beat samples and ant baiting. Presumably, these field works will take place in September and October 2021.

Challenges of the coronavirus pandemic:

As it was the case for most other subprojects the Covid pandemic also impacted B09. First of all, Arne Wenzel could not travel to Sumatra and had to oversee research activities remotely. But thanks to the extensive experience of our field team from the previous phases and their great dedication this turned out to be not an issue. Nevertheless, Covid restrictions still caused delays in logistics and travels. Also most members of our field team infected themselves over the course of the past year. Thankfully everyone recovered without lasting symptoms. And despite these difficulties the team managed to maintain their high spirits and were able to complete most field works as planned.

B10

TITLE: **Landscape-level assessment of ecological and socio-economic functions of rainforest transformation systems**

TEAM: Principal Investigators: Kerstin Wiegand (UGoe); Jann Lay (GIGA Hamburg); Surya Tarigan (IPB University).
Scientific Staff: Sebastian Fiedler (Postdoctoral Researcher), Julia Henzler (Doctoral Researcher).
Associated Scientist: Craig Simpkins (Postdoctoral Researcher), Eyal Goldstein (Doctoral Researcher).

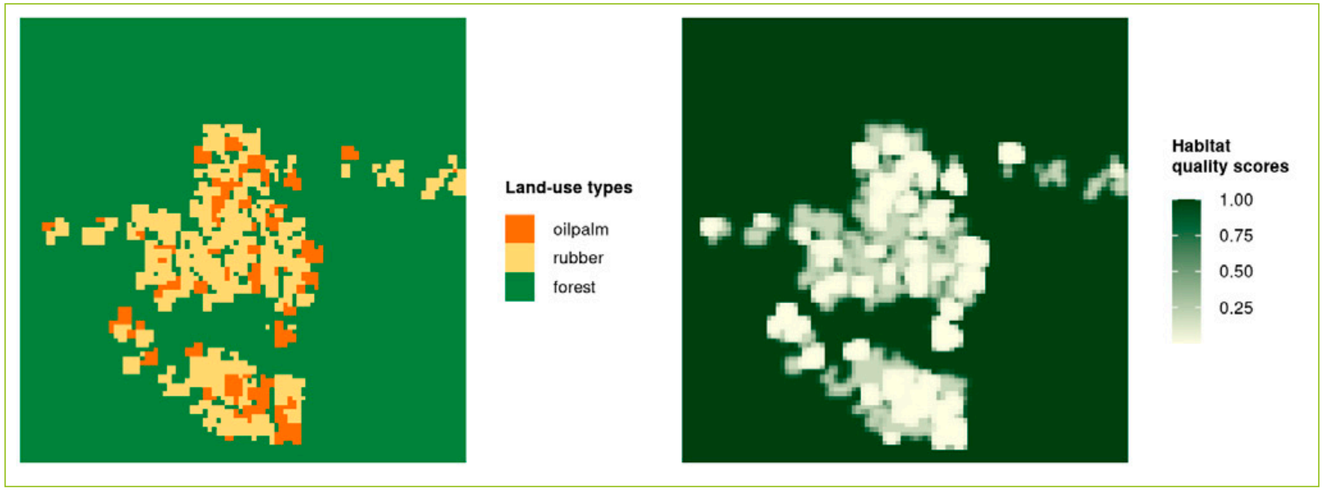


Figure 17. Estimation of biodiversity (habitat quality, right) based on the distribution of human-modified land use and land cover (left).

RESEARCH SUMMARY:

Our spatially explicit and agent-based land use change model, *EFForTS-ABM*, is being extended by further economic and ecological processes allowing a broader and more balanced assessment of ecological and socio-economic functions, and trade-offs among them, across the study region. We extended the model by land market processes allowing for dynamic land selling and buying. In addition, several ecological processes are in the progress of being added. *Biodiversity* can now be quantified (Fig. 17) based on the newly integrated habitat quality module of the model InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs). We are using structural complexity data from subgroup Z02 to parameterize this module. Similarly, the *carbon* module of InVEST is currently being added to *EFForTS-ABM* and parameterized based on the data from subgroups A05 and B06. In addition, statistical models that predict *plant understorey richness* and *arthropod richness* from various environmental variables will be added to the *EFForTS-ABM* model. Furthermore, *biological pest control* can now be quantified for palm oil plantations. We are working on parametrizing this module for rubber plantations based on the B09 data from the landscape assessment. In addition, we are currently summarizing the *EFForTS* findings on how *hydrological functions* are being shaped by land use types and transformation, and aiming at integrating those findings into the model. To estimate even further ecological functions such as soil nutrient contents, the Community Land Model adapted to the study region by group A07 is in the progress of being linked to *EFForTS-ABM*. Based on the findings from *EFForTS-BEE* and *EFForTS-OPMX*, we are implementing environmentally friendly management options that complement the conventional management options currently available in *EFForTS-ABM*.
In addition to extending *EFForTS-ABM*, other tools are either furtherly used or were newly developed. With our artificial landscape generator, *EFForTS-LGraf*, spatially explicit maps of the landscape portfolios (generated by the C12 group) are created and ecological implications of the different landscapes estimated by using a functional connectivity model (Fig. 18). We finalized the R package spectre (Simpkins *et al.*, under review) that allows us

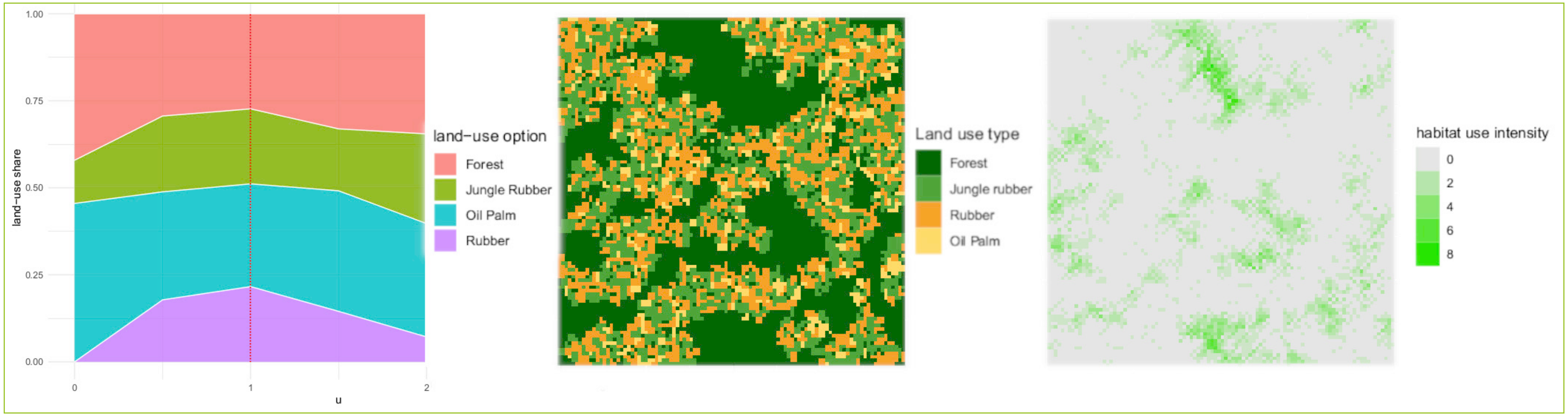


Figure 18. Estimation of ecological implications of non-spatial landscape portfolios. First, a portfolio generated using all indicators, with the risk value used to generate the map noted by the dotted line (left). Then, the landscape portfolio will be translated into a spatially explicit map using the *EFForTS-LGraf* land cover generator (center). Last, based on the spatial explicit map a bird home range map generated by the FunCon model is designed to estimate functional connectivity of the landscape (right).

Picture 27. B10 research team and collaborators. From top left to bottom right: Rebecca Groninga, Eyal Goldstein, Elsa Rommerskirchen, Julia Henzler, Jann Lay, Kerstin Wiegand, Suria Tarigan, Sebastian Fiedler, Christian Wiewelhove, Amsalia Pasila, Sebastian Reineke.

to predict species distributions on a wider spatial scale based on the knowledge from single field sites.

B14

TITLE: **The use of DNA barcoding to assess landscape effects on phylogenetic and functional diversity**

TEAM: Principal Investigators: Oliver Gailing (UGoe); Iskandar Z. Siregar (IPB University); Bambang Irawan (UNJA).
Scientific Staff: Carina Carneiro de Melo Moura (Postdoctoral Researcher).
Associated Scientists: Ulfah Juniarti Siregar, Fifi Gus Dwiyanti (IPB University); Essy Harnelly (UNSYIAH); Sri Rahayu (KRB LIPI).

RESEARCH SUMMARY:

Subproject B14 applies molecular tools to assess plants community composition using different sources of plant material (i.e. leaves, roots, pollen, seeds) for a better understanding of the effect of plant relatedness and functional diversity on above and below ground systems, which may contribute to comprehend ecosystem processes such as forest connectivity, restoration, and community dynamics.

In our collaboration with subgroups A01 (Behling) and B09 (Westphal/Grass), we identified a lack of differentiation between pollen material from pot-pollen of stingless bees (Tetragonula laeviceps) collected in the four land-use types. Interestingly, pollen from several plant families such as Dipterocarpaceae, Cannabaceae, Fabaceae, Lamiaceae, Euphorbiaceae, and

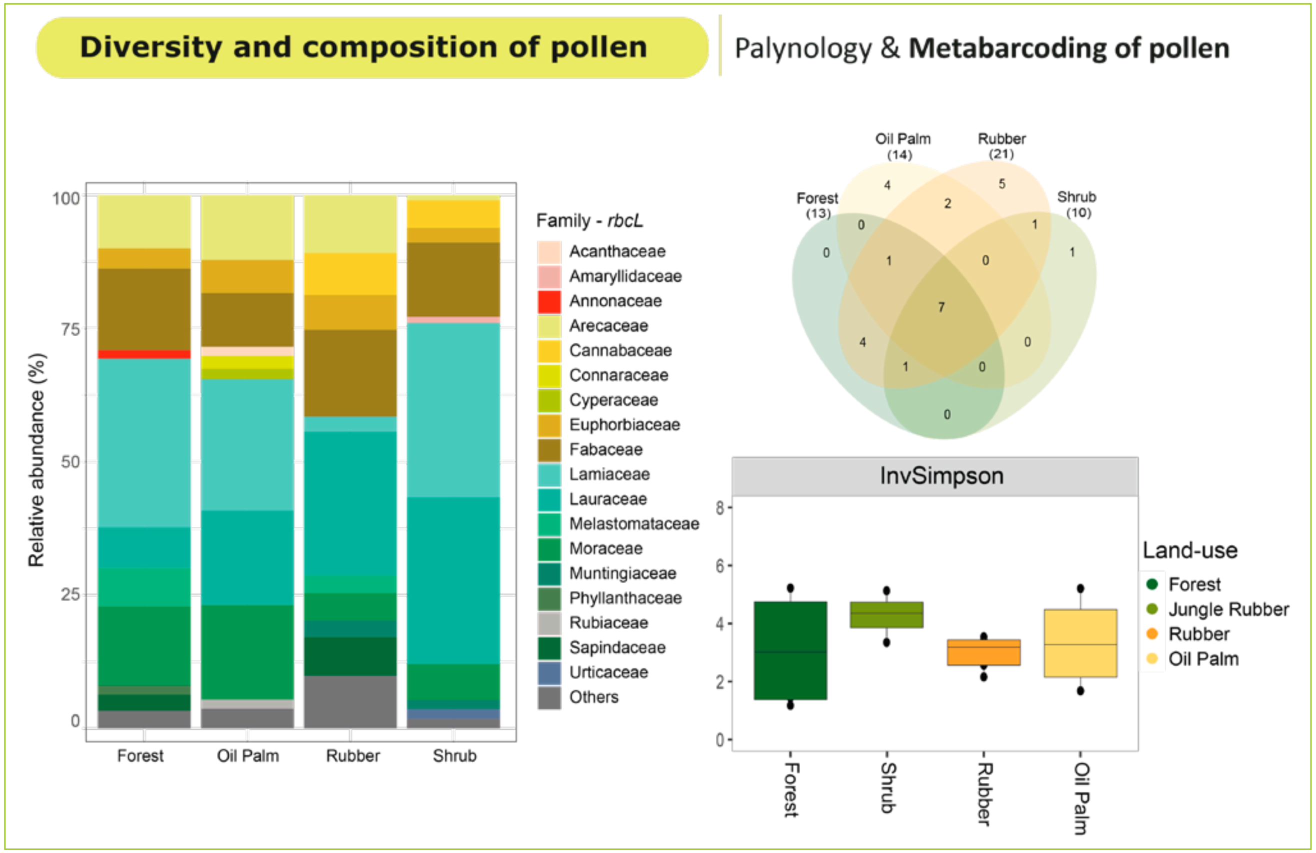


Figure 19. Top 10 most abundant plant families detected per land use type (forest, shrub, rubber, and oil palm) by DNA metabarcoding. On the right, Venn diagram showing the overlap between the occurrence of plant families among the four types of land use and diversity of pollen types based on palynology (Moura *et al.* 2022).

Moraceae were also deposited in colonies located in Oil Palm and Rubber plots, indicating an influx of pollen from adjacent areas to the plantations. Generalist pollinators apparently maintain ecosystem functioning and contribute to the connectivity of the forest remains (Fig. 19, Moura *et al.* 2022).

Our ongoing research also focuses on the reconstruction of co-occurrence networks between plant species and other associated taxonomic groups (e.g., fungi) to investigate drivers of community composition in response to host functionality. In cooperation with Prof. Polle's team (former subproject B07) and sub-

Roots and associated organisms

Fungi & **Metabarcoding of roots**

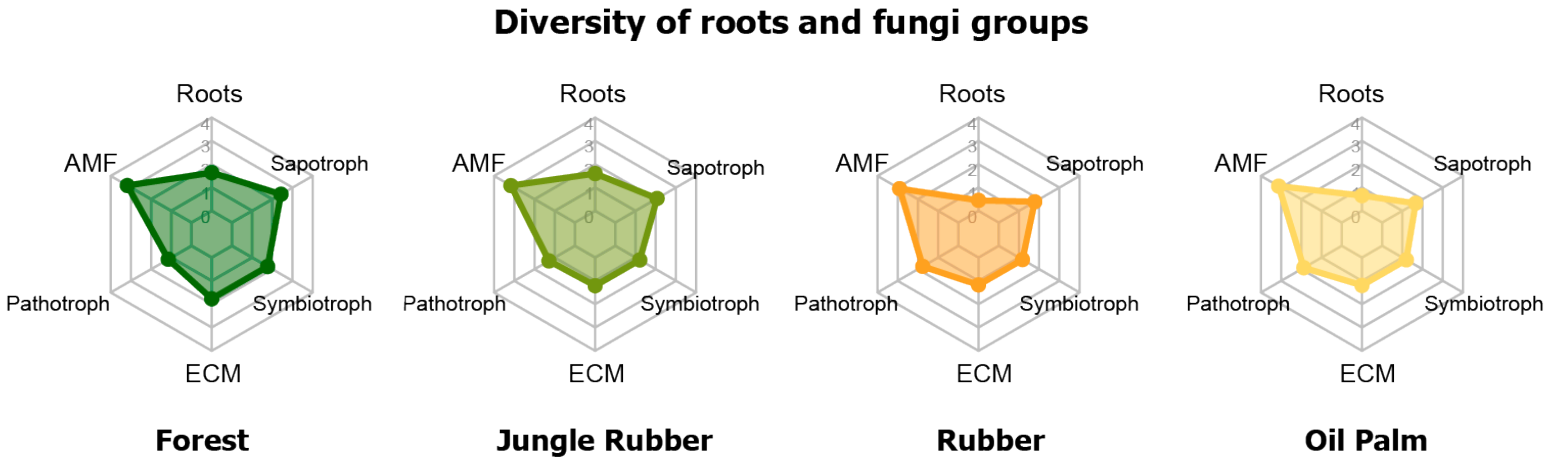


Figure 20. Diversity of roots and fungal functional groups in forest, jungle rubber, rubber, and oil palm plantation. Remarkably a negative relationship between roots diversity and diversity of pathogenic fungi in forest plots (Moura *et al.* in prep.).

project B08 (Scheu), we incorporated the richness of roots, and their functional traits as variables to test for non-random associations between roots and fungi (Fig. 20).

Field sampling in the Landscape Assessment is successfully completed (Picture 28). Roots and leaf material are ready for shipment to undergo DNA analysis. We greatly acknowledge the assistants and administrative team in Indonesia.

Challenges of the coronavirus pandemic:

Amid the coronavirus pandemic some interruptions, delays, and consequently adjustments in the planned schedule had to be accommodated for the development of our project. Specifically, it meant a setback of two years for sample acquisition and consequently precluded lab experiments, which might lead to the incompletion of some specific work packages until the end of the project. We have been working with samples available from the second phase of the project and running pilot experiments that will be scaled up to the landscape level with the Landscape Assessment samples. The last will allow robust inferences in the context of forest transformation. Furthermore, we implemented the use of a remote tool (Kobo) for data entry, allowing simultaneous information sharing between field assistants and researchers. Thus, the impact of the pandemic forced us to find alternatives to keep an acceptable level of productivity, however, planned analyses within the proposed schedule were hindered.

Ultimately, our plans in the framework of the Landscape Assessment include a DNA-based plant inventory to infer phylogenetic and functional diversity in the different land-use types and to obtain results with a focus on network interactions between plants and associated groups at the above and below-ground levels.

References:

Moura CCM, Setyaningsih CA, Li K, Merk MS, Schröck S, Raffiudin R, Grass I, Behling H, Tscharntke T, Westphal C, Gailing O (2022) Biomonitoring via DNA metabarcoding and light microscopy of bee pollen in rainforest transformation landscapes of Sumatra. BMC Ecology and Evolution 22: 51. *https://doi.org/10.1186/s12862-022-02004-x*

Picture 28. Impressions of field activities and meetings.

Group C

FIELDS OF RESEARCH

- Human dimensions

GROUP COORDINATORS

- Meike Wollni, Oliver Mußhoff (UGoe);
- Nunung Nuryartono (IPB University);
- Rosyani (UNJA)

C01

TITLE: **Smallholder productivity, market access, and international linkages in rubber and palm oil production in Jambi Province**

TEAM: Principal Investigators: Bernhard Brümmer (UGoe); Dedi Budiman Hakim (IPB University), Zulkifli Alamsyah, Mirawati Yanita (UNJA).
Scientific Staff: Gabriela Carbajo Alvarez (Doctoral Researcher).
Associated Scientists: Bernhard Dalheimer (Postdoctoral Researcher).

RESEARCH SUMMARY:

Smallholder productivity and environmental efficiency

One of the most alarming concerns in smallholder oil palm production systems is the substantial productivity differential compared with large estates. The yield gap between smallholders and commercialized enterprises amounts to 40 %. In closing the yield gap looms the opportunity of both environmental as well as economic benefits as smallholders would be more productive and require less land input. We found that technical efficiency (Fig. 21) in smallholder production is low and consequently highlight opportunities to boost yields without increased input – including land – use. Moreover, we investigated potential rebound effects (Fig. 22) resulting from increased technical efficiency. Our findings suggest that although net land savings prevail as a result of increased technical efficiency, expected land savings are offset by about half due to farmland expansion.

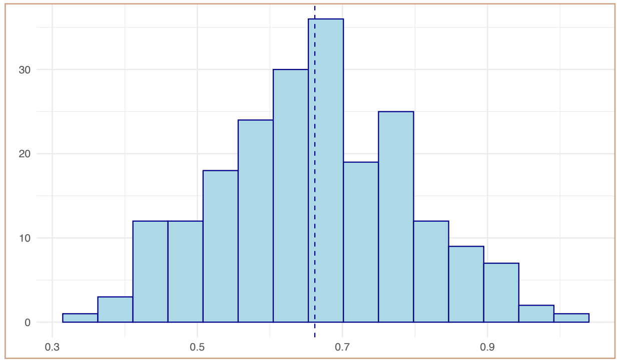


Figure 21. Technical Efficiency of oil palm smallholders.

Similarly, we find a substantial environmental inefficiency with regards to biodiversity in smallholder oil palm production, which is partly explained by both chemical and manual weeding practices, highlighting the potential for improvements in both the environmental and the economic dimension. Moreover, the value for conserving one species of the average biodiversity on a farmer's plantation was 340 USD in 2018. Payments for ecosystem services schemes (PES) could be a viable policy response to conserve meaningful levels of biodiversity while simultaneously allowing smallholders to increase palm oil output. In general,

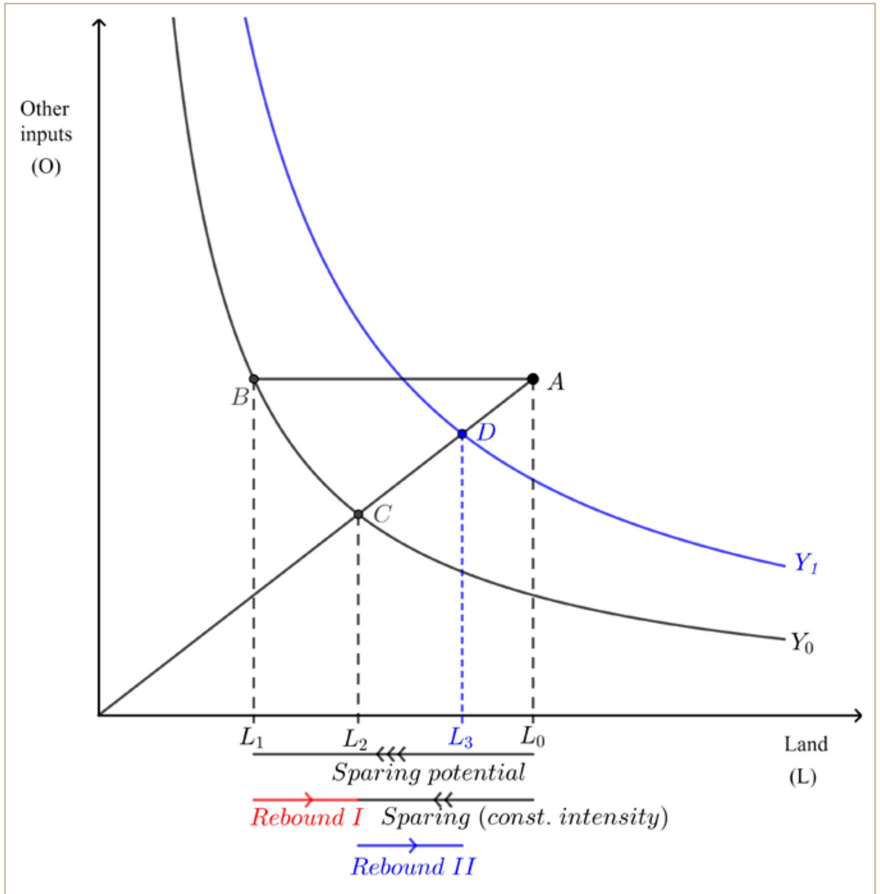


Figure 22. Land Sparing Rebound.

addressing drivers of environmental performance in PES designs amplifies its effect without reducing production levels.

Determinants of yield gap and the role of improved seedling varieties in smallholder oil palm productivity

In this phase, our ongoing research is examining the components of the yield gap in oil palm smallholders, and will compare productivity and efficiency measures among groups of seed users (traditional and improved). Firstly, we will investigate the existence of self-selection biases on seed user's adoption decision that would lead biased estimators. We will employ methodological specifications to amend for it and then compare productivity and technical efficiency scores between the two groups. As previous work had identified technical efficiency of oil palm cultivation reasons for the persisting yield gap between commercial estates and smallholders, further research will also be carried out to decompose the yield gap and pinpoint the role of improved seed varieties.

C02

TITLE: **Social transformation processes and sustainable resource use in rural Jambi**

TEAM: Principal Investigators: Heiko Faust (UGoe); Endriatmo Soetarto, Soeryo Adiwibowo, Rina Mardiana (IPB University); Rosyani (UNJA).
Scientific Staff: Jasper Knieling, Heinrich Petri (Doctoral Researcher).
Associated Scientists: Jonas Hein (DIE Bonn); Yvonne Kunz (KITLV Den Haag).

RESEARCH SUMMARY:

Since the last Newsletter (no. 7, 2020), the German-Indonesian research team of C02 concentrated on four activities: 1. publications in international journals on risks of flooding and impacts of international environmental governance, 2. analysis of smallholders decision-making processes and crop diversification, 3. literature review concerning replanting processes and effects on smallholder livelihoods, 4. forest governance in Jambi.

The first research reveals that, today, increased flooding has become an environmental hazard and a threat to people's livelihoods and health (Merten *et al.* 2020). Based on qualitative research and literature that has developed relational approaches to risk and water, we investigated past and present hydro-social relations in Jambi province and reconstructed the changing meaning of flooding (see Picture 29).

Picture 29. Drainage channel in one of the studied villages

We suggest that flooding as a hazard in Jambi was produced through the introduction of the plantation business to the area and its prioritization of dry land for agro-industrial development. This development altered the materiality of water flows, reconfigured power relations and changed the socio-cultural dimensions of flooding. It shows how tracing the socio-natural production of hazards may help explain the increasingly systemic nature of risks and provide insights into the wider social meaning of environmental risks (Merten *et al.* 2021a). Further, we show how an increasingly transnational network of state and non-state actors has become involved in developing new laws, policy programs and land-use agreements on Sumatra's coastal peatlands, aiming at supposedly win-win low-carbon development pathways. We argue that such efforts are open to much of the same criticism that has been raised regarding previous policies and projects aimed at reducing greenhouse gas emissions (GHGE) from deforestation and forest degradation. These projects disregard local perspectives on development, fail to deliver the promised benefits and, through a reconfiguration of local land-use rights, reduce the capabilities of smallholder farmers to benefit from their land. In sum, our analysis suggests that recent policies and projects aimed at mitigating GHGE from tropical peatlands contribute to a redistribution of the global climate mitigation burden onto smallholder farmers in Indonesia. This occurs through their threefold assignment to protect forests, prevent fires and help restore degraded peatlands. (Merten *et al.* 2021b).

The second investigation deals with drivers and barriers to crop diversification in Jambi, therefore 64 interview protocols were coded and analyzed (Thomas 2021). Findings show that few promoting factors for crop diversification exist and niches of crop di-

Picture 30. Home garden with sugar cane in Talang Belido.

Pictures 31. Home garden with and with vegetables, banana, and areca nuts in Sumber Jaya.

versification notably manifest themselves in the form of gardens (see Pictures 30 and 31). Farmers who practice diversification either have a strong intrinsic motivation linked to values and perceptions (e.g. family, health, risk management), or apply traditional practices and use the crops for home consumption or subsistence purposes. Some also produce for the market. Smallholders who grow diversely stand out by their greater knowledge on different crops. Contrary to the assumption which was developed during a literature research, social change agents do not seem to play a role for crop diversification in Jambi. However, contrary to most publications on smallholders' motivations, monetary incentives are a major but not the only possible motivational factors for smallholders' crop choices. What is necessary above all to increase the crop diversity are measures that create a more favorable environment for diversification, supporting existent diverse practices and fostering those farmers who want to start it.

The third study reviews the state of the art of the oil palm replanting process. Three decades after the establishment of many smallholder oil palm plantations, large areas of oil palm will require replanting soon or are already overmatured. In this review, we collect relevant literature on replanting of oil palm, especially in the realm of smallholder cultivation, to highlight the challenges smallholders will face when replanting. We find that access to inputs, finances and know-how differ greatly between groups of smallholders. This will likely affect smallholder's decisions when, how and what to replant. Information on replanting, access to high-quality seedlings as well as eligibility for public replanting funds will determine the success of smallholder replanting efforts in Indonesia but are distributed unevenly currently. We finish the review with recommendations for both policy-makers and researchers on how to overcome the challenges replanting holds and capitalize on the opportunity replanting offers rather than exacerbating existing issues (Petri *et al.* under review).

The fourth focus of investigation deals with community forestry licenses and programs in Beringin Jaya Lampung and Hajran Jambi. With the involvement of our Indonesian group members the study focused on community access for social forestry license holders during the pre-license and post licensing phases. The findings show that successful facilitation to increase access of community members requires a networked capacity across community members and with stakeholders outside the community. The high level of access and networking capacity among a community determines how they obtain benefits from the implementation of social forestry policy, which is also influenced by the accuracy of the broader plan prepared by the community for the license area, which helps to grant supporting services and facilities (Budi *et al.* 2021).

Challenges of the coronavirus pandemic:

C02 was hit hard and has fundamental deficits in generating data. Field work was not possible, even the Indonesian partners could not go to the field for a long time. Further, the assistants do not have the expertise for challenging qualitative in -depth interviews.

Alternatively, in August 2021 we conducted a Focus Group discussion with key stakeholders within the field of environmentalism, religious environmentalism and included two smallholder farmers from the province of Jambi. The discussion took place in a zoom meeting with a keynote speech provided by Pak Iskandar, head of *Bumi Langit*, a religiously motivated permaculture farm with significant reach on Indonesian social media.

Simultaneously, together with C08 we experimented with different approaches to do quantitative research without putting researchers, participants and RAs in danger of contracting COVID by using the widespread messenger service "WhatsApp" to contact possible participants for an online survey. These Participants were provided with online-links to fill the surveys out on their own end devices. Following this experience, we developed a research design for further quantitative studies in the area. Currently, together with C08 we are conducting a survey on nature perceptions, replanting intents and possible successors of the current farmers.

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Budi B, Kartodihardjo H, Nugroho B, Mardiana R (2021) Implementation of social forestry policy: Analysis of community access. Forest and Society 5: 60-74. *https://doi.org/10.24259/fs.v5i1.9859*

Merten J, Østergaard NJ, Rosyani, Soetartoe E, Faust H (2021) From rising water to floods: Disentangling the production of flooding as a hazard in Sumatra, Indonesia. Geoforum 118: 56-65. *https://doi.org/10.1016/j.geoforum.2020.11.005*

Merten J, Østergaard NJ, Rosyani, Soetartoe E, Faust H (2021) Climate change mitigation on tropical peatlands: A triple burden for smallholder farmers in Indonesia. Global Environmental Change 71: 102388. *https://doi.org/10.1016/j.gloenvcha.2021.102388*

Merten J, Stiegler C, Hennings N, Purnama ES, Röll A, Agusta H, Dippold MA, Fehrmann L, Gunawan D, Hölscher D, Knohl A, Kückes J, Otten F, Zemp DC, Faust H (2020) Flooding and land use change in Jambi Province, Sumatra: integrating local knowledge and scientific inquiry. Ecology and Society 25(3):14. *https://doi.org/10.5751/ES-11678-250314*

Petri H, Bähr T, Hendrawan D, Rosyani, Mußhoff O, Wollni M, Faust H (under review): The challenges Indonesian oil palm smallholders face when replanting becomes necessary, and how they can be supported – a review.

C06

TITLE: **Understanding the certification and replanting behavior of Indonesian smallholder farmers.**

TEAM: Principal Investigators: Oliver Mußhoff (UGoe); Dompak Napitupulu (UNJA).
Scientific Staff: Dienda Hendrawan (Doctoral Researcher).
Associated Scientist: Charlotte Reich (Doctoral Researcher)

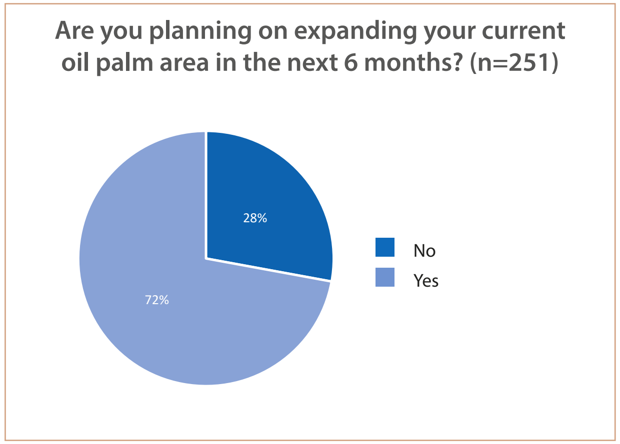
RESEARCH SUMMARY:

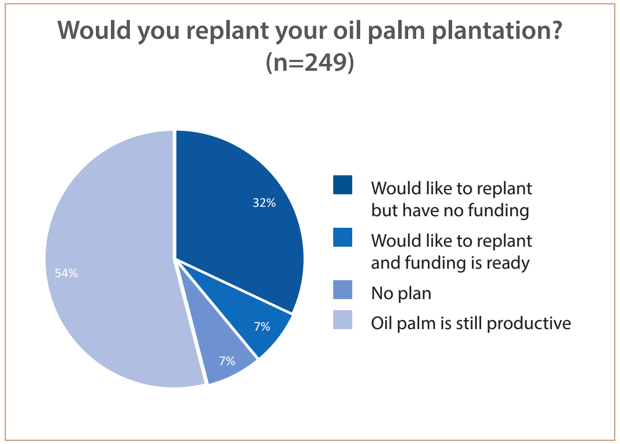
During the third Phase, C06 has completed an initial round of data collection from October until December 2021. Despite difficult circumstances, we were able to successfully conduct a first data collection while part of the team worked remotely from Göttingen.

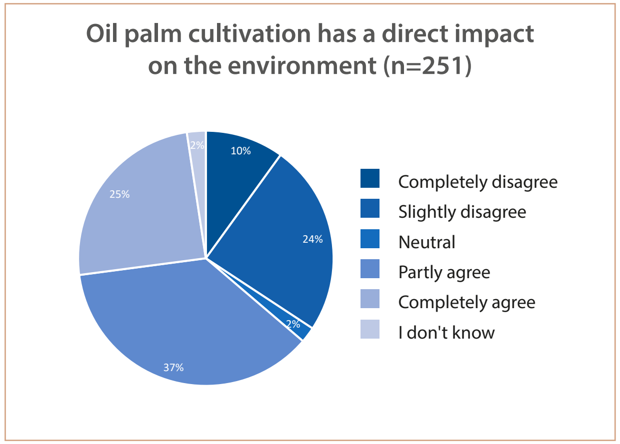
The initial data collection of C06 aimed at eliciting smallholders' preferences towards replanting subsidy schemes as well as certification schemes. With this research, we are aiming to answer how schemes for replanting as well as certification should be designed to foster smallholders adoption. We ran two experiments which were embedded in a structured questionnaire. Each farmer was presented either with a discrete choice experiment on replanting subsidy schemes or on certification schemes. Additionally, we explored farmers' general attitude and perception towards oil palm cultivation and sustainability through a structured questionnaire. We also measured the financial literacy among smallholders and are thus able to explore the potential role of financial literacy on farmers' decision-making towards certification and replanting schemes. Thanks to the great collaboration with the C06 enumerators, we had successful trainings over the course of several weeks on the nature of the experiments and thus ensured a common understanding before we ran pre-tests. The team (Picture 32) visited 500 households spread across the five biggest oil palm producing regencies within the province of Jambi. Our team was well received in the villages and the overall rejection rate resulted in 5 %. A total of 249 respondents were presented with the experiment on replanting, while 251 respondents answered the experiment on certification. 70 % of the respondents stated they perceived the discrete choice experiments as easy or neutral in difficulty. The team was able to wrap up the overall data collection over the course of 8 weeks. Preliminary results were presented at the annual conference of the Agricultural Economists Society in early April 2022. Our study reveals that clarity of prerequisites and information about subsidy schemes are perceived as essential, and group-based registration for subsidy schemes is highly preferred to individual registration. Simultaneously, trainings and capacity building on farm management and sustainability practices are perceived as effective tools to increase the farms' efficiency among the respondents and could potentially foster certification adoption. The results also showed a high approval rate of 62 % towards the statement that oil palm cultivation directly impacts the environment, which further hints at the awareness of smallholders around oil palm cultivation. However, the need for more transparent economic benefits is stressed through 45 % of our sample stating they agree or slightly agree to the statement that the adoption of certification schemes is expensive.

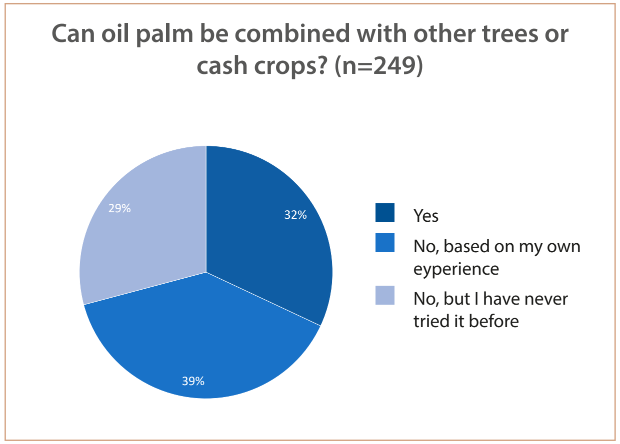
These early hints in our results highlight the need for structured programs within the industry, particularly since the majority (72 %) of smallholders stated they are planning to increase the current plantation area within the coming months.

Picture 32. C06 Enumerators: Reza, Indri, Fitryah, Dedi, Idil (from left to right).









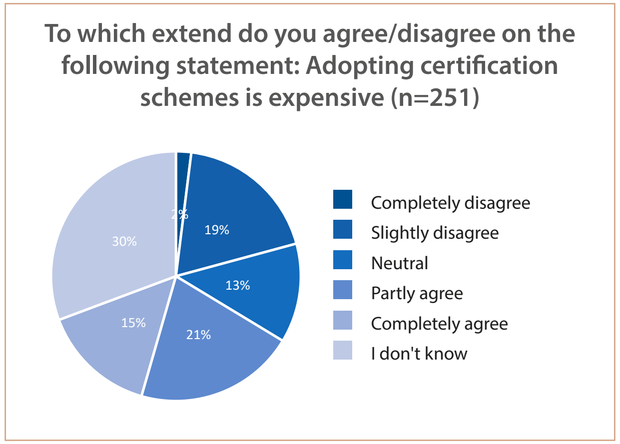


Figure 23 a–e

Challenges of the coronavirus pandemic:

Due to the ongoing travel restrictions for Indonesia, we ran into difficulties in collecting data within the given timeframe of the project. Since our research relies greatly on experiments, we were uncertain whether we would be able to train our enumerators via video conferences. However, as entry regulations remained uncertain and the development of the pandemic did not allow for planning security, we decided for a remote data collection despite initial concerns. We ran trainings with our local team over the course of several weeks, followed by multiple pre-tests and mock data collections. Although the advancement of technology made things possible, we believe an in-person training would have benefited the data collection and the overall research progress. Nonetheless, we are highly satisfied with how well the data quality has turned out and are very grateful to the enumerators for their collaboration and support despite unfavorable circumstances.

C07

TITLE: **Determinants of land-use change and impact on household welfare among rural farm and non-farm households**

TEAM: Principal Investigators: Matin Qaim (ZEF, University of Bonn), Hermanto Siregar (IPB University), Zulkifli Alamsyah (UNJA).
Scientific Staff: Kibrom T. Sibhatu (Postdoctoral Researcher), Jakob Latzko (Doctoral Researcher).

RESEARCH SUMMARY:

The goal of the C07 project is to investigate the dynamics and the long-term impacts of land-use change on the welfare of farm and non-farm households in Jambi. In the current phase of *EFForTS*, we completed a household survey as part of the *EFForT's Landscape Assessment* (LA experiment). The survey involved 300 farm households. The data are analyzed to examine the impact of COVID-19 on rural households and to understand the heterogeneous contribution of agroforestry land-use systems for farm, socioeconomic, cultural, and ecological services in the smallholder sector. Using the panel survey data collected in earlier project phases (2012, 2015, and 2018), we have also examined the long-term impacts of land-use change on-farm structural transformation and on the welfare dynamics in smallholder farm households in Jambi. Our findings

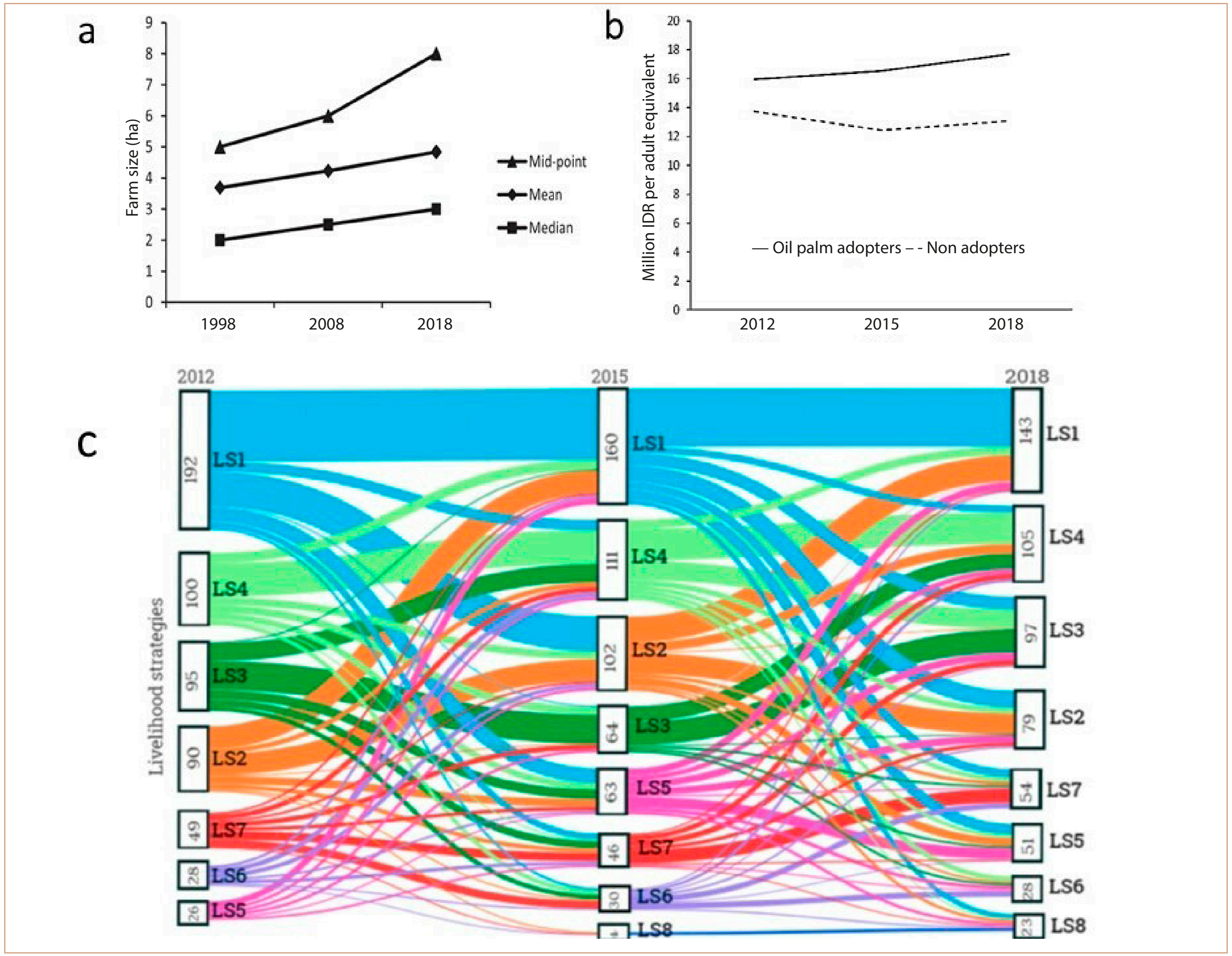


Figure 24. Long-term impacts of land-use change on-farm structural transformation and welfare dynamics in smallholder farm households in Jambi

Figure 24 a. Development of average farm size in Jambi (1998-2018)
Figure 24 b. Mean consumption expenditures among oil palm adopters and non-adopters (2012–2018)
Figure 24 c. Livelihood strategy transition matrix (2012-2015-2018). Note: Results of the Chi-squared test (Pearson X2 (14) = 68.61, P = 0.000). Notes: LS1 = Rubber Farmers; LS2 = Rubber Farmers & Non-Agricultural Diversifiers; LS3 = Oil palm Farmers; LS4 = Mixed Farmers & Non-Agricultural Wage Laborers; LS5 = Diversifiers; LS6 = Intense Mixed Farmers & Diversifiers; LS7 = Entrepreneurs; LS8 = Off-Farm Diversifiers.

suggest that oil palm adoption contributes to structural transformation in terms of rising farm sizes (Fig. 24a). Oil palm cultivation has positive effects on living standards and household resilience to economic shocks (Fig. 1b). Our findings also reveal that farm households in Jambi pursue diversified livelihood strategies, actively switching between the identified strategies (Fig. 24c).
In the remaining time of Phase 3, we will analyze further the longer-term economic and social effects of land-use change, including effects on individual diets, off-farm employment, and intra-household gender roles. Also, we will investigate how the Covid-19 crisis has affected the livelihoods and livelihood activities of oil palm and rubber smallholders in rural Indonesia. We will also contribute to the *Landscape Assessment of EFForTS* by combining the socioeconomic survey data we have collected to analyze relationships between land-use composition and configuration and regional economic and social development.

Picture 33. C07 researchers, Kibrom Sibhatu and Jakob Latzko, training field assistants (Amsalia, Rizki and Wildan) during the landscape assessment 2021 (credit: Kibrom Sibhatu).

Picture 34. C07 field assistants Amrina and Shara during a household interview in 2018. (credit: Kibrom Sibhatu).

Picture 35. A farmer delivering fresh oil palm fruit bunches at a trader's collection point (credit: Kibrom Sibhatu).

C08

TITLE: **Designing effective policy instruments to induce sustainable land use**

TEAM: Principal Investigators: Meike Wollni (UGoe); Edison (UNJA).
Scientific Staff: Tobias Bähr (Doctoral Researcher).
Associated Scientists: Jana Juhrbandt (Postdoctoral Researcher).

RESEARCH SUMMARY:

Empty fruit bunch mulching could potentially help to increase the sustainability of oil palm systems. In an interdisciplinary study, we explored whether empty fruit bunch mulching is associated with improved yields and soil properties in oil palm smallholdings (Rudolf *et al.* 2022). Results show that mulching is associated with 39% higher yields and 19% higher soil organic carbon content, but not with an improvement in other soil properties. Overcoming supply constraints is a major challenge for the promotion of empty fruit bunch mulching among smallholders. We found strong correlations between smallholders having close links to palm oil mills and their mulching uptake. Thus, strengthening inclusive value chains may be a means to support wider adoption (Fig. 25).

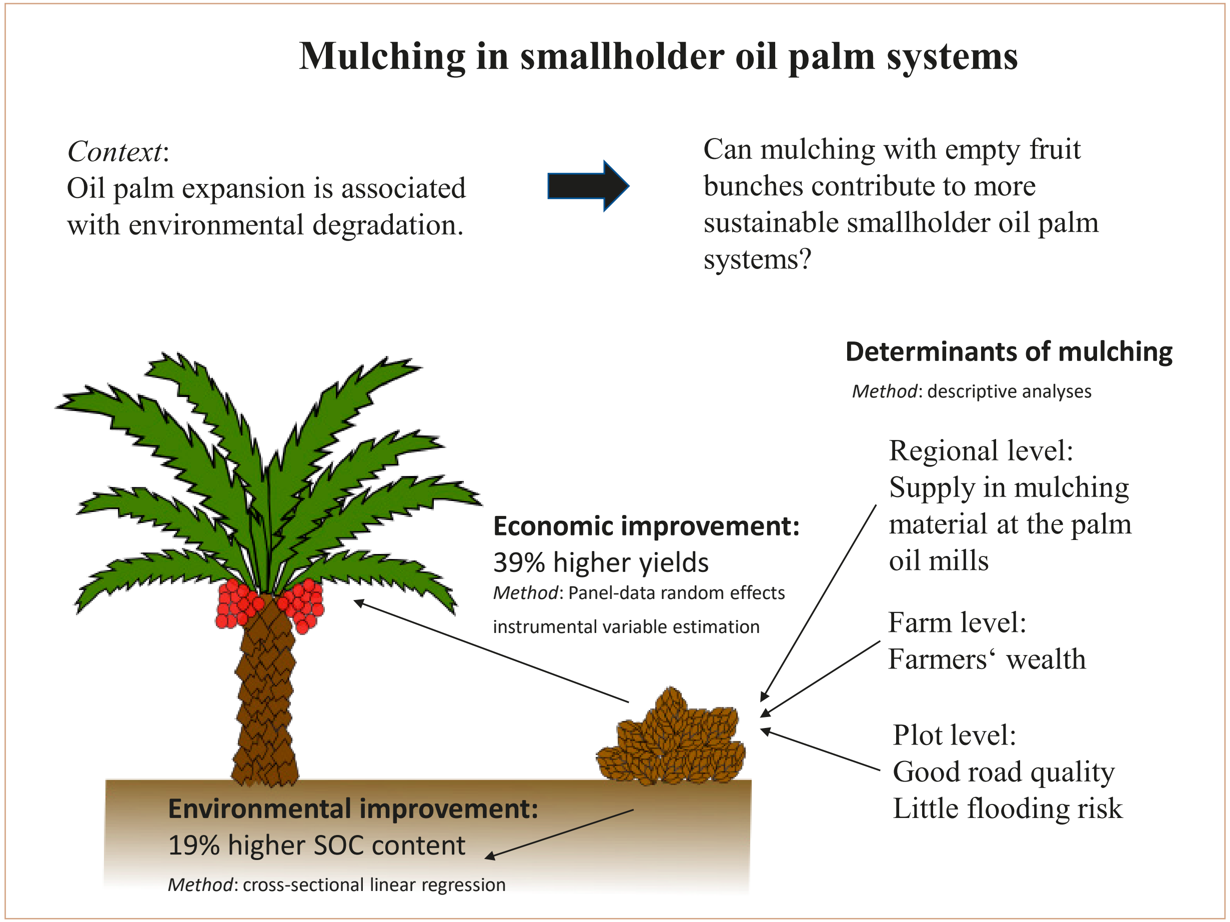
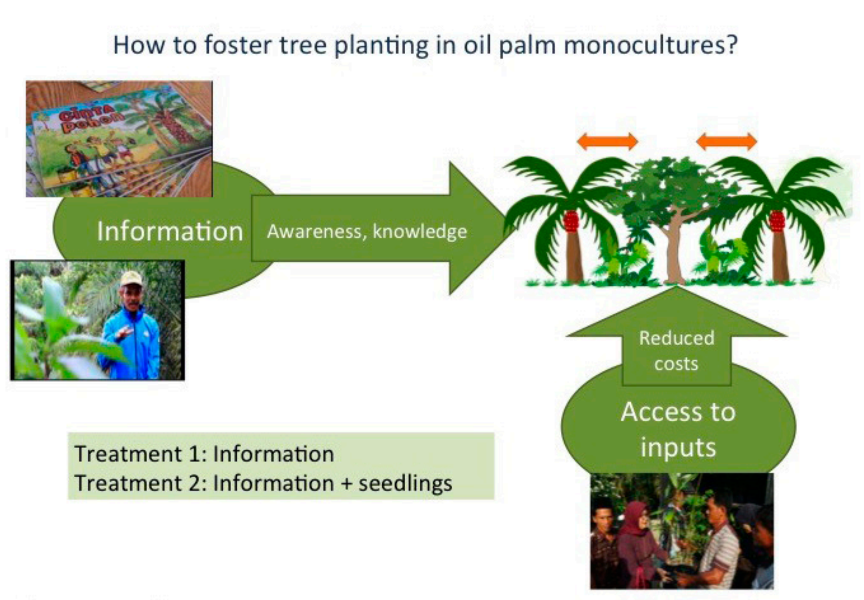


Figure 25. Mulching in smallholder oil palm systems

Payments for ecosystem services can encourage land owners to manage their land in a biodiversity-friendly way. To increase the effectiveness of PES for biodiversity conservation, incentives could be set to reach a minimum size of conservation area and a suitable spatial connectivity between conserved areas. Within a framed field experiment with Indonesian oil palm farmers we compared the effectiveness between two conditional group payment schemes: In the first one, the size threshold payment, payments are made if at least three farmers in the group conserve. In the second one, an agglomeration payment, payments are made if at least three farmers with bordering land engage in conservation. Our results suggest that both PES designs are similarly effective in the absence of communication. Under both, communication increases conservation outcomes in the case of previous successful coordination and is ineffective in the case of previous coordination failure. Yet, for individuals who are reluctant to conserve, communication only increases conservation outcomes under the size threshold payment.

Biodiversity-enhancing agricultural management options such as tree species enrichment in plantations can be introduced via subsidies to accelerate diffusion and adoption. However, because they mainly generate positive environmental effects, it is not clear how to encourage adoption, maintenance, and additional investments most effectively. Two policy interventions to foster tree planting were introduced in an oil palm hotspot in Indonesia. In the subsidy treatment, oil palm farmers receive information about native tree planting and three different native tree seedlings for free. In the price treatment, oil palm farmers receive the same information and the opportunity to buy three different native tree seedlings through an auction. Results from negative binomial regressions reveal that a full subsidy leads to higher tree planting at first, but the results from a double hurdle model show that conditional on being planted there is no significant difference in survival rates between the two treatments. Our results further show that conditional on tree planting, farmers in the price treatment apply a higher number of maintenance practices than farmers in the subsidy treatment. Finally, the subsidy treatment has a significantly negative effect on additional planting efforts (Fig. 26).



Treatment effects

	Number of trees/ha	Adoption of trees	Number of trees/ha conditional on adoption
Info (T1)	0.92**	0.06*	7.61***
Info+Seed (T2)	1.66***	0.38***	0.91

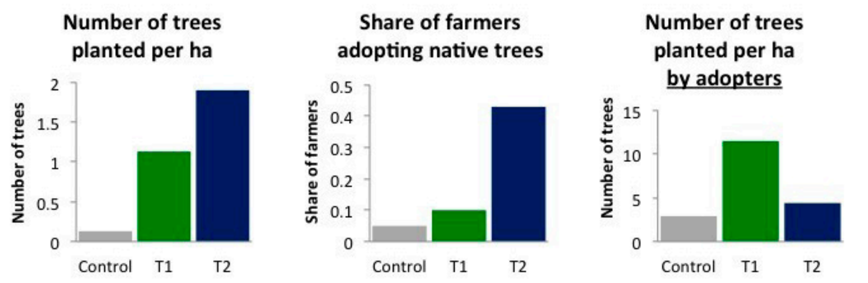


Figure 26. Tree seedling ready for planting in oil palm plantations

The negative environmental effects of the oil palm boom in Indonesia can influence the environmental concern (EC) and pro-environmental behavior (PEB) of the local urban and rural population in different ways. An analysis of factors that influence EC and PEB of urban and rural residents living in a hotspot for oil palm cultivation (OLS regressions) show that rural residents directly involved in oil palm cultivation tend to be more concerned than the urban respondents. This is true for general EC, as well as for the oil palm-related EC, which points towards oil palm farmers being aware of the environmental repercussions of oil palm plantations. We also find that connectedness with nature, connectedness with oil palms, and preferences for homogenized landscapes are important factors that are correlated with EC. PEB is measured in terms of donations made to a local environmental organization. The results reveal strong positive correlations between EC measures and PEB and that rural respondents make significantly higher donations. In addition, a higher connectedness with oil palms decreases donations among the respondents, while the hours participated in other environmental activities correlate positively with donations.

Replanting of oil palm, succession plans and generational differences are the focus of an ongoing data collection. Estimations show that around 50 % of all smallholder oil palm acreage requires replanting between 2020 and 2030. Additionally, farmers from the largest transmigration waves in the 1980s and 1990s are entering an age close to retirement. We investigate, which smallholders have recently replanted or are planning to replant soon, what inputs they use to replant and if any changes are made to replanted plots. As replanting is a significant long-time investment for smallholders, decisions could be linked to long-term goals of farmers. In this regard, succession plans of farmers will also be assessed. Additionally, we are testing a follow-up survey with adult successors to mirror their expectations to those of their parents.

Challenges of the coronavirus pandemic:

The restrictions connected to Covid-19 in Indonesia have affected and are still affecting our research today. First and foremost, we are still unable to conduct research ourselves in Indonesia as permits for foreign researchers are not being issued due to Covid. Therefore, any activity in the field had to be carried out by research assistants, once they were allowed to visit villages again. While this helps to gather some data in tested surveys, it is much more difficult to test new surveys and types of questions. In order to circumvent some of these problems, we designed and tested multiple online surveys in collaboration with C02. Although most farmers were accessible by smartphone, both response rates as well as data quality were significantly lower than during in-person interviews, ultimately forcing us to fall back on in-person interviews through research assistants. Finally, despite few official cases in Indonesia today, our research assistants still report problems trying to visit households selected for in-person interviews, either due to locals being sick or afraid to welcome researchers from Jambi City. All of these factors have delayed our planned research activities significantly and may delay them further, should visa restrictions not be lifted soon.

C10

TITLE: **Localized environmental and land use policies, palm oil conversion and deforestation**

TEAM: Principal Investigators: Krisztina Kis-Katos (UGoe); Nunung Nuryartono (IPB University); Dearmi Artis (UNJA).

Scientific Staff: Tobias Hellmundt (Doctoral Researcher).

Associated Scientist: Elías Cisneros (Postdoctoral Researcher)

RESEARCH SUMMARY:

Our subproject aims at understanding economic and environmental dynamics at the country level by combining remotely sensed data on forest loss with spatially localized policy indicators and measures for ecologic and socioeconomic outcomes. In our current research activities, we are addressing three different dimensions: decentralization policies, socioeconomic outcomes, and ecological outcomes.

Our first research focus lies on the horizontal devolution of power that resulted from the creation of new administrative units in Indonesia. Induced by district splits and corresponding new boundaries, discontinuous changes in the spatial distance of villages to their administrative capital provide exogenous variation. Using a boundary discontinuity design, our preliminary results show that after splits, deforestation is higher in areas that are located further away from their (new) capital. Among potential mechanisms, we discuss institutional capacity of new districts and reshaped spatial dynamics with regards to the location of the capitals.

Our second focus is on conflicts associated with rapid land use change in Indonesia. Although the palm oil boom has led to widespread rural development, it also caused a redistribution of resources and of economic benefits, potentially leading to new divisions and conflict among rural communities. We analyze the impact of the palm oil boom on violent crime and community conflict using a yearly panel of violence events across 10 years and linking it to variations in remotely sensed oil palm plantation area. Preliminary results show that a 1% increase in oil palm area leads to a 0.11 % – 0.47 % higher conflict incidence at the local level, in contrast to the reduction of violence in rural areas over time. These adverse effects seem to increase in places with high population growth, which is potentially associated with the migration of workers. On the upside, effects on violence are mitigated in newly electrified areas, highlighting that agricultural development can translate into inclusive economic growth when accompanied by public policies (Fig. 27).

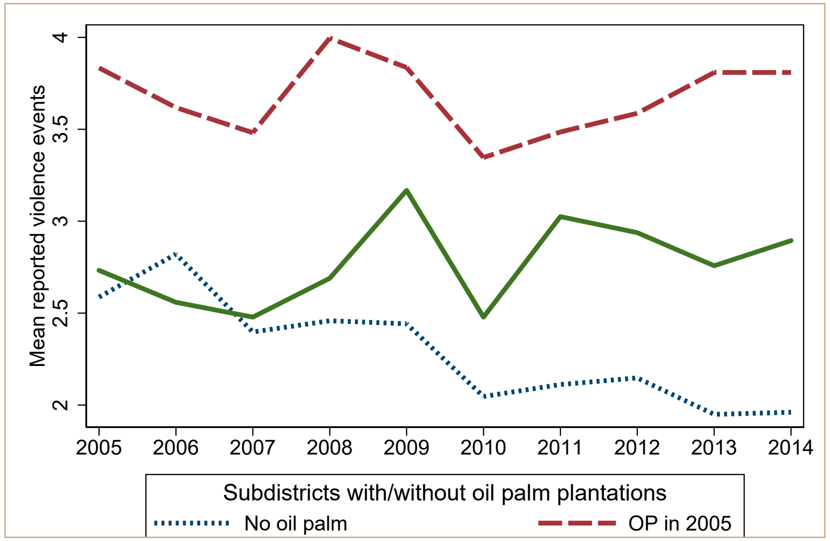


Figure 27. Yearly trends in the average number of violent incidents reported at the level of Indonesian subdistricts (kecamatan) based on newspaper articles collected by Indonesia's National Violence Monitoring System. Trends are disaggregated by subdistricts without any oil palm during the study period, subdistricts with pre-existing oil palm plantations at the start of the period in 2005, and subdistricts where plantation expansion first occurred during the observation period of 2005-2014.

Our third study focuses on the impact of economic incentives for an expansion of intensive agriculture on forest fragmentation in Southeast Asia. We employ remotely sensed forest loss information for the years 2001 to 2019 to calculate yearly forest fragmentation metrics on a grid cell level. These outcomes are linked to global fluctuations in the prices of agricultural commodities using a measure of price exposure based on crop-specific local agricultural suitability. While we find that forest fragmentation overall strongly increased, our empirical results also show that price incentives for an expansion of oil palm cause forest loss patterns that cause less fragmentation locally by resulting in a higher aggregation of the remaining forest and simpler forest shapes. Suggestive evidence links this outcome to the expansion of industrial plantations rather than smallholder farming.

In two further planned studies, we analyse the effects of natural disasters on deforestation in Indonesia, contrasting the effects of the COVID-19 pandemic and of natural hazards like earthquakes on forest-related outcomes. Initial results show a 2–5 percent increase in forest losses after earthquakes with a peak ground acceleration larger than 0.092 g (VI on the Modified Mercalli Intensity scale).

Challenges of the coronavirus pandemic:

Due to the pandemic-related travel restrictions our planned research visit to Indonesia had to be postponed. Since our project is mostly relying on secondary and policy data, there were no substantial limitations to our work, other than a slight shift of focus for some of our planned research topics.

C11

TITLE: **Integrated analyses of policies for sustainable rural economies**

TEAM: Principal Investigators: Jann Lay (GIGA Hamburg), Marife Corre, Ingo Grass, Kerstin Wiegand, Meike Wollni (UGoe); Nunung Nuryartono (IPB University); Aiyen Tjoa (UNTAD).
Scientific Staff: Anette Ruml (GIGA Hamburg).

RESEARCH SUMMARY:

While plot- and farm-level analyses have improved our understanding of socio-economic and ecological trade-offs and synergies, an analysis of these relationships at a higher scale is required to design policies to improve the sustainability of tropical transformation systems. This is why the integrative project C11 Goals aim (1) to develop a comprehensive accounting framework to aggregate, synthesize, and link existing and future *EFForTS* data on socio-economic and ecosystem functions at the level of a local rural economy, and (2) to evaluate the effects of land-use change scenarios and policies on socio-economic and ecological functions and the trade-offs between them.

The local rural economy is defined in functional economic terms, as an area comprising a large-scale company plantation with processing facilities and the surrounding villages economically linked to the plantation, through the supply of agricultural produce and labor (Fig. 28). Information on the company plantation and processing facilities, as well as the linkages to the local population were collected through a company survey in 2022 (Pictures 36–37).

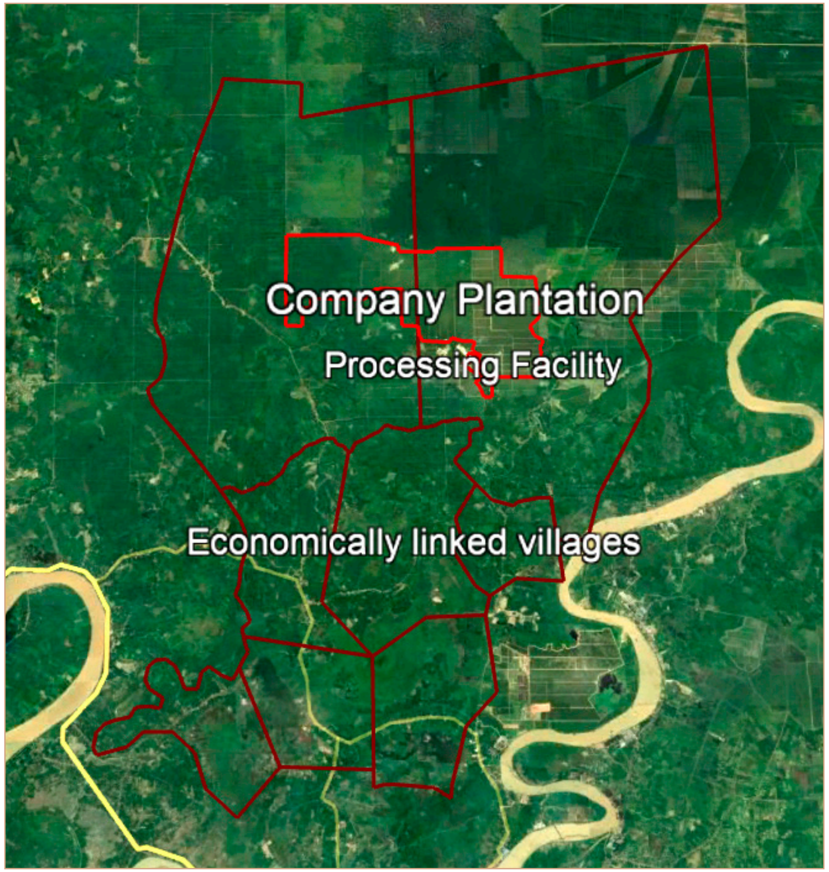


Figure 28. Example of a local rural economy. Own graph developed with Google Earth Pro.

For the local rural economy, we develop a stylized social accounting matrix (SAM), which represents all transactions between economic agents. These transactions include the production and sale of oil palm fresh fruit bunches and all other products produced and sold within the economy. In a first step, existing socio-economic and ecological *EFForTS* data will be aggregated to develop the SAM. In a second step, different land-use scenarios will be simulated through multiplier analyses. These simulations include for example and increase in the demand for (certified) palm oil or for other goods produced in the local rural economy. The advantage of this approach is that the potential multiplier effects within economies on other farm- and non-farm sectors through economic interlinkages, i.e., forward and backward production linkages and consumption linkages, are captured and accounted for. It further allows us to differentiate by economic activities and actors, as benefits are not necessarily evenly distributed. Based on the results, we aim to derive differentiated and robust policy implications. A key question is thereby whether and how transformation processes characterized by an increasing importance of large-scale commercial agriculture can become more inclusive and sustainable.

Pictures 36 and 37. Interview by Dila Armalia Darhani with a manager of an Indonesian palm oil company.

C12

TITLE: **Collaborative farm-modelling for reconciling socio-economic and ecological functions**

TEAM: Principal Investigators: Carola Paul (UGoe); Leti Sundawati (IPB University); Bambang Irawan (UNJA).
Scientific Staff: Volker von Groß (Doctoral Researcher).
Associated Scientist: Kai Husmann (Postdoctoral Researcher).

RESEARCH SUMMARY:

This subproject aims to develop an integrative and collaborative farm-modeling approach to identify potential farm designs that balance the farmer's needs with desirable ecological functions under heterogeneous household and site conditions. To achieve this, we developed the R package optimLanduse. The package provides tools for easy and systematic applications of the robust multiobjective land-use allocation model of Knoke *et al.* (2016), further developed by inter alia Gosling *et al.* (2021). It includes tools for determining and visualizing compromise land-cover compositions that best balance the multiple requirements and functions of the landscape defined by the decision-maker, considering his/her level of risk aversion. Illustrating the consequences of alternative requirements and functions on the theoretically optimal landscape composition shall support landscape modeling and decision-making. A manuscript on this package was submitted in April and is currently under review. We created a Shiny app that serves as a graphical user interface for communication and dissemination of the R package. This app allows a straightforward application of our package, and interested groups can use our package without prior knowledge in R with a few simple steps. Figures 29 A and 29 B exemplify the use of our package via the Shiny app. Socioeconomic functions were derived from preliminary data from the 2018 household surveys by C07, while ecological functions were compiled by Grass *et al.* (2020). We analyzed theoretically optimal land-cover compositions at the farm level. Which functions are considered in the optimization can be regulated dynamically through the checkboxes on the left. Figure 29A shows the optimization result for four selected socioeconomic functions over a range of different uncertainty levels. A higher uncertainty level reflects a higher risk aversion of the decision-maker. As the level of uncertainty increases, the farm portfolio also becomes more diverse, and the model suggests increasing the share of environmentally-friendly options like jungle rubber or even forest. Optimizing all ecological functions simultaneously suggests a farm portfolio consisting of about 50 % forest and 50 % jungle rubber at a low-

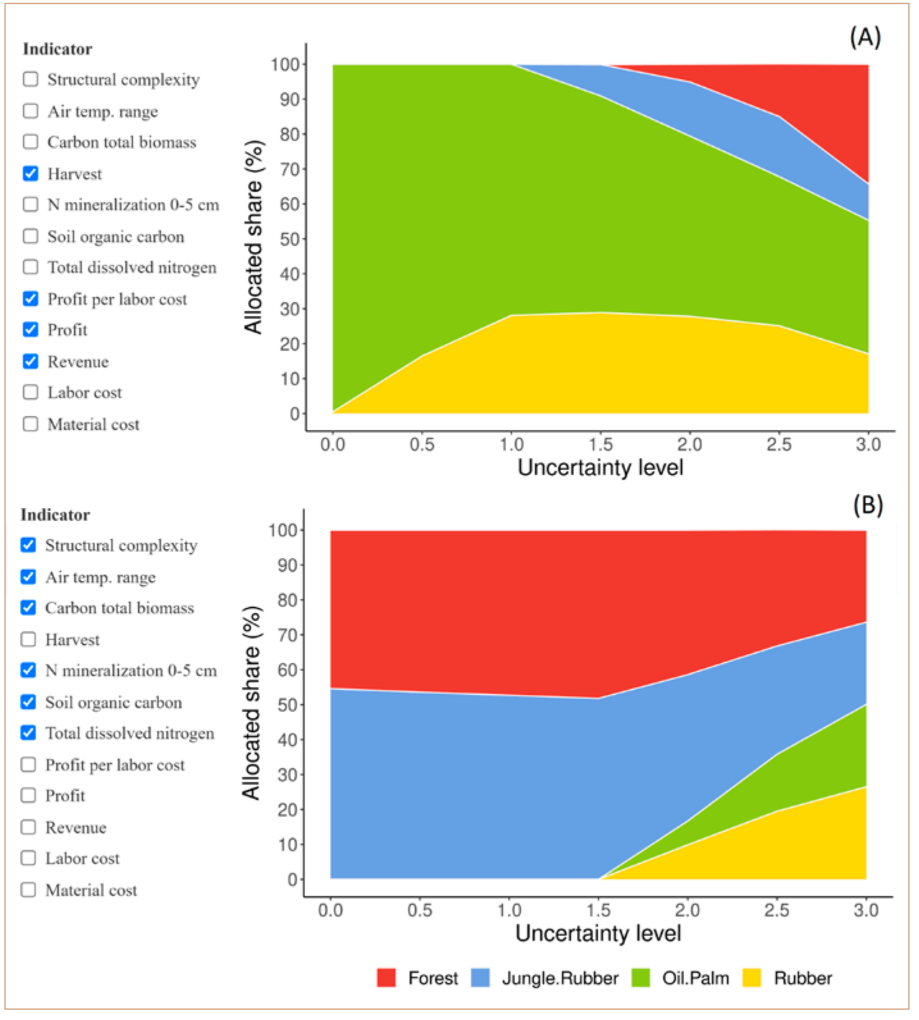


Figure 29. Exemplary use of the Shiny app for the R package optimLanduse. The socioeconomic functions used are based on the 2018 household survey data (subproject C07). The ecological functions were derived from Grass *et al.* (2020). The model incorporates uncertainty in the provision of each function by the standard deviation of the estimated mean value and the uncertainty level. The uncertainty level refers to the multiple of the standard deviation. A high uncertainty level can thus be interpreted as a higher risk aversion of the decision-maker. A) Exemplary results considering four economic functions. B) Exemplary result considering all ecological functions simultaneously.

er uncertainty level. With an increasing uncertainty level, the farm portfolio will also become more diverse through rubber and oil palm (Fig. 29 B). The increasing diversification can be explained as a buffering effect. The partially high uncertainties of the various functions for the different land-cover alternatives are mitigated by diversification (Knoke *et al.* 2016). Beyond the described R package, the model was further developed by an automated (iterative) search function approximating the combination of functions that would theoretically lead to the currently observed land-cover or any other specifiable composition. It allows analyzing which selection of ecological and socioeconomic functions best describe the current land-cover distribution of the participating farmers. These tools shall form the base for developing a collaborative modeling exercise with farmers, policy-makers, and scientists to inform desirable landscape design under heterogeneous site and household conditions. optimLanduse (version 1.0.0) has been released on CRAN and can be accessed via the project page *https://github.com/Forest-Economics-goettingen/optimLanduse*. The Shiny app can be reached via *http://134.76.17.50/optimlanduse_shiny/*.

Challenges of the coronavirus pandemic:

The pandemic caused delays in the work package 2 “Collaborative modelling with farmers, stakeholders and local policymakers” in our project. Planned interviews/workshops with farmers and stakeholders are delayed, which complicates the implicit valuation of functions through collaborative modeling.

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Knoke T, Paul C, Hildebrandt P, Calvas B, Castro LM, Härtl F, Döllerer M, Hamer U, Windhorst D, Wiersma YF, Fernández GFC, Obermeier WA, Adams J, Breuer L, Mosandl R, Beck E, Weber M, Stimm B, Haber W, Fürst C, Bendix J (206) Compositional diversity of rehabilitated tropical lands supports multiple ecosystem services and buffers uncertainties. Nature Communications 7: 11877. *https:// doi.org/10.1038/ncomms11877*

Scientific projects Z02 and INF

Z02 FIELDS OF RESEARCH

- Monitoring of meteorological variables
- Remote sensing
- Monitoring of aboveground animal biodiversity
- Function as central unit of the Convention of Biological Diversity (CBD)

INF FIELDS OF RESEARCH AND DATA MANAGEMENT

- Statistical consulting
- Data management and data long-term sustainability
- WebGIS integration and support
- Research data consultation, support and training
- Network, dissemination, outreach

Z02 – Central Scientific Service Project

TITLE: **Monitoring meteorological variables (WP1)**

TEAM: Principal Investigators: Alexander Knohl (UGoe); Dodo Gunawan (BMKG).
Scientific Staff: Christian Stiegler (Postdoctoral Researcher).
Technical Staff: Marek Peksa, Edgar Tunsch.

RESEARCH SUMMARY:

We continued with the meteorological measurements at all forest, rubber and oil palm plots and at our reference meteorological stations in Reki, Humusindo, Bungku, PTPN 6 office, Lubuk and Permatang Kabau. The collected and quality-checked data can be accessed via Göttingen Research online (GRO.data).

During the *Landscape Assessment* (LA) field campaign, we performed instant measurements of soil moisture and soil temperature at each subplot within 120 LA-plots. Soil temperature and soil moisture was measured at approx. 10 cm depth. In addition, we performed measurements of soil water infiltration at 13 different plot locations, using double-ring infiltrometers (Picture 38). The collected data can be accessed via Göttingen Research online (GRO.data).

Picture 38. Infiltration measurements using double-ring infiltrometer. (Picture credit: A03-*Landscape Assessment* team).

Z02 – Central Scientific Service Project

TITLE: **Remote Sensing (WP2)**

TEAM: Principal Investigators: Stefan Erasmi (Thünen Institute, Braunschweig); Nengah Surati Jaya (IPB University); Muhammad Zuhdi (UNJA).
Scientific Staff: Nicolò Camarretta (Postdoctoral Researcher).
Associated Scientist: Michael Schlund (University of Twente).

RESEARCH SUMMARY:

During Phase 3 of the *EFForTS* project the new work package 2 "Remote Sensing" has focused on the mapping of 2D- and 3D-stand structure of the main land uses found in Jambi province (forests, oil palm, rubber plantations and shrublands), using both airborne Light Detection And Ranging (LiDAR) and hyperspectral data. All remotely sensed data was acquired by February 2020, and it has since been validated,

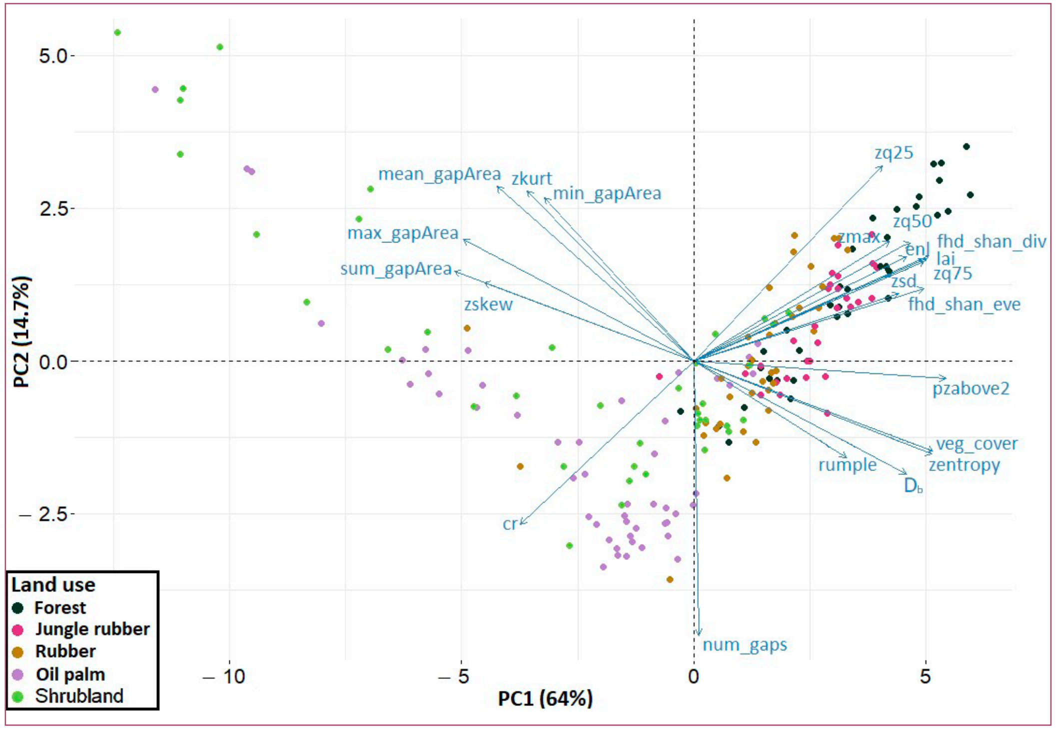

Figure 30. PCA-biplot representing the distribution of plots (coloured according to their land use), and the projected directionality of the LiDAR-derived metrics (blue vectors) on the first two principal components (PC1 and PC2).

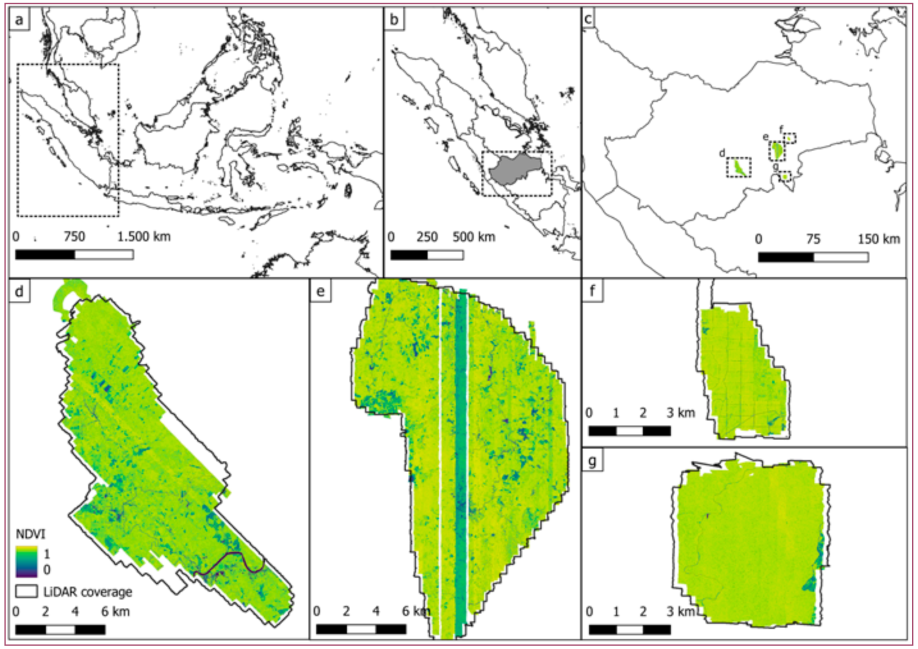

Figure 31. Panel (a) shows the location of the island of Sumatra in relation to Indonesia, (b) the location of Jambi province within Sumatra and (c) the location of the four study areas covered by hyperspectral data within Jambi province. Underneath are normalized difference vegetation indices (NDVIs) maps of the four areas: (d) Sarolangun regency, (e) Batanghari regency, (f) the state-owned oil palm estate PTPN 6 and (g) the Harapan rainforest protected area.

quality-checked and processed. A number of spatial data sets are now ready to be used, especially for any upscaling efforts within the *EFForTS* project. Several models related to topography (e.g. elevation, slope, aspect, planform) have been calculated at 1 m resolution as well as a vector layers of streams derived from the terrain models. A suite of 37 vegetation structural metrics, including canopy density, gap fraction, vegetation cover and height percentiles, has been identified and calculated both at plot level (*Landscape Assessment* plots and *Core Plots*) and for the whole LiDAR coverage area, at 10 m and 50 m pixel resolution. These metrics were also used to investigate structural differences between five key land uses in Jambi province (forests, jungle rubber, rubber plantation, oil palm plantation and shrubland). Interestingly, structural metrics were able to show a clear pattern following a gradient in land-use management intensity (Fig. 30): vegetation structural complexity increased moving from shrubland and oil palm plots, rubber plantation, jungle rubber and secondary rainforest. Moreover, the same vegetation structural properties were identified between secondary rainforest and jungle rubber plots, suggesting a likely widespread degradation in forest status. Oil palm plantation and shrubland were consistently less structurally complex then forest and rubber plots, while rubber plantation plots generally showed intermediate structural complex-

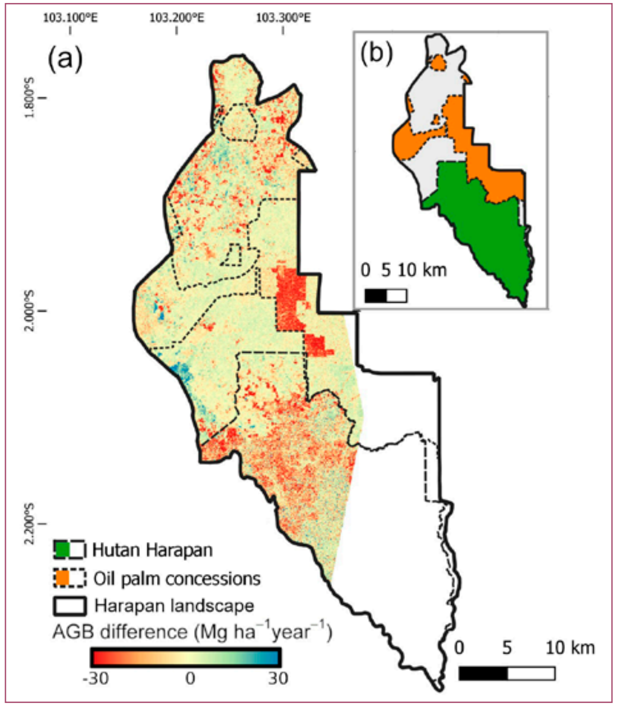

Figure 32. Annual aboveground biomass change map estimated with TanDEM-X InSAR height models from October 30, 2012 and February 25, 2019 (a) and overview of land categories in the Harapan landscape to support the visual interpretation (b).

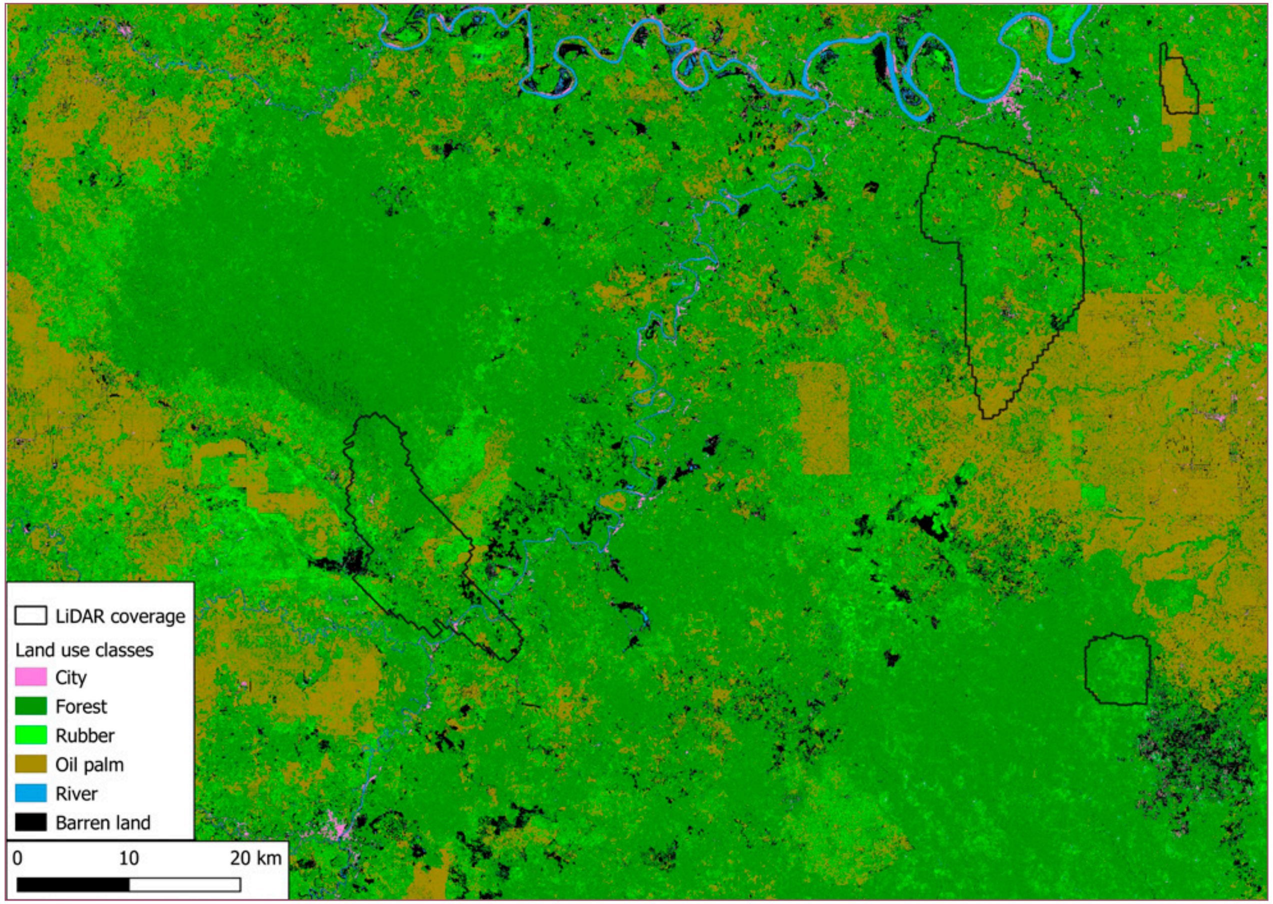

Figure 33. Land use map for the year 2019, based on Sentinel-1 and Sentinel-2 data.

ity between forest plots and oil palm and shrublands.

In total, 12 vegetation indices were also computed for all hyperspectral passes acquired, and summary statistics have been extracted and compiled for all plots available (both *Landscape Assessment* and Core Plots). Furthermore, normalized difference vegetation index (NDVI) layers at 1 m resolution have been produced for the four acquisition areas (Fig. 31).

In addition to the airborne data, spaceborne radar data were used to estimate canopy height, aboveground biomass and their changes on landscape level (Fig. 32). The aboveground biomass change was estimated with a root mean square error of 2.38 Mg ha^{-1} year^{-1}, equivalent to 13.32 % of the actual aboveground biomass difference range. Furthermore, it was found that initial canopy height and fire occurrences affected the aboveground biomass change significantly. Additionally, a land use map covering most of Jambi province was computed for the year 2019 using a combination of Sentinel-1 and Sentinel-2 satellite data (Fig. 33). Six maps of oil palm coverage were also computed for each year in the interval 2015-2021, as well as yearly maps of oil palm coverage changes in the same time period. All maps are provided at a 10 m pixel resolution.

OTHER ACTIVITIES RELATED TO *EFFORTS*:

WP2 group has remotely lead part of the *Landscape Assessment* plot establishment work (i.e. plot coordinates acquisition), by closely interfacing with the local team on the ground.

Z02 – Central Scientific Service Project

TITLE: **Monitoring aboveground biodiversity: Canopy Arthropods (WP3)**

TEAM: Principle Investigators: Stefan Scheu (UGoe); Damayanti Buchori, Purnama Hidayat (IPB University).
Scientific Staff: Jochen Drescher (Postdoctoral Researcher)
Associated Scientists: Melanie Maraun (Postdoctoral Researcher), Tamara Hartke (Scientist, ZFMK Bonn), Danilo Harms, Martin Husemann (ztm Hamburg); Amanda Mawan, Daniel Ramos Gutierrez (Doctoral Researcher).

Picture 39. First authors of Z03 WP3 publications in 2020-2022. (a) Rizky Nazarreta, (b) Naufal Rizqulloh, (c) Jan Kreider, (d) Kasmiatun, (e) Rawati Panjaitan, (f) Azru Azhar, (g) André Junggebauer and (h) Daniel Ramos Gutierrez.

RESEARCH SUMMARY:

From 2020-2021, the work of subproject Z02 WP3 (canopy biodiversity monitoring) has largely focused on three objectives: (1) Publishing general biodiversity patterns of focal taxa within Z02 WP3 and connected taxonomic documentations, mostly using samples from the first canopy fogging across the dry season 2013 and rainy season 2013/14 in *EFForTS* Core Plots. (2) Establish new data using samples from the second canopy fogging campaign in *EFForTS* Core Plots and Riparian Sites of the dry season 2017. (3) Collecting samples from the *EFForTS Landscape Assessment*.

Regarding objective (1), we were able to publish several studies on general biodiversity patterns of aboveground arthropods, mostly under first authorship of *EFForTS* ABS students, but also associated scientists and students from UGOE (Picture 39). Papers by R. Nazarreta and M. N. Rizqulloh showed that overall richness and abundance of canopy ants declined in response to the land-use change studied in *EFForTS*, both in the canopy and soil, while the relative abundance of exotic tramp ants increased (Nazarreta *et al.*, 2020, Rizqulloh *et al.*, 2021). These publications were supported by a field guide to the ants of Jambi including an updated identification key to the ant genera of Southeast Asia (Nazarreta *et al.*, 2021). Using community phylogenetics and a trait-based approach, J. Kreider further showed that rainforest conversion to monocultures favored generalist ant species with large colonies (Kreider *et al.*, 2021). This taxonomic work also led to the description of a new ant species, *Overbeckia jambiensis* sp. nov., from a very rare and elusive ant genus in Southeast Asia (Klimes *et al.*, 2022). We also published a number of studies showing similar biodiversity and population declines along the rainforest-to-monoculture gradient in other taxa, e.g. in beetles (Kasmiatun *et al.*, in review), butterflies (Panjaitan *et al.* 2020), parasitoid wasps (Azhar *et al.*, 2022), and spiders (Junggebauer *et*

al., 2021; Ramos *et al.*, in review). Further, we released a field guide to butterflies the butterflies of Jambi (Panjaitan *et al.*, 2021) and are close to publishing a similar field book for beetles (Hidayat *et al.*, 2022). A similar guide for canopy spiders is in preparation (Ramos *et al.*, in prep.).
Currently we work on further publications including a biodiversity study on canopy Collembola (Mawan *et al.*, in prep.), an analysis of the canopy food web (Maraun *et al.*, in prep.), a comparison of energy fluxes between canopy and soil (Potapov *et al.*, in prep.), a method paper presenting rapid assessment strategies (Hartke *et al.*, in prep), biodiversity and functional diversity comparisions between canopy and soil (spiders: Fardiansah et al, in prep; ants: Drescher et al, in prep.) as well a re-analysis of butterfly biodiversity and ecological traits from *EFForTS* Core Plots and the Biodiversity Enrichment Experiment (collab. with B11, in prep.).

Objective (2): Using samples collected in the third canopy fogging campaign in 2017 we sorted 17.000 canopy ants (Formicidae) to 48 genera, ca. 7.000 canopy spiders to 48 families and ca. 3000 beetle specimens from four focal families (Chrysomelidae, Curculionidae, Elateridae and Staphylinidae) to more than 350 morphospecies. Abundance data per taxon per plot will be used in several planned publications,

Picture 40. The field team of Z02 WP3 during the 2021 Landcape Assessment and their sampling methods: (a) Adi Parulian Lubis, Marianus Jan Mario, Roni Juangga (driver), Ahmad Roni (driver), Y. Toni Rohaditomo, Fajar Sidik, Yudhi Pangestu, M. Naufal Rizqulloh (from left to right); (b) canopy fogging in a mature oil palm plantation; (c) leaf litter sampling in a $1 m^2$ area, followd by (d) Winkler extraction.

Picture 41. The lab teams of Z02 WP3 during the ongoing processing of collected samples: (a) the general sorting team at UNJA, with Kasmiatun, Juwita Maharani Sihombing, Rizky Nazarreta, Febrina Heraweni and Handriyani (clockwise from bottom), and (b) the ant specialists at IPB with Naufal Rizqulloh, Rani Novita and Ferdian (top to bottom).

including one study in which we test the usefulness of airborne LiDAR derived canopy metrics to estimate canopy arthropod biodiversity and biomass (Camarretta, Drescher *et al.*, in prep.). Additionally, for each of the four beetle families, the trophic ecology of a representative subset of the local community will be analyzed using stable isotopes of ^{13}C and ^{15}N, and the phylogenetic architecture of each local community will be analyzed by barcoding at least one individual for each morphospecies using standart barcoding markers COI and 28S.

Objective (3): >120 plots of the *EFForTS Landscape Assessment* have been successfully sampled by a field team led by T. Rohaditomo (UNJA) and N. Rizqulloh (IPB University). Two types of samplings were conducted, canopy fogging and leaf litter collection followed by Winkler extraction (Picture 40a-c). A dedicated lab team under R. Nazarreta sorted more than 420.000 specimens to 12 major arthropod orders (Picture 41a), and more than 12.000 individual measurements of body length and body width of a representative subset will allow to estimate biomasses across the major invertebrate groups, both in the canopy and litter. A second lab team under N. Rizqulloh has started to further sort about 130.000 ant specimens (Picture 41b), first to genus and later to species, to create a robust proxy for overall arthropod biodiversity in the litter and canopies of the *EFForTS Landscape Assessment*.

Challenges of the coronavirus pandemic:

The Corona virus pandemic substantially influenced our work, both at our lab in UGOE at the Animal Ecology department (AG Scheu), as well as the labs of our counterparts at the Plant Protection Department of IPB University Bogor (Buchori lab). In both locations, sorting work is almost always ongoing, or other kinds of analyses which require physical presence of staff and students. The Corona virus-related restrictions were more severe at IPB University labs, where physical presence was not possible for a substantial amount of time and heavily restricted almost up until now. Restrictions at the UGOE labs were similar, but as we had space to isolate students, some theses could be conducted. Supervision of theses was almost entirely per videocall, even if supervisor and students were physically in the same building, at least during the first one and a half years of the pandemic. This affected efficiency; personal meetings are more constructive as discussons flow more freely, and tools like whiteboards or paper can be used to sketch graphs or analyses. On the other hand, videocalls for other kinds of meetings became a very welcome new tool, indeed increasing efficiency due to not having to physically move between faculties of the university, or even to different locations in Germany or worldwide.

Fieldwork was naturally not possible during the Corona virus pandemic, at least not for staff from Göttingen University. This caused a one-year delay in the *Landscape Assessent*, which was originally planned for 2020. Sampling in 2021 was conducted "remotely", as again no research permits or visa were issued to any Göttingen University staff. This remote field campaign turned out to be a complete success, however. The main reason behind this is likely that Z02 WP3, but also other projects, could rely on a highly professional research infrastructure that was built in *EFForTS* over the first two funding phases. The coordination offices in Göttingen (Barbara Wick), Bogor (Rahadian Pratama), Jambi (Aiyen Tjoa) worked well together in providing researchers with whatever was needed to conduct their research, and Aiyen Tjoa managed the field campaign in a superb manner. Another crucial component to the successful *Landscape Assessment* were central key figures in the local assistants. In the case of Z02 WP3, this was first and foremost Toni Rohaditomo, who had been already hired since funding Phase 1 and who was able to rise to the challenge to organize and supervise the Canopy Fogging Campaign of the *Landscape Assessment*. Two more local assistants proved to be key to the success of the field campaign: Rizky Nazarreta, likewise a long-time assistant since funding Phase 1, who could organize and supervise a sorting team in UNJA lab space, and Naufal Rizqulloh, who had been to Göttingen University during an ABS-funded visit but was new to the sampling method of Z02 WP3; he contributed key ideas to the final sampling design (litter sampling, Winkler extraction), which he organized and taught the other field assistants; and lastly, Arne Wenzel from subproject B09 (Westphal, Grass) at Göttingen University, who organized the scientific cooperation of the concerted, *EFForTS*-wide *Landscape Assessment* field campaign. So overall, a previously unheard of massive and complex "remote field campaign" during a global pandemic was made possible due to long-term cooperation within the *EFForTS* project, with well-established coordination and research infrastructure, highly trained local research assistants at key positions and efficient cooperation among *EFForTS* postdocs.

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INF Research Data Management and Integrative Statistical Analysis

TEAM: Principle Investigators: Wolfram Horstmann, Thomas Kneib, Ramin Yahyapour (UGoe); Suria Darma Tarigan (IPB University); Junaidi Sutan (UNTAD).
Scientific Staff: Philipp Wieder, Daniel Kurzawe, Faraz Fatemi Moghaddan, Miryam Sarah Merk, Aytaj Badirova.

RESEARCH SUMMARY:

Since the start of Phase 3, the most important objective of the INF data management group was to design and implement the new information system for *EFForTS*. There were several meetings with our colleagues in the other sub-projects of *EFForTS* to ensure the final system meets the expectations and requirements of researchers in terms of Application Programming Interface (API), metadata, security, and privacy of data. The processes of design and development were done based on the results. The other challenging issue which was successfully managed was to migrate the data previously uploaded in the old information system (BeXIS) from the beginning of the project in 2012 to the new system (Dataverse). The initial version of Dataverse was ready in fall 2020 and available for testing to a limited number of colleagues in *EFForTS*. After several tests and final modifications, the new information system was officially launched in summer 2021. There were several online workshops for researchers of *EFForTS* to demonstrate how to work with the new platform. Furthermore, it is planned to organize a F2F workshop in Indonesia after the pandemic (probably summer 2022).

Apart from implementation and migration to Dataverse, the INF data management group conducted several other tasks including: managing and supporting the general and financial Sharepoints, regular consultations with *EFForTS* researchers from other sub-projects, helping to design and develop specific information systems for some of sub-projects, regular meetings with *EFForTS* postdoctoral researchers to share ideas, etc.

Apart from the main Dataverse, INF has also contributed in the development of GeoMapper, which visualizes geospatial files from GRO. Data research repository, local desktop or remote links. The GeoMapper extension is available for *EFForTS* Dataverse datasets.

In addition, INF provided individual consultancy regarding the statistical analysis and evaluation of research data, involving the selection of suitable statistical methods, their implementation, and technical support in R and other statistical software. Furthermore, two well-attended statistical courses were offered online. In December 2020, an extensive introductory course on spatial data analysis and applications in R was held, and in April 2022, a workshop on data visualization with ggplot2 and extension packages was conducted. Apart from that, INF has contributed to several *EFForTS* research papers, including one published article (Camarretta *et al. 2021*), two submitted papers, and other ongoing collaborations, which are planned to be completed and submitted by summer 2022. For some of the research articles, advanced statistical learning methods such as Random Forests and gradient boosting were utilized.

Regarding personnel changes, Miryam Sarah Merk has joined the INF as a statistical consultant in April 2020 replacing Peter Pütz, Faraz Fatemi Moghaddam has joined CRC990 as a data management specialist in May 2020 replacing Johannes Biermann, and Aytaj Badirova has joined INF as a student assistant in March 2021.

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Public relations – Project Ö (PR)

TITLE: **Teacher education for society: Making *EFForTS* knowledge available for Indonesia**

TEAM: Principal Investigators: Susanne Bögeholz (UGoe); Leti Sundawati (IPB University); Upik Yelianti (UNJA); I Nengah Suparta (Undiksha/Bali).
Scientific Staff: Finn Matthiesen (Junior Scientist).
Associated Scientist: Sabina Eggert (Central Institute for Teacher Education and Research, UGoe).

RESEARCH SUMMARY:
Our *EFForTS* PR project has just (April 2022) completed the third testing phase of teaching and learning modules for *EFForTS* education. Testings began in May 2021. *EFForTS* education is based on integrative *EFForTS* research, *EFForTS* knowledge and resources. *EFForTS* education modules are collaboratively and iteratively designed for Higher Education in a German-Indonesian team of educational researchers, lecturers, master students, assistants, and *EFForTS* researchers (Picture 42). So far, *EFForTS* education includes two evaluated and optimised modules (Fig. 33): one on oil palm management (mainly related to *EFForTS OPMX*) and one on oil palm agroforestry (with a strong focus on *EFForTS BEE*). While the first is designed for teacher education, the second is for forestry education. Up to now, almost 880 students worked with *EFForTS* education modules for three to four weeks and 16 Indonesian lecturers have been involved in preparing, conducting, and optimising the modules. Both modules are available in English and Bahasa Indonesia.

Picture 42. Core team of developing and testing EFForTS education since 2020
- UGoe: Ivo Daumann, Jacqueline Dischereit, Gina Göhmann, Dominik Finke, Simon Oberdörfer, Mai Pham
- Indonesian lecturers involved in Oil Palm Management module: Junior lecturers: Raissa Mataniari (UNJA), I Made Oka Riawan (Undiksha), I ede Arjana (Undiksha), Ida Ayu Putu Suryanti (Undiksha), Erti Hamimi (UM). Senior lecturers: Upik Yelianti (UNJA), Evita Anggereini (UNJA), I Wayan Sukra Warpala (Undiksha), I Wayan Muderawan (Undiksha), Indra Fardhani (UM), Safwatun Nida (UM)
- Indonesian lecturers involved in Oil Palm Agroforestry module: Junior lecturers: Fitta Setiajiati (IPB University), Rince Muryunika (UNJA). Senior lecturers: Leti Sundawati (IPB University), Bambang Irawan (UNJA), Adisti Permatasari Putri Hartoyo (IPB University)

OUTLOOK: Our main focus in the next months will be to analyse the evaluation data in detail to prepare publications. In the second half of 2022 and in 2023, we will further develop,

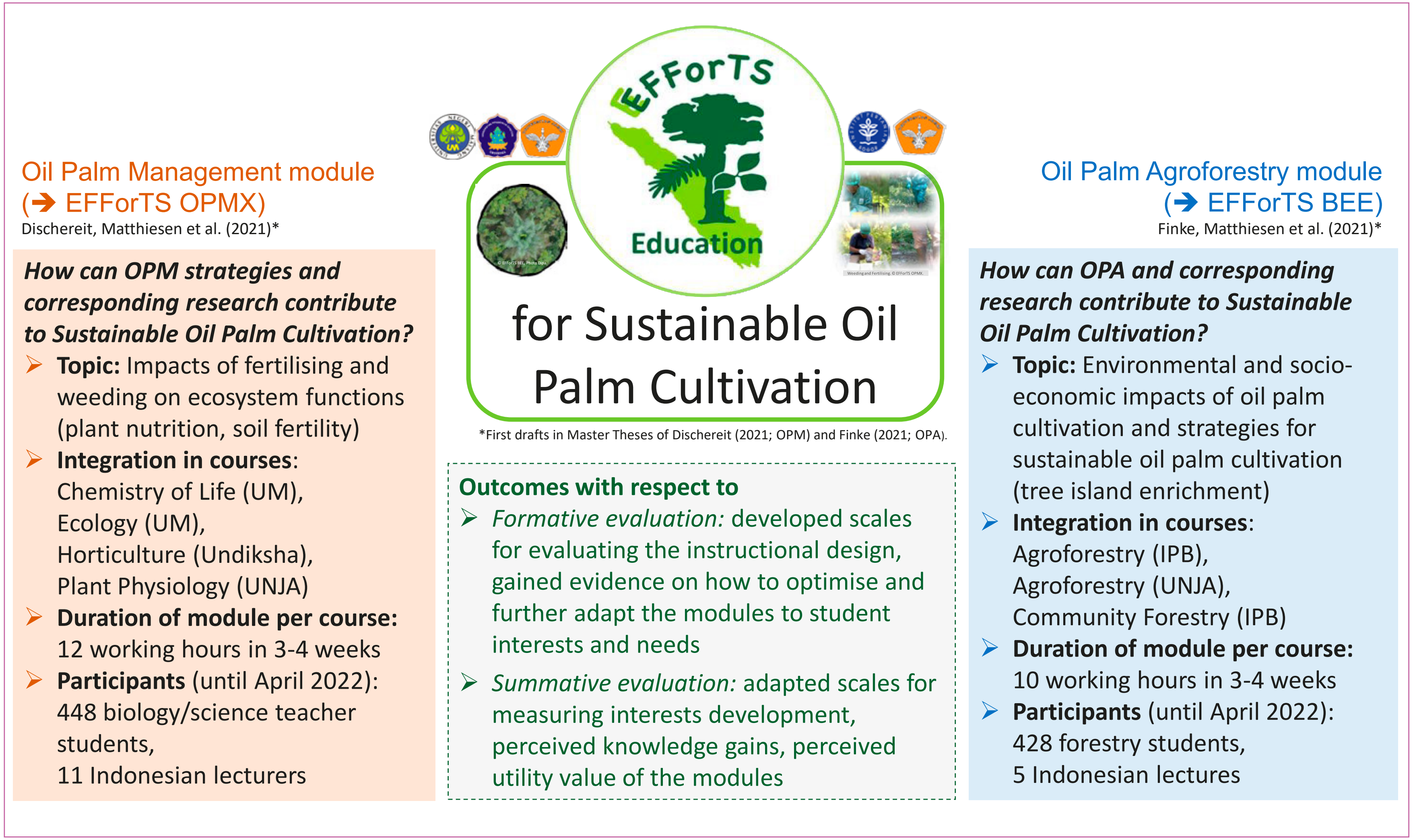

Figure 33. *EFForTS* education modules on Oil Palm Management (OPM) and on Oil Palm Agroforestry (OPA).

enrich, and disseminate *EFForTS* education – to make *EFForTS* knowledge even more available for society in Indonesia and beyond.

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Polle – associated

TITLE: **Impact of land-use and management changes on soil and root associated fungal communities**

TEAM: Principle Investigators: Andrea Polle (UGoe), Bambang Irawan (UNJA).
Scientific Staff: Johannes Ballauff (Postdoctoral Researcher).
Associated Scientists: Nur Edy, Aisjah Ryadin (Postdoctoral Researcher).

BACKGROUND AND METHODS:

The interaction of plants and soil fungi at the level of fine root rhizosphere provides a key link between above and belowground ecosystem. Saprotrophic decomposition of plant material as well as numerous symbiotrophic interactions, such as mycorrhiza, facilitate carbon and nitrogen turnover. However, land transformation severely alters the functional composition of fungal communities and impairs key plant fungi interactions. We used next-generation DNA sequencing techniques to investigated fungal communities living in soil as well as directly associated with plant roots across all *EFForTS* core and riparian research plots. Further we analyzed essential soil and root chemical properties to identify the underlying environmental drivers of the fungal community turnover in the root and soil compartment.

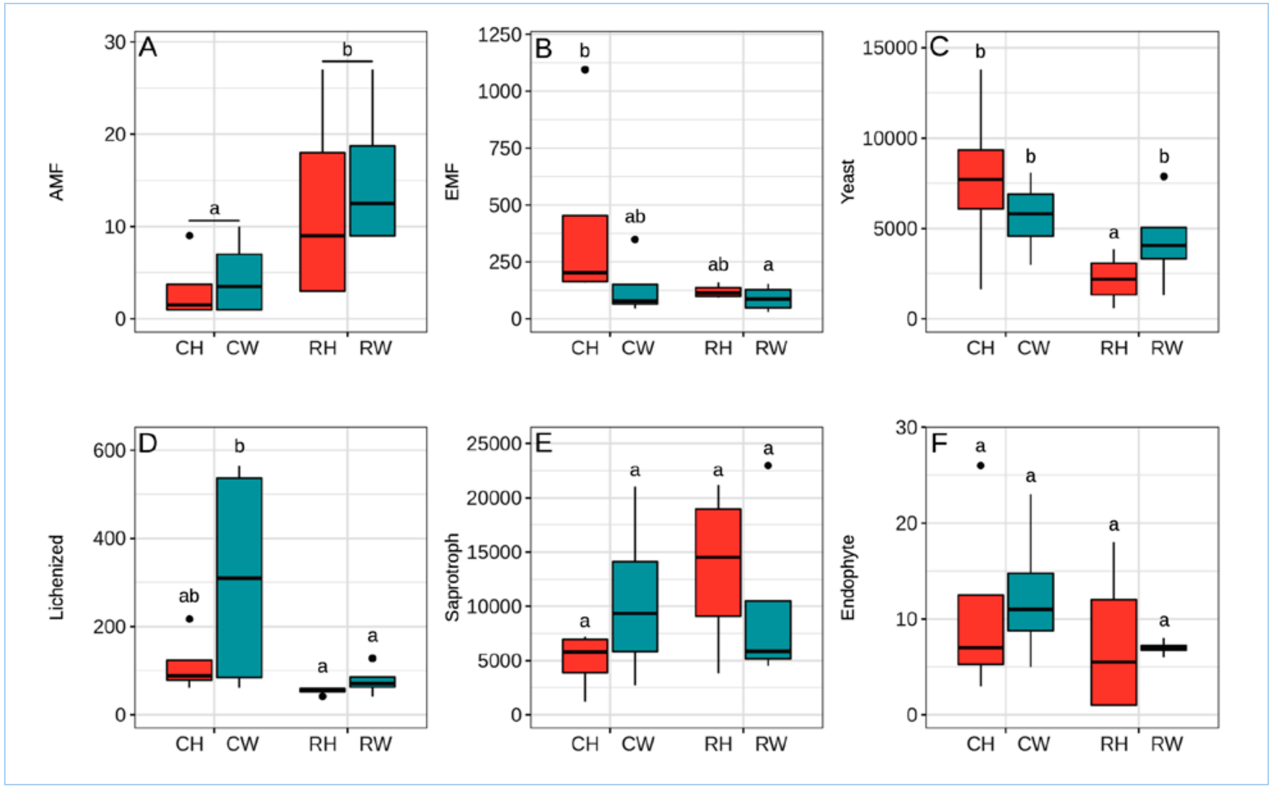

Figure 34. Species richness of fungal guilds associated with oil palm roots. A: Arbuscular mycorrhizal fungi, B: Multiguild fungi with ectomycorrhizal potential; C: yeasts; D: Lichenized fungi; E: Saprotrophic fungi; F: endophytic fungi. CW = conventional fertilization and weeding, RH = reduced fertilization and herbicide treatment, RW = reduced fertilization and weeding. Species richness in four plots per treatment with three replicate samples per plot. Data show box-plots (20% to 80%, horizontal line = mean). Different letters above the boxed indicate significant treatment effects at $chi^2 < 0.05$.

In cooperation with *EFForTS-BEE* and the *EFForTS-OMPX* experiments we also investigated how alternative oil palm management strategies affect fungal communities and whether sustainable management can recover symbiotroph fungal interactions.

HIGHLIGHTS:

We showed that root- and soil-associated fungal communities are distinct and that environmental filters differ in their relative importance of driving the assembly of those communities. Root traits can stabilize the associated fungal community against distance

decay and changes in edaphic conditions while soil fungal communities present in the landscape may serve as a pool for colonizing plant roots via long distance dispersal, thus promoting the recovery of disturbed communities (Ballauff *et al.* 2021). While the B07 subproject ended with Phase 2 of the *EFForTS* project, we will be further investigating the structuring effects of landscape composition and specific plant fungus interactions within the ongoing *Landscape Assessment* (LA) sampling in collaboration with B08 and B14.
Soil fungal communities in the *EFForTS-BEE* experiment were affected by soil abiotic conditions as well as a strong legacy effect of intensive land-use in the first years of Agroforestry plantations (Ballauff *et al.* 2020). However, we observed early positive responses of arbuscular mycorrhizal fungi (AMF) under low fertilizer treatment in the OPMX, while multiguild fungi (EMF) decreased and other fungal groups were unaffected (Ryadin *et al.* 2022) (Fig. 34). Studying the further succession of root-associated communities will help to predict future effects of more sustainable management strategies on the microbiome in monoculture plantations.
Last but not least, we are very happy to announce the successful graduation of our Indonesian colleague Dr. Aisjah Rachmawaty Ryadin in April 2022. Congratulations, Aisjah!

II. Integration of Ecological and Socioeconomic Research

Integration / integrative research activities across disciplines is realized through

- the establishment of a joint enrichment planting experiment (B11, *EFForTS-BEE*)
- oil palm management experiment (*EFForTS-OPMX*)
- *Landscape Assesment*
- four thematic foci / overarching joint hypotheses.

1. Integrative research activities

The enrichment experiment (*EFForTS-BEE*, B11)

TITLE: **Biodiversity enrichment in oil palm plantations: plant succession and integration**

TEAM: Principal Investigators: Dirk Hölscher , Holger Kreft, Meike Wollni (UGoe); Leti Sundawati (IPB University); Bambang Irawan (UNJA).
Scientific Staff: Gustavo Brant Paterno (Postdoctoral Researcher).
Associated Scientist: Delphine Clara Zemp (University of Neuchâtel), Yevgeniya Korol (Doctoral Researcher), Vannesa Montoya-Sánchez (Doctoral Researcher, University of Neuchâtel).

RESEARCH SUMMARY:

Oil-palm plantations can promote the well-being of farmers but this usually comes at the expense of declining biodiversity and ecosystem services in tropical regions. But is it possible to alleviate the environmental impacts from oil-palm plantations without compromising oil palm yield? Here, we ask if enriching oil-palm plantations with native trees promotes the natural restoration of biodiversity and ecosystem functioning and how this trades off with oil-palm yield. To answer this question, the Biodiversity Enrichment Experiment (*EFForTS-BEE*) was established in Indonesia, Sumatra. In total, 52 tree islands varying in size (25 m^2, 100 m^2, 400 m^2, 1600 m^2), the richness of native trees (0, 1, 2, 3, 6), and species composition were established within an oil-palm plantation. In addition, four control plots were established in management as usual oil-palm plantations. Tree performance, oil palm yield, natural regeneration, vegetation structure, several ecosystem functions, and multiple taxonomic groups are monitored in *EFForTS-BEE* in collaboration with many subprojects (Picture 43).

After eight years of planting, enriched oil palm plantations already have some large trees (e. g. ~ 20 meters in height) while many tree individuals are already flowering and producing fruits (i. e. Jengkol) (Picture 43). The performance and survival of the six planted tree species is highly species-specific. While *Peronema canenses* and *Archidendron jiringa* shows high survival in most plots (e. g. > 80 %), *Shorea leprosula* and *Durio zibethinus* are failing to thrive in the experiment (e. g. less than 10 % of planted individuals survived) (Fig. 35). In general, planted species are continuously increasing in size through time which leads to higher above-ground biomass and enhanced vegetation structural complexity and microclimatic conditions.

A synthesis analysis using data collected by multiple subprojects during Phase 2 showed

Picture 43. An overview of different field monitoring and lab activities performed in collaboration with several subprojects in *EFForTS-BEE* experiment.

that in comparison to oil palm monocultures, tree islands promoted much higher multi-taxa diversity (enhanced by 250 %) and also ecosystem multifunctionality (enhanced by 75 %) without significant decrease in oil palm yield (Fig. 36). In Phase 3 we are implementing a joint interdisciplinary field campaign, including the assessment of below- and above-ground functional diversity of *EFForTS-BEE* plant community. Next steps will be to evaluate if long-term tree-palm competition generates trade-offs between the recovery of ecosystem multifunctionality and economic function in oil palm agroforestry systems.

Tree-based restoration in oil-palm plantations also promoted the natural regeneration of a diverse plant community, enhancing taxonomic and phylogenetic diversity of tree species (Fig. 37). In total, 4445 tree individuals, from 62 tree species and 31 plant families, established spontaneously in *EFForTS-BEE* since the start of the experiment. More importantly, larger and more diverse tree islands increased phylogenetic and taxonomic diversity of the

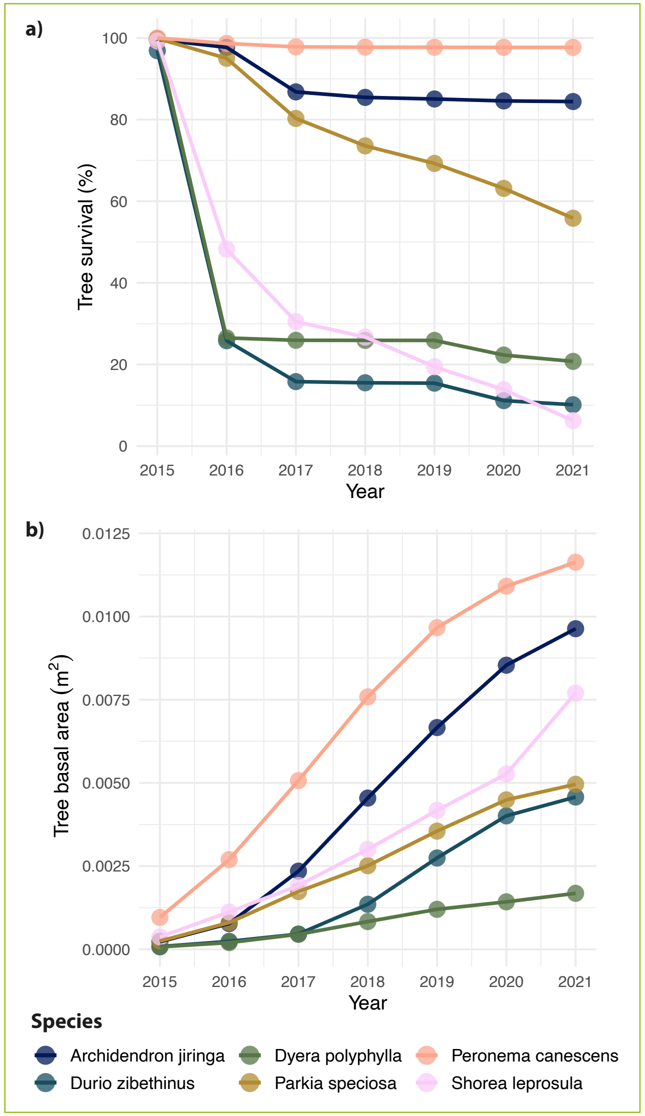

Figure 35. Tree performance in *EFForTS-BEE*. Survival (a) and basal area (b) of planted tree species through time. Points represent average values of survival and basal area across all plots for every tree species and monitoring year.

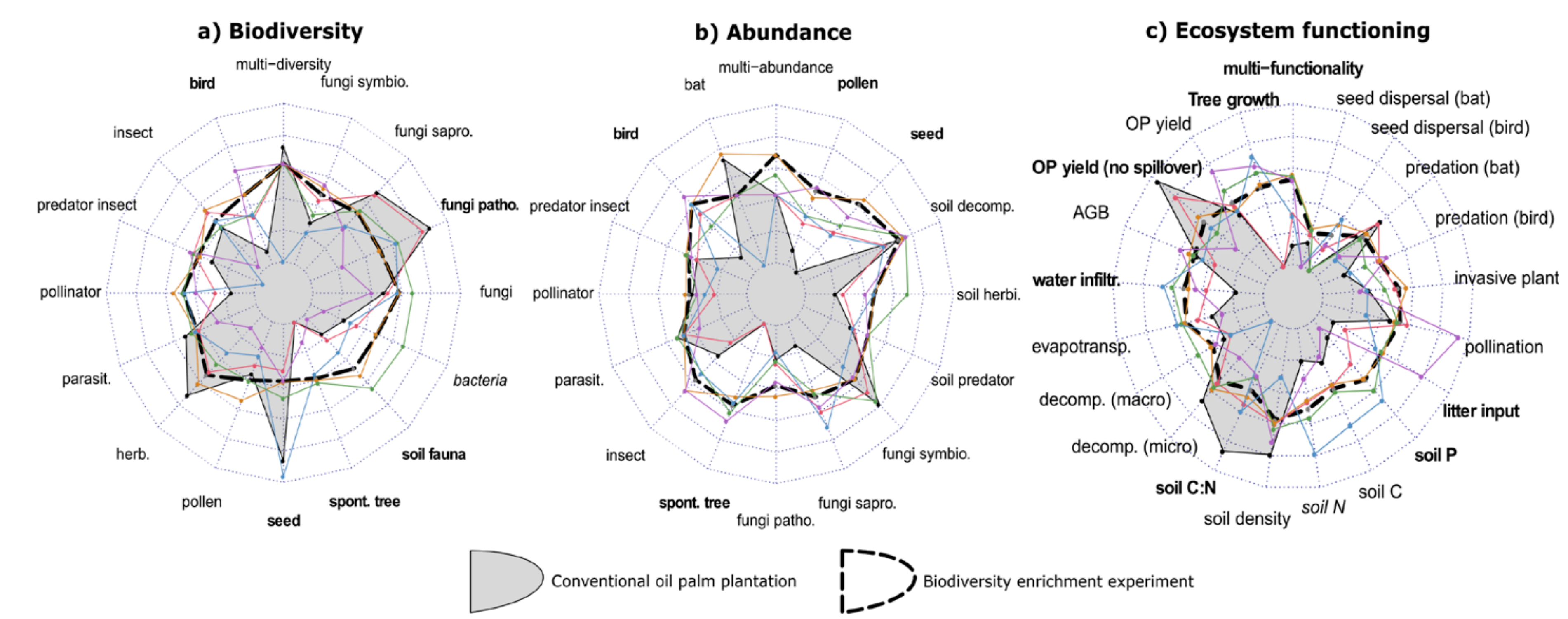

Figure 36. Overall restoration success. Restoration outcomes in terms of (A) biodiversity quantified as the effective number of species in different taxonomic groups, (B) abundance quantified as the number of individuals in the groups and (C) ecosystem functioning as compared between the experiment (black dashed line, unfilled polygon) and conventional oil palm plantation (thick black line, filled polygon). The restoration outcomes that are significantly different (p-value < 0.05) are shown in bold, and marginal differences (p-value < 0.1) are shown in italics. For each outcome, the inner and outer circles indicate the 5th and 95th percentiles, respectively, and the line indicates the mean value of the transformed data. Variability within the experiment is shown with color lines pointing to restoration outcomes at different tree diversity levels. Figure and caption provided by Delphine Clara Zemp.

regenerating tree community (Fig. 37). We also found evidence that soil nutrient availability and propagule limitation might be important constraints to natural regeneration. The next steps will be to understand what are the main internal and external drivers (i.e landscape) promoting community succession in enriched oil-palm agroforestry systems.

In conclusion, creating islands of diversity in mono-specific oil palm landscapes is a promising strategy to restore multiple facets of biodiversity and ecosystem functioning without compromising farmers' income and livelihood.

Challenges of the coronavirus pandemic:

The cov-19 pandemic has seriously hampered the implementation of many planned activities in the *EFForTS-BEE* experiment. The main interdisciplinary field campaign that was to be carried out in 2021 in collaboration with other *EFForTS* subprojects had to be postponed. Many students who would

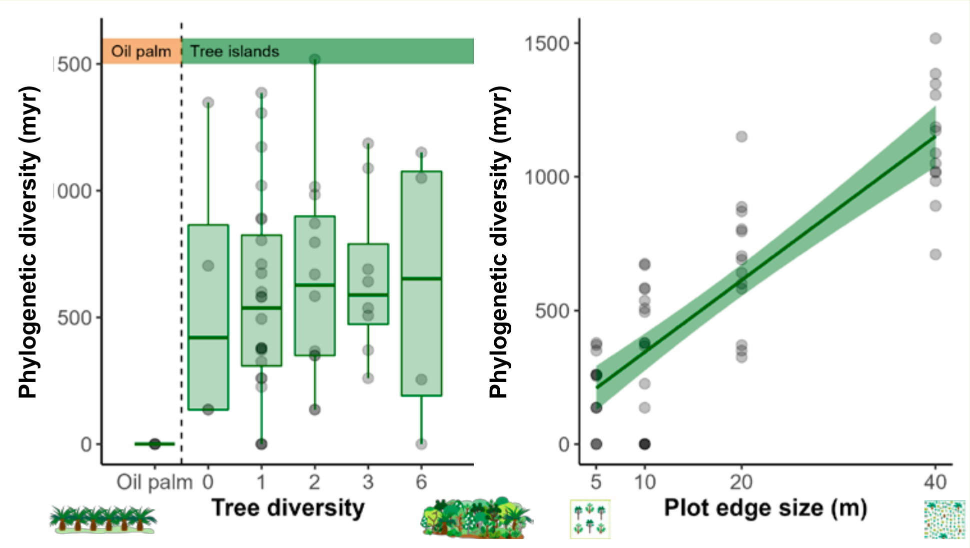

Figure 37. Phylogenetic diversity (millions of years) of naturally regenerating tree communities in *EFForTS-BEE* experiment. Left panel: comparison of the phylogenetic diversity between oil palm and tree islands with increasing diversity of planted trees. Right panel: Phylogenetic diversity against plot edge size. Dark green line represents fitted regression by simple linear model and associated 95 % confidence interval (shaded area).

have done their MSc thesis or part of their PhD studies with field work in Indonesia were also unable to complete their research due to pandemic-related restrictions. Some of our assistants were also sickened by covid and this interrupted field monitoring and data collection activities.

EFForTS-OPMX

TITLE: **Effects of different management practices on ecosystem functions and profitability in a large-scale oil palm plantation**

TEAM: Principal investigators: Marife D. Corre, Edzo Veldkamp (UGoe); Bambang Irawan, Muhammad Damris (UNJA); Aiyen Tjoa (UNTAD).
Scientific Coordination: Najeeb Al-Amin Iddris (Postdoctoral Researcher).

RESEARCH SUMMARY:

Oil palm plantations are very productive but strongly depend on high fertilizer and herbicide applications, which can diminish other ecosystem services. There is therefore the need to identify optimal fertilizer application rates and weed control that provide sufficient nutrients for high productivity while minimizing associated losses of ecosystem functions and biodiversity. Thus, in Phase 2, we established the Oil Palm Management Experiment (*EFForTS-OPMX*) in November 2016 in a large-scale oil palm estate (PT Perkebunan Nustanrat VI). The aim of the management experiment is to experimentally test whether a reduced management intensity can contribute to a more sustainable oil palm production than current conventional management. Using a full factorial field experiment of two fertilization levels × two weeding practices, we assessed the effects of conventional vs. reduced (i. e., only compensating for harvest export) fertilization rates and herbicide vs. mechanical weeding on ecosystem functions, biodiversity and profitability. The A, B and C projects analysed the ecological and economic consequences of the different treatments, and a synthesis of the results of the first two years was published in Darras *et al.*, (2019). In Phase 3, further synthesis of results after 4 years of the management experiment showed that ecosystem multifunctionality (an aggregated measure of multiple ecosystem functions) was higher under mechanical as compared to herbicide weeding (Fig. 38). Biodiversity was also higher in the mechanical than herbicide treatment, and this was mainly driven by the strong increase in understory vegetation species richness in the mechanical weeding treatment (Fig 38). Of

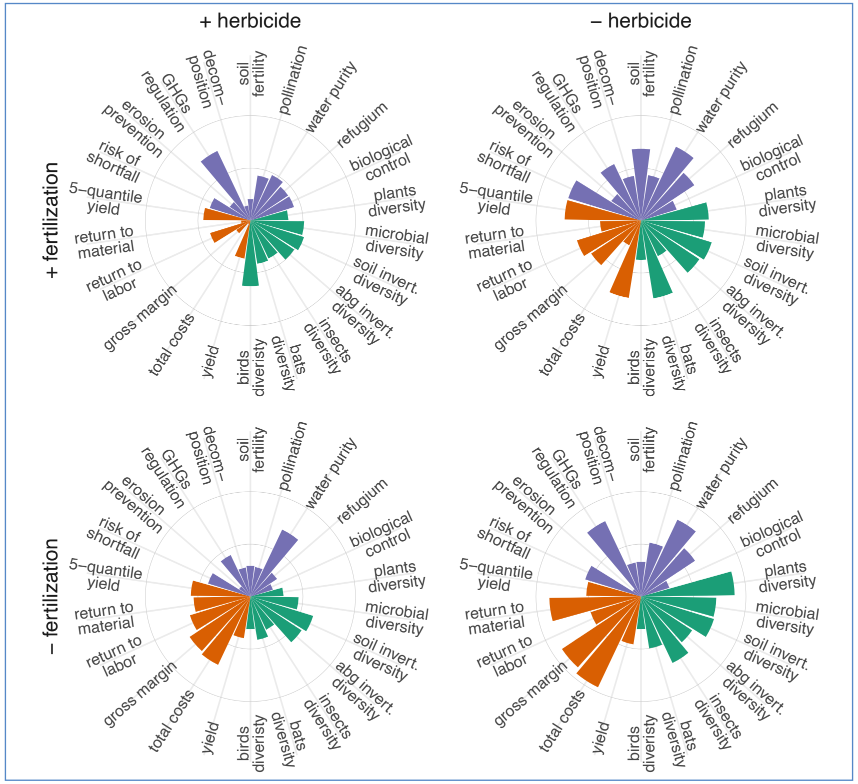

Figure 38. Ecosystem (purple), biodiversity (green) and economic functions (orange) in different fertilization and weeding treatments (n = 4 plots) in a large-scale oil palm plantation in Jambi, Indonesia. The outer edge of the petals represents the mean of the z-standardized values of eight ecosystem functions, seven multitrophic richness for biodiversity, and six indicators of economic function. Each function was standardized between 0 (circle center) and 1 (circle edge). 22 factorial treatments: + indicates conventional fertilization and herbicide weeding; – denotes reduced fertilization and mechanical weeding.

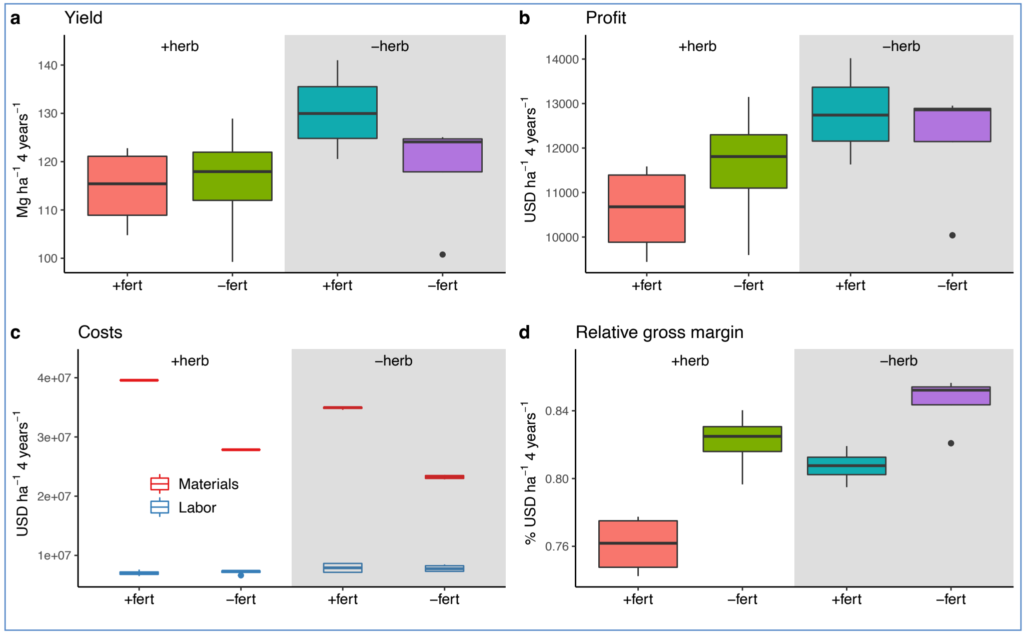

Figure 39. Economic functions (cumulative values for 2017-2020) in different fertilization and weeding treatments (n = 4 plots) in a large-scale oil palm plantation in Jambi, Indonesia. Boxplots indicate the 25th percentile, median and 75th percentile, and whiskers are 1.5 times the interquartile range. 22 factorial treatments: +fert +herb – conventional fertilization with herbicide weeding; -fert +herb – reduced fertilization with herbicide weeding; +fert -herb – conventional fertilization with mechanical weeding; -fert -herb – reduced fertilization with mechanical weeding. Profit was calculated based on the 2016-2017 average oil palm price and costs (taken from Darras *et al.*, 2019).

the 126 plant species recorded in the plantation, 33 % more species occurred in the reduced management treatment compared to conventional management. Reduced fertilization and mechanical weeding also resulted in a 12 % increase in profit and 11 % increase in gross margin while attaining comparable yield as the conventional management (Fig. 39). The *EFForTS-OPMX* provide strong experimental evidence that mechanical weeding with reduced compensatory fertilization in oil palm plantations is a sustainable management practice for increasing profit and improving biodiversity and ecosystem multifunctionality.

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Landscape Assessment

TEAM: Scientific Supervisors: Catrin Westphal, Ingo Grass (B09), Stefan Scheu (B08, Z01, Z02).
Scientific Coordination: Arne Wenzel (B09).

RESEARCH SUMMARY:

Motivation

The *Landscape Assessment* (*EFForTS-LA* or short "LA") is the novel collaborative research platform of the third phase. Initiated and coordinated by B09, the mayor motivation of the LA is to go beyond the local scale and embed the data from previous phases in a larger spatial framework that consists of over 100 field sites distributed evenly across a large area in the Harapan and Bukit Duabelas landscapes. By incorporating this large number of plots and by focusing on rapid assessment methods we aim to scale up previous socioeconomic and ecological findings to a regional level.

Study design and plot selection

The plot selection process, which included intensive travels and innumerous visits to farm sites and villages throughout our entire study area was mainly spearheaded by B09's team member Erick Mandelson, supervised by Kevin Darras (B09's former Postdoc) and Arne Wenzel. This selection process was finally completed in April 2021. In the end, 132 field sites had been selected (Fig. 40).

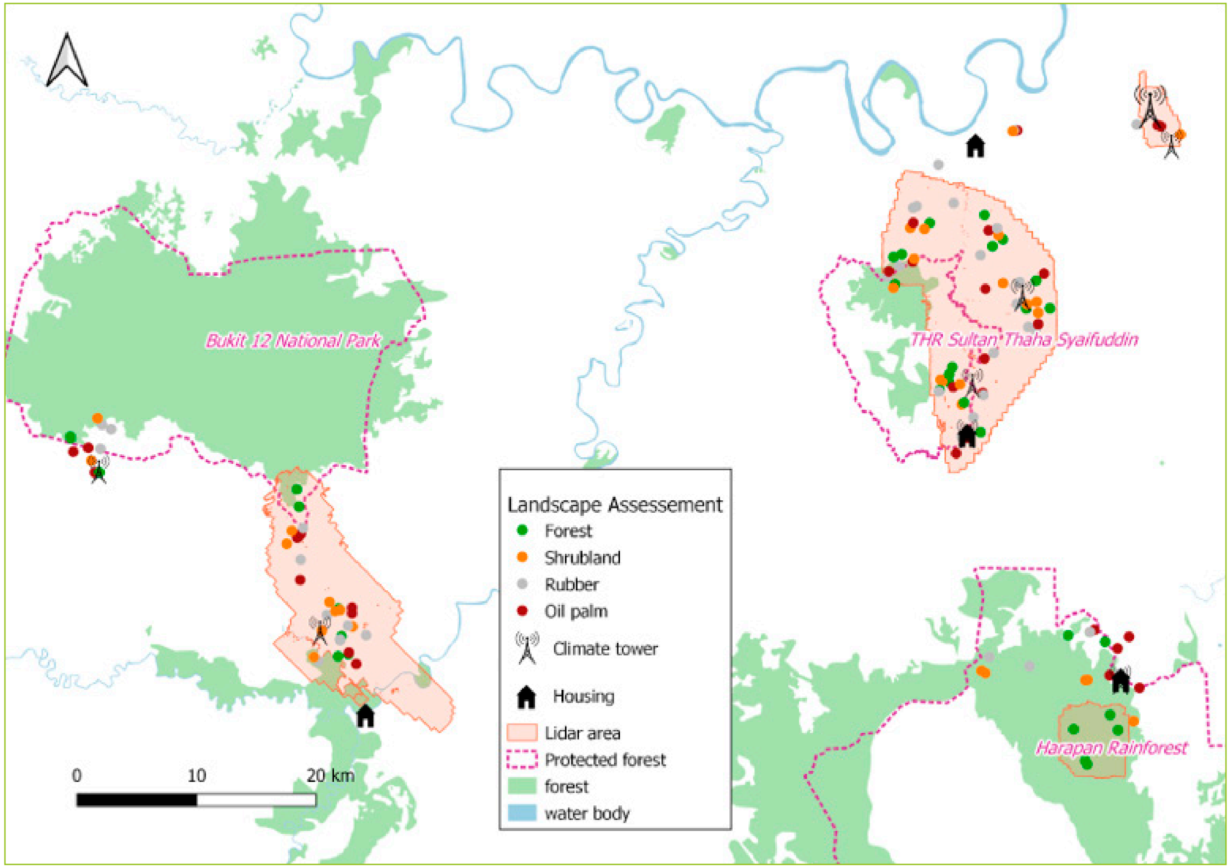


Figure 40. Map showing the *Landscape Assessment* plots (circular dots). Colors indicate the four land uses. The *EFForTS* climate towers and field housing locations are also displayed. Areas covered by airborne LIDAR are highlighted with red polygons.

Field sites covered the four main land uses of the region: forest, shrubland, rubber plantations and oil palm plantations. Shrubland is an important addition, not considered in the first phases, that includes fallows that were typically forested before being cleared for plantations; it represents so far unstudied economic and ecological dimensions. Plots were selected along multiple gradients, such as surrounding forest cover, plantation age and management intensity or plot ownership.

Almost all *EFForTS* subprojects planned to contribute to the LA with rapid assessments of their routine sampling protocols, meaning that the final data covers a wide spectrum of environmental or ecological functions, taken both above and below the ground. Additionally, airborne and terrestrial LIDAR measures provides high-resolution information on vegetation structure and complexity. Finally, an extensive household panel led by C06 provides detailed socioeconomic data.

Field campaign in 2021

As the global Coronavirus pandemic was still making it impossible to travel to Sumatra in 2021 the decision was taken to conduct a remotely supervised field campaign, meaning that the research staff based in Göttingen would organize and oversee fieldwork activates from abroad relying totally on their teams of local research assistants. For this purpose, we employed modern data collection tools such as the collection of data via an app (KoboToolbox), which was synchronized with a server hosted in Göttingen by the GWDG. This setup allowed for immediate data access and checkups by the researchers in Germany.

The main LA field campaign started in May 2021 with a virtual kickoff gathering of all involved researchers and field assistants. Core field teams were formed around related fieldwork packages (i.e. stationary measures, vegetation sampling, canopy fogging, household surveys or DGPS coordinates). These core teams visited the plots in sequence, coordinating among themselves, which plots to tackle when, to avoid interferences and ensure the best data quality. In the background, the relentless efforts of the local coordination team, led by Aiyen Tjoa, ensured a smooth implementation and helped greatly to organize transportation, storage space, field accommodation, permits and much more. The scientific coordination of the field teams was done by the respective Postdocs and PhDs, who met every two weeks during the field campaign for mutual updates, planning and discussions.

To minimize the any risk of an outbreak among our local assistants, a Covid protocol was developed and put into place for the duration of the campaign. This protocol entailed Covid vaccinations, regular tests of all our field assistants and how to behave in case of an infection.

In the end, the decision for a remotely managed field campaign paid dividends, largely due to the remarkable dedication and commitment of our field teams. Despite the ongoing pandemic and despite an unusual rainy dry season, the field teams overcame all obstacles and the main LA field campaign was completed in October 2021, after almost 5 months of intensive fieldwork.

OUTLOOK:

While a few teams are still busy in the field closing some last remaining data gaps or working on follow up projects, the *EFForTS*-LA has now entered into the phase of data analyses and manuscript preparations. Overall, 26 publications are currently planned within the framework of the *EFForTS-LA*, including some exciting synthesis projects that aim to make use of the wealth of data collected during the successful field campaign.

2. Four thematic foci

Focus 1

TITLE: **Assessment of ecological and socioeconomic functions, synergies and trade-offs across different land-use systems**

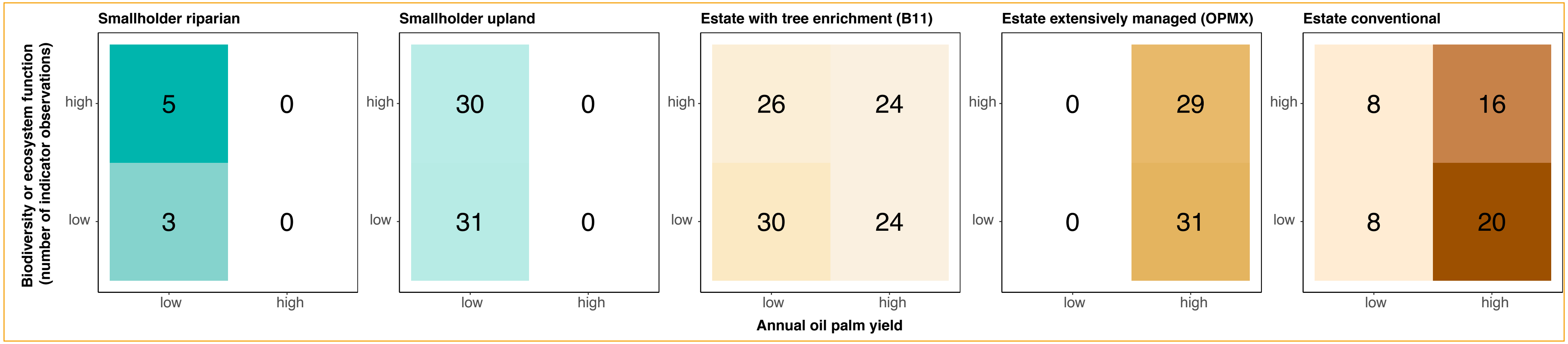
REPRESENTATIVES: Ingo Grass (B09, C11), Oliver Mußhoff (C06)

RESEARCH SUMMARY:

In an ongoing synthesis led by Arne Wenzel (postdoc B09), Focus 1 aims to identify management practices that mitigate economic-ecological trade-offs of oil palm production and ideally create win-win situations of high biodiversity and high crop yield. To this end, a large dataset combining data on biodiversity, ecosystem functions and oil palm yields, covering different oil palm systems (smallholder, estate, upland vs. riparian), oil palm management strategies (*EFForTS-OPMX*) and oil palm biodiversity enrichment (*EFForTS-BEE*), was assembled. All data were standardized to allow for comparisons of biodiversity/ecosystem functions and crop yield across oil palm systems. Oil palm yield was lowest in smallholder upland systems and highest in oil palm estates that were either conventionally or extensively managed (manual weeding, reduced fertilizer application; *EFForTS-OPMX*). Biodiversity and ecosystem functions exhibited great variability, with high and low biodiversity/function outcomes independent of variation in oil palm yield – indicating possibilities for combining high biodiversity with high yields (e.g., in extensively managed oil palm estates or estates enriched with tree plantings; *EFForTS-OPMX* and *EFForTS-BEE*) (Fig. 41).

To further explain (co-)variation in biodiversity/ecosystem functions and oil palm yield, remote sensing information from Lidar were used, and indices of vegetation structural complexity and cover fitted to two-dimensional ordinations of the standardized data. In this way, plot-level characteristics that correlate with high oil palm yields (e.g., the effective number of vegetation layers; enl) or high biodiversity/ecosystem functioning (e.g., total extent of gaps in the canopy; sum_gapArea) can be identified (Fig. 42). For specific taxa and ecosystem functions, economic-ecological

Figure 41. Contingency tables of biodiversity/ecosystem function indicators and oil palm yield. Shown are the number of cases for indicators having a high or low value, respectively, i.e., above or below the mean value of standardized indicators. Note that crop yields are generally low for smallholder oil palm systems, and high for extensively and conventionally managed oil palm estates. By contrast, both high and low values of biodiversity/ecosystem function indicators are observed, irrespective of the associated crop yield.



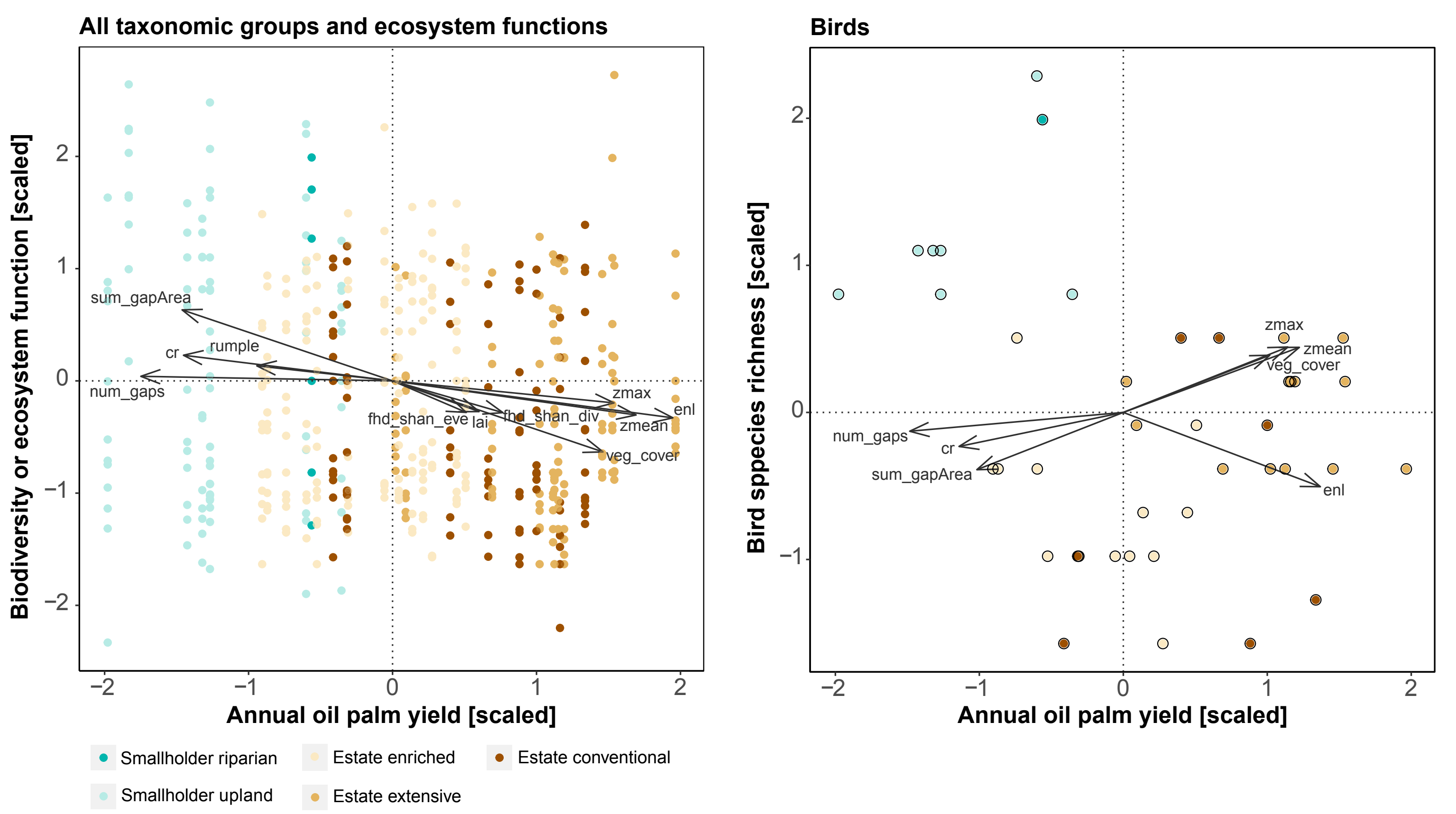


Figure 42. Variation in biodiversity/ecosystem functions and oil palm yield across the studied oil palm systems. Shown are scaled values (standardized to zero mean and unit variance). Colors indicate oil palm systems. The left panel shows the raw data for all biodiversity and ecosystem functioning indicators included in the dataset. The right panel shows only data for bird species. Arrows indicate plot-level Lidar metrics of structural complexity that significantly ($p < 0.05$) explain the two-dimensional variation in biodiversity/functions and yield. Arrow tips indicate the direction of steepest increase. Dotted lines seperate win-win situations (i.e., upper right quadrant) from trade-offs (upper left, lower right) and lose-lose situations (lower left). Lidar metrics: zmax = maximum canopy height; zmean = average canopy height; rumple = surface roughness; lai = leaf area index; fhd_shan_eve/div: foliage height diversity index, calculated either as evenness or diversity; sum_gapArea: total extent of gaps in the canopy (> 2.5 m) in 0.5 m increments; enl: effective number of layers; veg_cover: percentage cover; cr: canopy ratio.

win-win situations appear to be possible, as in the case of vegetation cover and canopy height, which correlates positively with both bird species and crop yield (Fig. 42). In addition to the plot-level Lidar metrics, landscape-level effects of habitat composition on local economic-ecological relationships will be investigated. These analyses are still ongoing.

As a follow-up, Focus 1 will contribute to synthesizing local findings on the social, economic and ecological functions of tropical rainforest transformation systems within the framework of the *Landscape Assessment*.

Focus 2

TITLE: **Spatial and temporal variability: Quantifying the effects of spatial, temporal and social heterogeneity on ecological and socioeconomic functions**

REPRESENTATIVES: Holger Kreft (B06, B11); Oliver Gailing (B14)

RESEARCH SUMMARY:

In Phase 3, the ecological projects will continue to investigate the different land-use systems within *EFForTS Core Plot* Design that are nested within farm, community and landscape levels. This research will generate data on temporal and spatial heterogeneity in ecological, and socioeconomic functions allowing complex and comprehensive analyses and general conclusions. Likewise, the continuation of data collection in the socioeconomic projects is expected to generate time series and panel data at plot, farm, household, and village levels, which will allow in-depth analyses of how socioeconomic functions vary in space and time dependent on the social context. For example, using structured additive regression models with nonlinear spatial effects, large spatial heterogeneity in oil palm production was detected. While much of the variation remained unexplained, proximity to urban centers and land titles were positively associated with oil palm productivity (Sibhatu *et al.* 2022, Fig. 43). Biomonitoring via DNA metabarcoding and visual identification of bee pollen revealed a lack of differences in pollen composition across land-use types suggesting the potential of generalist pollinators such as stingless bees to connect fragmented forest patches (Moura *et al.*

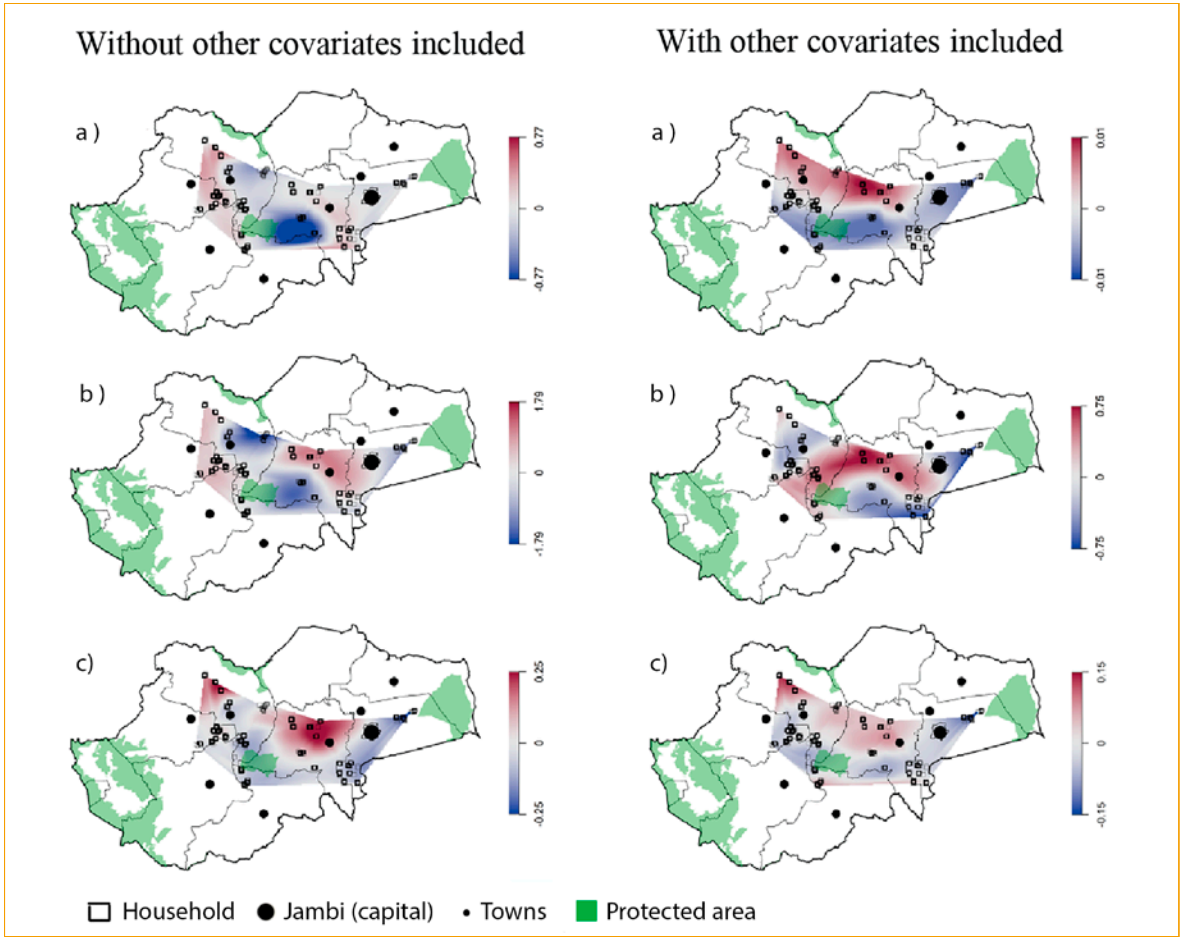


Figure 43. Estimated geosplines for (a) oil palm yield, (b) input use, and (c) output price. Areas colored in red indicate above-mean yield, input use, and output prices, while areas in blue indicate below-mean values. The scales represent coefficient estimates. Outcome variables are log-transformed (Sibhatu *et al.* 2022).

2022). Concordantly, widespread losses of species richness were associated with land-use intensification. However, agricultural intensification did not result in biodiversity loss on all scales revealing more complex land-use effects on tropical species communities than expected (Salecker *et al.* in preparation, Fig. 44). In Phase 3, the *EFForTS-OPMX* (see above), which experimentally varies the land-use intensity of oil palm plantations, and the *EFForTS-BEE* (B11 Hölscher/Kreft/Wollni, see above), which consists of varying levels of tree diversity in oil palm plantations, will generate more data to understand sources and implications of heterogeneity within oil palm. Finally, the novel Landscape Assessment planned in Phase 3 is designed to cover more of the heterogeneity within land-use systems. A coordinated collection of ecological and socio-economic data from 100 new study plots and the associated land-owners will allow us to analyze how heterogeneity across different ecological and socioeconomic functions is correlated within and across land-uses. Overall, Focus 2 investigates the following three Hypotheses:

(1) Ecological and socioeconomic functions of a given land-use system differ between landscapes, over time and by social context, i.e. statistically there are interaction effects between ecological and socioeconomic factors not only across but also within a particular land-use system.

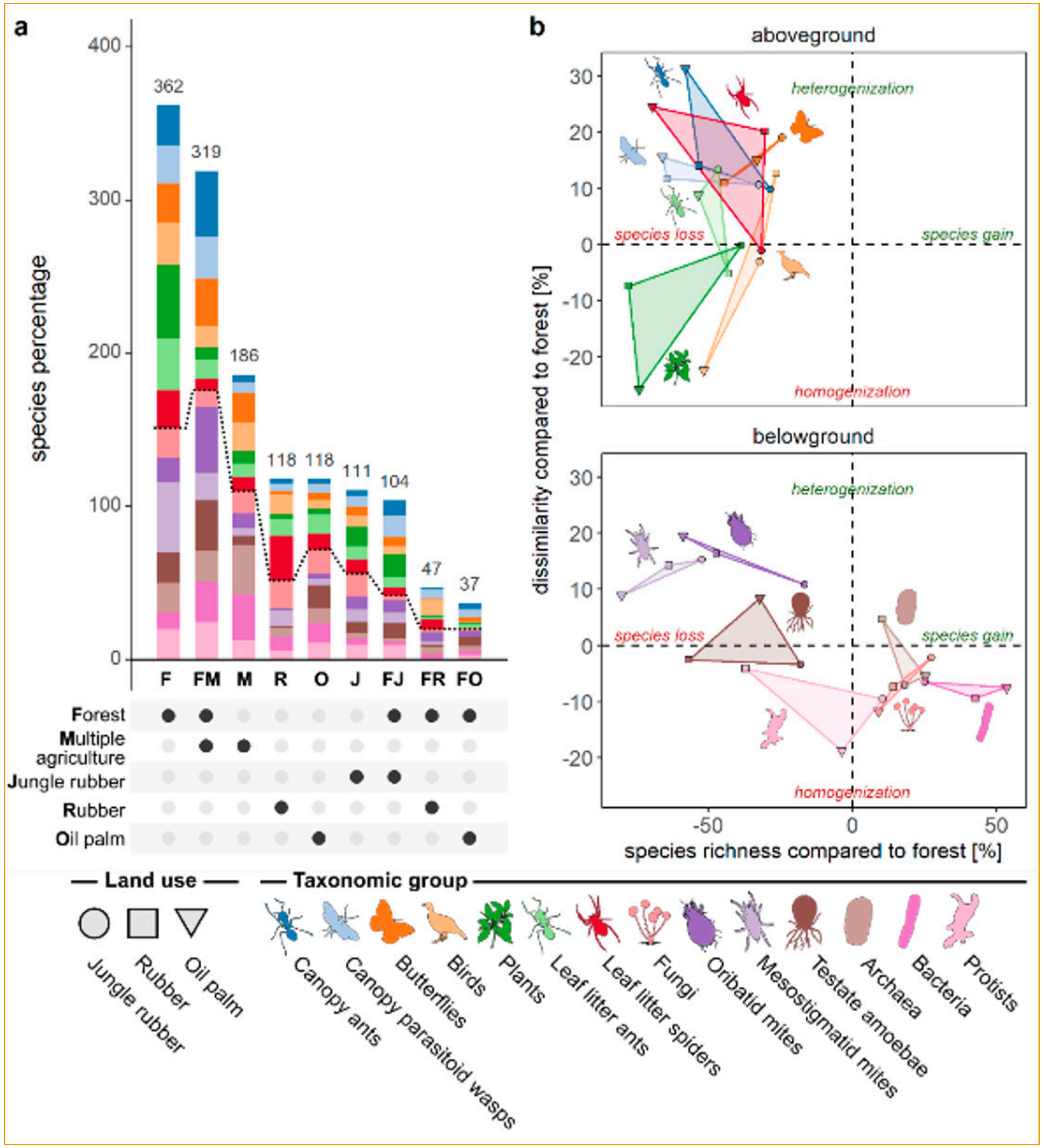


Figure 44. Trends in species richness, turnover, and biotic homogenization of 14 taxa across a land-use intensity gradient from rainforest to oil- palm plantations (Salecker *et al.*, in preparation)

(2) Within land-use systems, there are large differences in profitability, risk, biodiversity and ecological functions between farms and over time, and these can be explained by differences in the ecological and socioeconomic setting and/or management practices of the farm.

(3) Heterogeneity in local, regional, national and international economic and institutional conditions affects land-use change and management, and associated implications for biodiversity and ecological functions.

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Focus 3

TITLE: **Scaling-up of ecological and socioeconomic functions from local to landscape and broader scales**

REPRESENTATIVES: Krisztina Kis-Katos (C10), Thomas Kneib (INF-ZfS), Carola Paul (C12) & Catrin Westphal (B09)

RESEARCH SUMMARY:

In the current Phase 3, focus 3 activities center around exploring ecological and socioeconomic functions and trade-offs across multiple spatial scales ranging from plot surroundings up to several kilometres to the scale of Jambi province and beyond.

Alexander Knohl and Ali Ashehad (A03, A07, Z02), together with the Indonesian partners Tania June (IPB) and Ummu Ma'rufah, developed further a land-change model (LCM) to

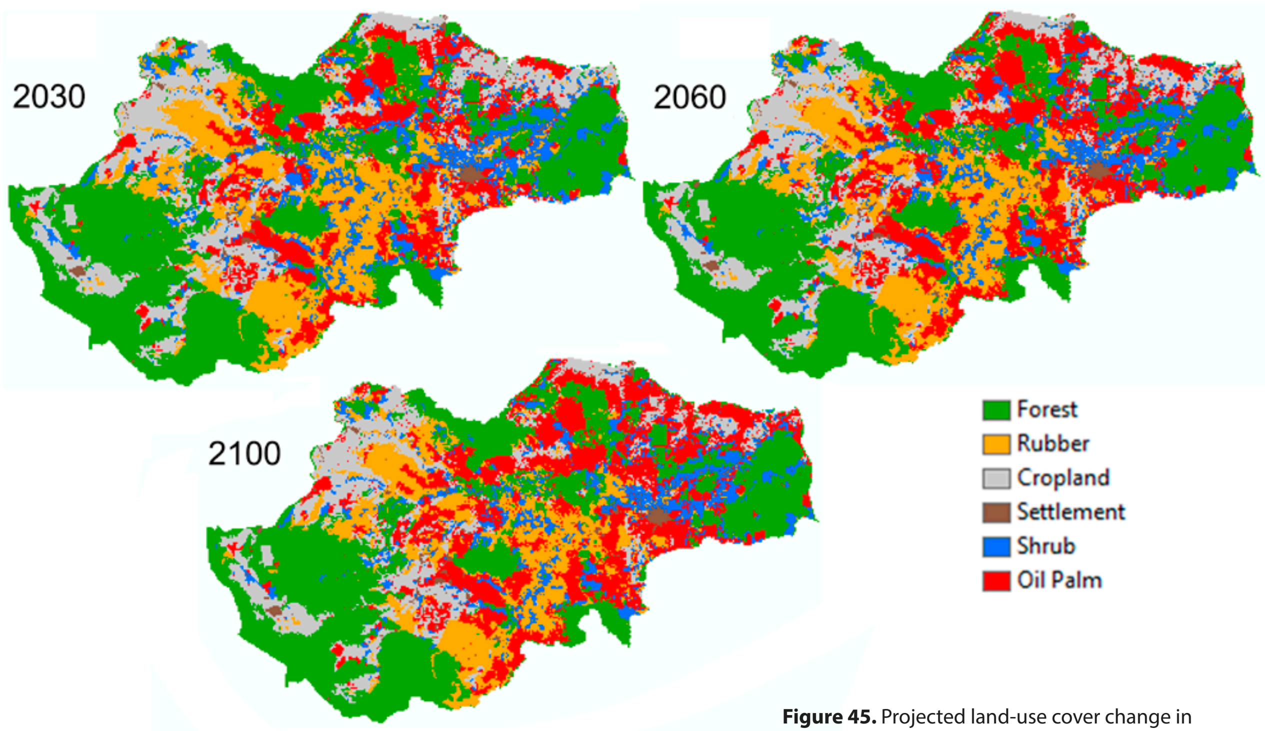

Figure 45. Projected land-use cover change in 2030, 2060 and 2100 for the conservation scenario.

project land-use change. Land-use maps from Melati (2017) in 1990 and 2011 are utilized for developing and training the model, while the land-use map in 2013 is used for model validation. Elevation, distance from the river, distance from the forest, distance from the road, and slope are the driving elements of land-use change in this projection. Distance from the forest is the most critical factor in expanding oil palm plantations. Elevation and road become the second most essential contributors to land-use change in Jambi Province. In LCM, the projection was performed for two scenarios; with and without conservation. In the conservation scenario, forests will not be converted into another land cover in the future. In this scenario, oil palm plantation expansion increases about 3 %, 7 %, and 10 % in 2030, 2060, and 2100, respectively, compared to the baseline in 2013 (Fig. 45). In the absence of conservation, oil palm expansion accelerates. From the baseline in 2013, the area of oil palm plantations in 2030, 2060, and 2100 will likely expand by 6%, 12 %, and 18 %, respectively (Fig. 46). Spatially, oil palm plantations develop primarily in low land areas and low slopes. In the remainder of Phase 3, in collaboration with Kerstin Wiegand and her group (B10), the predictions of LCM will be compared and contrasted with the *EFForTS-ABM* model to identify areas wherein the two models complement each other.

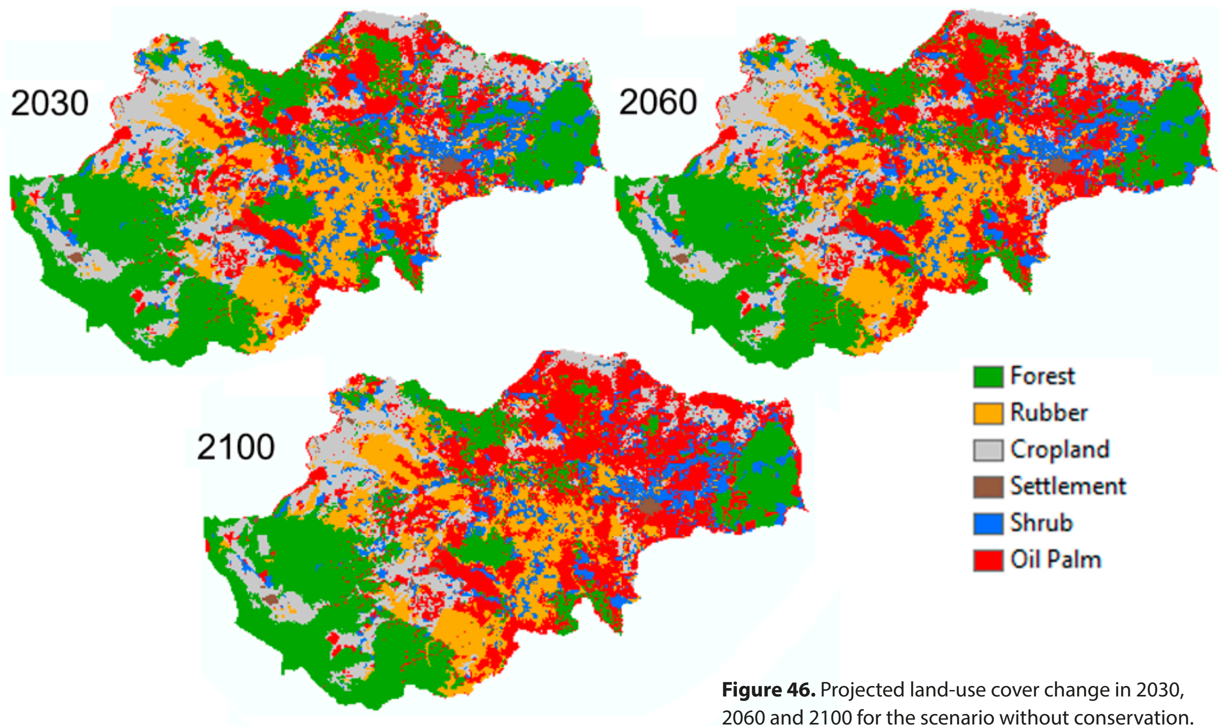

Figure 46. Projected land-use cover change in 2030, 2060 and 2100 for the scenario without conservation.

Anette Ruml, Daniel Chrisendo and Jann Lay (C11), with the collaboration of the Indonesian partner Nunung Nuryartono (IPB) and three further external researchers (Abdul Malik Iddrisu – The Institute for Fiscal Studies (IFS), London, United Kingdom, Alhassan A. Karakara – Covenant University, Ota, Nigeria & University of Cape Coast, Cape Coast, Ghana, and Evans Osabuohien – Covenant University, Ota, Nigeria) focus on smallholders in agro-industrial production, performing a comparative analysis of Ghana's and Indonesia's oil palm sectors. By successfully including smallholders, the oil palm boom in Southeast Asia has contributed significantly to rural economic development and poverty alleviation, notwithstanding its huge environmental costs. Palm oil production in other world regions is currently picking up, including in Africa. Yet it is uncertain whether the positive socioeconomic impacts from Southeast Asia can be replicated elsewhere. Little development gain may thus accompany severe environmental harm if oil palm expansion leads to deforestation. To shed light on the (prospective) role of oil palm for rural development this upscaling project provides a systematic comparison of Ghana's and Indonesia's oil palm sectors, focusing on smallholder inclusion. Existing *EFForTS* knowledge and data are used to analyze differences between Indonesian and Ghanaian policy making and smallholder production patterns. The performed comparison identifies substantial differences in structural conditions and policy foci that have shaped the oil palm sectors we observe today. Based on these findings, we derive concrete policy implications for the West African context, to foster the sector's potential to contribute to rural development in a more inclusive and sustainable manner.

Focus 4

TITLE: **Towards sustainable land use in tropical lowland regions**

REPRESENTATIVES: Meike Wollni (C08, B11, C11), Carola Paul (C12)

RESEARCH SUMMARY:

In the third phase of *EFForTS*, Focus 4 aims to identify policy responses and scenarios that contribute to reconciling trade-offs between ecological and socio-economic functions of land use. During the first and second phase, research in the A and B groups has generated substantial knowledge on the heterogeneities of ecosystem services across spatial and temporal scales. Results from *EFForTS-BEE* and *EFForTS-OPMX* provide increasing data on how oil palm cultivation can be made more sustainable by reducing the trade-offs between ecological and socio-economic trade-offs. Yet, implementation of sustainable practices requires effective policy and/or support measures.

The different projects in the C group have focused on a broad range of policy measures including REDD+ (C02), international trade agreements in the rubber chain (C01), the regulatory framework for land-use rights (C07), sustainability certification of oil palm (C01, C06), payments for ecosystem services (C08) and the provision of training and seedlings to promote enrichment planting in oil palm (C08 and B11). Results have shown that policies with certain objectives can have unintended consequences and that multiple interactions between policy measures at different scales need to be taken into account to achieve sustainable pathways.

Focus 4 provides a platform to integrate these different research activities and develop joint policy scenarios to derive recommendations towards more sustainable land use in Jambi. Policy scenarios will integrate various options for scaling up scenarios from location-specific micro-policies to the landscape and regional scales. C12 and B10 are developing modelling approaches at farm and landscapes scales to inform future policy processes. Both projects have developed the technical basis for future collaborative modelling, such as the Shiny app of the optimLanduse R package (see C12) and the integration of InVEST biodiversity module into Agent-based Net Logo models (B10). An initiative led by Sebastian Fiedler (B10), e.g., aims to integrate data from field experiments on payments for ecosystem services conducted in C08 into the agent-based model *ABM-EFForTS*. The behavioral data generated in C08 will allow to assess how different PES designs will affect land use choices and accordingly economic and ecological functions at the landscape level. The assessment of landscape implications of different policy scenarios can be further refined, once the data from the landscape assessment is complete and cleaned.

Participatory consultation is critical to develop relevant policy scenarios (C02, C12). Trade-offs do not only play a role in current decision making on resource use, but also between current and future generations. Therefore, ongoing research looks at intergenerational transfer of values and preferences related to sustainability (C08, C02). A joint paper on the current status and challenges of replanting in the smallholder oil palm sector, derives recommendations for policy makers to facilitate this transition and harness opportunities for increasing sustainability (C02, C06, C08). In collaboration with Documenta 15, a participatory process is implemented in one oil-palm dominated village in Jambi province to achieve a sustainability transformation. Results from this participatory process will generate valuable information on the priorities and community-based solutions for more sustainable oil palm systems.

III. ABS – Biodiversity Research, Access to Genetic Resources and Benefit Sharing (ABS)

1. **Research projects of counterparts and stakeholders in 2020/2021**
2. **Scholarships for early career researchers of counterparts and stakeholders**
3. **Capacity building workshops**
4. **Publications**
5. **The contribution of ABS-EFForTS to the Sustainable Development Goals: Lessons learned and best practices**

The Convention on Biological Diversity (CBD) is a multilateral treaty dedicated to promoting sustainable development. It was signed by 150 government leaders at the *1992* Rio Earth Summit (Brazil). CBD has three main goals: the conservation of biological diversity (or biodiversity), the sustainable use of its components, and the fair and equitable sharing of benefits arising from genetic resources.

The Nagoya Protocol on *Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization* (ABS) to the Convention on Biological Diversity is a supplementary agreement to the Convention on Biological Diversity. It is the legally binding mechanism to implement access and benefit sharing. Both Germany and the EU signed it on 23 June 2011 and the Republic of Indonesia on May 11, 2011.

The Deutsche Forschungsgemeinschaft (DFG; German Research Foundation) is one of the few funding agencies around the world that has implemented (since 2008) its own Guidelines to promote the application of the principles and procedures of ABS among its applicants (see article 8a[1] of the Nagoya Protocol, *https://www.cbd.int/abs/text/*). In 2013, DFG approved funding of ABS measures with central research funds of the CRC 990, and since November 2013, *EFForTS* supports the project partners in Indonesia.

In Phases 1 and 2 (*2012–2019*), *EFForTS* awarded
- 108 short-term research grants to counterparts and stakeholders (LIPI, PTPN VI, PT Humusindo, BKSDA, PT REKI, Ministry of Forestry) to strengthen the research cooperation
- 13 research grants and scholarships for early career researchers of counterparts and stakeholders
- Set up of a research station at PT. Humusindo, a field laboratory at the National Park Bukit Duabelas and a herbarium at UNJA.
- 3 capacity building workshops at partner universities in Indonesia

With the start of Phase 3 (2020–2023), we continued to support our partners in Indonesia. To date we
- Granted 23 research grants for counterparts and stakeholders in 2020 & 2021
- Extended 8 scholarships and awarded one new one
- Granted 8 capacity building workshops
- Support the education of two master students (law and environmental sciences) at UNJA – one student from TNBD (Ibu Asri Buliyansih) and one student from PT REKI
- Support the bachelor education of two Batin Sembilan (indigenous community in Jambi province) at UNJA in cooperation with Jambi University.

1 Nagoya Protocol, article 8a. Special considerations: Create conditions to promote and encourage research, which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries, including through simplified measures on access for non-commercial research purposes, taking into account the need to address a change of intent for such research.

1. ABS – RESEARCH PROJECTS OF COUNTERPARTS AND STAKEHOLDERS IN 2020/2021

SUMMARY REPORTS OF FUNDED ABS PROJECTS IN 2021

IPB University

Research projects of counterparts funded at IPB

Name	Counterpart	Title
Herdatha Augusta	**A02**	Role of surface covers on ground water quality of oil palm plantation area

Background and objectives

The surface cover of oil palm plantation consist of frond piles, where its covering rate represents about 10-20% of the total planted area, and understory vegetation, where its covering rate varies depending on the vegetation types, soil texture and properties, water availability in the wet or dry season, and management practices. After infiltration and percolating in the soil, the flowing water is distributed with different quality depending on the filtration capacity of the surface vegetation and root system to filter the accompanying dissolved minerals and other probable contaminants. In this study, the groundwater quality of oil palm plantation up to a soil depth of 4.0 m is related to the frond piles covers, understory vegetation and its rooting system. The water quality parameters observed are pH, Total Dissolved Substances (TDS), electrical conductivity, the concentration of ammonium, nitrate, potassium, calcium, sodium, and herbicides in the water. At the same time, the water quality of the water body at the site in question is evaluated.

Water quality in the soil and water bodies of an oil palm plantation is driven by management practices that intensively used fertilizer and pesticides. Oil palm plantations in Jambi are intensively managed by the application of fertilizer ranging from 48–88 kg N, 21–38 kg P, and 40–157 kg K ha^{-1} yr^{-1} (Ballauf *et al.* 2021) to 260 kg N, 50 kg P, and 220 kg K ha^{-1} yr^{-1} (Formaglio *et al.* 2020). The lower uptake efficiency of the applied fertilizer supports the residual nitrogen content in the soil (Edy *et al.* 2020). It has the potency to contribute an additional nitrogen footprint in water bodies and groundwater. The leaching rate reaches 74±20 kg N ha^{-1} yr^{-1} (Formaglio *et al.* 2020). Due to the lack of technical equipment and manpower, especially in Sumatra and Kalimantan, the use of synthetic pesticides is unavoidable and tends to increase year by year. In Jambi, the application rate reaches 2.25 l glyphosate ha^{-1} yr^{-1} (Formaglio *et al.* 2020). The control of environmental impact, especially nitrate flux and pesticide input to groundwater and water bodies, must be observed. The relationship between vegetation surface cover as filtration agent of potential contamination in water bodies by conventional agriculture system in oil palm was analyzed.

The study's objective was to identify the role of understory vegetation and frond piles covers on water quality of oil palm groundwater quality and contamination in water bodies. The water quality was also related to the distance from the water bodies.

Methodology

The observation was conducted at the riparian zone PTPN6 installed plots area. A synergy with other interested researchers in this plot area was coordinated priorly. The destructive area outside of the core plots was selected as observation point. Data collection took place from August-December 2021.

Distance points in 4 replications from the water body of the riparian zone at the available area of the contracted research plot area were: water body of the riparian zone, 5 ± 5 m, 10 ± 5 m, 20 ± 5 m, 40 ± 5 m and 60 ± 5 m.

Conducted on the measurement of the parameters were:

- Groundwater quality with pH (Horiba Ion Meter), Total Dissolved Substances (TDS) (Horiba Ion Meter), Electro Conductivity (EC) (Horiba Ion Meter), K^+ (Horiba Ion Meter), Na+ (Horiba Ion Meter), Ca^{2+} (Horiba Ion Meter), NO_3^- (Horiba Ion Meter/Nitrate Stick test pack), NH_4^+ (Ammonium test pack), herbicide (glyphosate) (Gas Chromatography-Mass Spectrometry)
- Monitoring of soil water level, 0-400 cm (manual method, with cylinder pipe)
- Identification of understory vegetation existence and its domination status

Results and Conclusion

The vegetation cover and the results of the analyses show that grass vegetation tend to grow in the closer vicinity of the water body, while broadleaves plants were more likely to be found in wider vicinity of the water body (Tables 1 and 3).

Table 1. Vegetation covers and analyses at oil palm in PTPN6

Species	**Vegetation Type**	Distance to the water body				
		3 m	10 m	20 m	40 m	60 m
Elaeis guineensis	Broadleaves	5	3	5	12	6
Axonopus compressus	Grass	11	32	0	15	3
Digitaria adscendens	Grass	5	5	0	3	0
Borreria alata	Broadleaves	6	1	0	19	14
Clidemia hirta	Broadleaves	4	3	2	6	7
Phyllantus niruri	Broadleaves	0	1	0	7	1
Cyperus kyllingia	Sedge	1	5	0	3	1
Nephrolepis exaltata	Fern	3	0	10	1	2
Melastoma malabatrichum	Broadleaves	0	0	0	0	1
Saoropus androgynus	Broadleaves	0	0	1	0	0
Dryopteris filix-mas	Fern	0	0	0	0	1
Ottochloa nodosa	Grass	4	1	0	0	0
Richardia scabra	Broadleaves	0	0	0	0	0
Pilea depressa	Broadleaves	0	0	0	0	0
Althernanthera sessilis	Broadleaves	0	0	5	4	0
Cyrtomium fortunei	Fern	0	0	0	0	0
Veronica officinalis	Broadleaves	0	0	0	0	0
Peperomia pellucida	Broadleaves	1	1	0	0	0
Asystasia gangetica	Broadleaves	0	1	0	0	0
Asplenium adiantum nigrum	Fern	2	0	0	0	3
Adiantum capillus veneris	Fern	0	0	0	0	0
Eclipta prostata	Broadleaves	0	0	0	0	0
Echinochloa crus galli	Grass	0	0	0	0	0
Viola odorata	Broadleaves	0	0	0	0	0

Nitrate concentration in the water body showed higher value due to intensive fertilizer application in this area. Glyphosate in groundwater closed to water body showed an average lower value of 1 mg/l both in the water body and in the groundwater of the oil palm plantation (Table 2)

Table 2. Ground water quality at 0-60 m to water body*

		Distance to the water body					
		0m**	3 m	10 m	20 m	40 m***	60 m***
pH	-	5.5±0.5	5.2±0.2	5.1±0.3	4.9±0.1	--	--
NO_3^-	ppm	122.5±0.8	113.5±85.1	77.1±9.0	80.0±42.7	--	--
NH_4^+	ppm	1.0±0.2	1.6±0.2	3.5±0.0	2.4±0.8	--	--
Conductivity	µS/cm	23.5±2.2	52.5±13.6	53.8±9.5	32.3±4.9	--	--
K^+	ppm	111.3±22.3	268.7±369.5	284.9±237.0	112.0±90.5	--	--
Na^+	ppm	31.3±2.3	47.7±19.3	42.9±18.5	31.6±6.0	--	--
Ca^{2+}	ppm	98.8±4.5	347.5±167.8	275.8±20.0	253.3±117.8	--	--
Glyphosate	ppm	0.45±0.05	0.39±0.03	0.37±0.03	0.44±0.06	--	--

* ± (standard deviation) **Waterbody *** Not observed, no ground water found until 4.0 m soil depth

Table 3. Oil palm growth and flower fertility at 0-60 m from water body*

		Distance to the water body				
		3m	10 m	20 m	40 m	60 m
Plant Height	cm	9.24 ±0.99	9.04 ±0.92	8.95 ±0.56	8.06 ±1.37	8.80 ±1.23
Frond number	per tree	39.43 ±8.28	35.33 ±11.55	40.80 ±5.40	40.56 ±4.47	41.33 ±4.57
Male flower number	per tree	7.86 ±3.80	5.67 ±3.39	6.50 ±3.08	6.64 ±1.51	7.00 ±2.31
Female flower number	per tree	4.14 ±1.86	2.33 ±1.37	1.33 ±1.51	2.89 ±1.07	3.17 ±1.21
Aborted flower number	per tree	14.29 ±7.21	15.56 ±10.68	19.00 ±5.87	17.32 ±3.80	17.39 ±3.66
Flower fertility	%	13.35	10.75	10.67	10.97	11.35

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Tania June, **Ummu Marufah**	**A03** **A07**	Evaluating the impact of land use change on surface energy balance partition and rainfall in Jambi Province

Background and Objectives

Jambi is one of provinces on the island of Sumatra that experienced extensive forest transformation (Drescher *at al.* 2016). Forest degradation in Jambi has been caused mainly by the expansion of palm oil and rubber plantation. Deforestation has led to changes in surface biophysical characteristics such as albedo and surface roughness, and influencing the climate (Burakowski *et al.* 2018). This study aims to analyze land use change in Jambi and its impact on surface energy balance partition and rainfall.

Methods

The simulation of land use change was conducted using the data from the land use map of Jambi province from Melati (2017) reclassified into four types: forest, oil palm, rubber, and other land use types (shrub, grass, agriculture like soybean). Land use change was projected using the Cellular Automata-Markov (CA-Markov) of Land Change Modeler (LCM). Elevation, slope, distance to river, distance to road, and distance to forest were used as driving factors for land use change. In this land use change modelling, we performed Cramer's V test to understand the power of driving factors in influencing land use change. The surface energy balance partition was simulated using the Community Land Model (CLM). CRUNCEP from 2001 to 2015 was used as the meteorological forcing. Analysis of spatial heat flux and rainfall were performed using ECMWF, CHRIPS data and Time Series, Area-Averaged of Merged satellite-gauge precipitation estimate from NASA, respectively.

Results and Discussion

Important driving factors for land use change in Jambi are distance from forest and elevation. Our projected land use cover in 2020 and 2030 show that forest, rubber, and other land uses continue to decrease, while oil palm continue to increase (Fig. 46). Most land use change will occur in the lowlands since this area is suitable for plantation, especially oil palm.

Forest transformation to other land uses result in losses in Leaf Area Index (LAI), especially at the beginning of forest opening and early planting. Low LAI indicates small surface roughness. Surface roughness will affect the transfer of momentum, energy and mass. In early planting of oil palm, the differences of

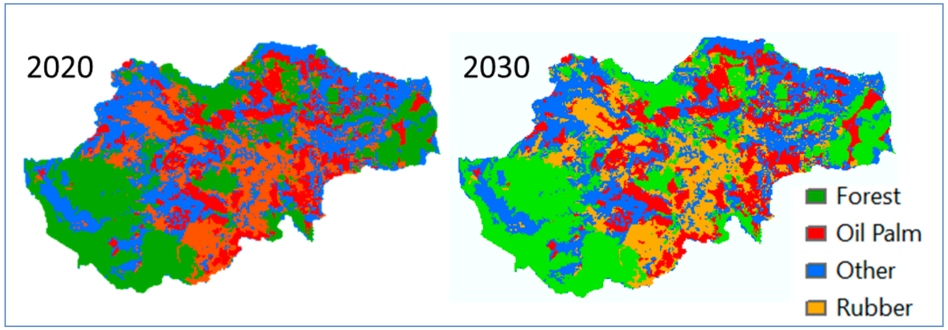


Figure 46. Projected land use cover in Jambi 2020 and 2030 (other land uses include schrub, grass and agricultural crops like soybean etc).

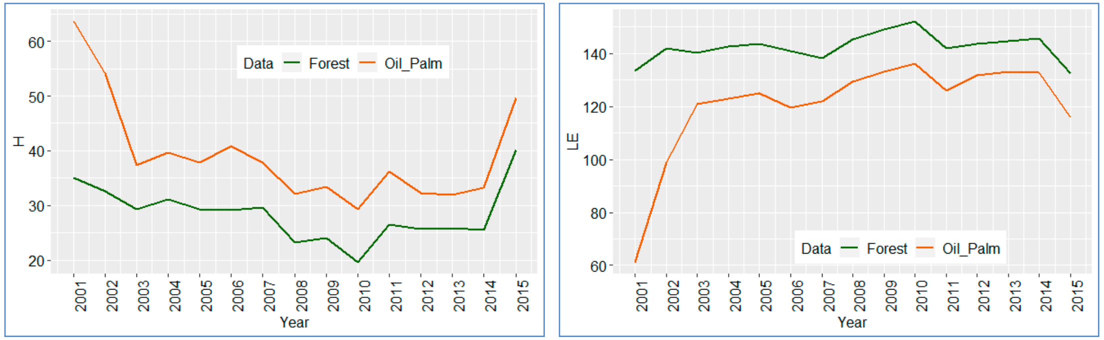
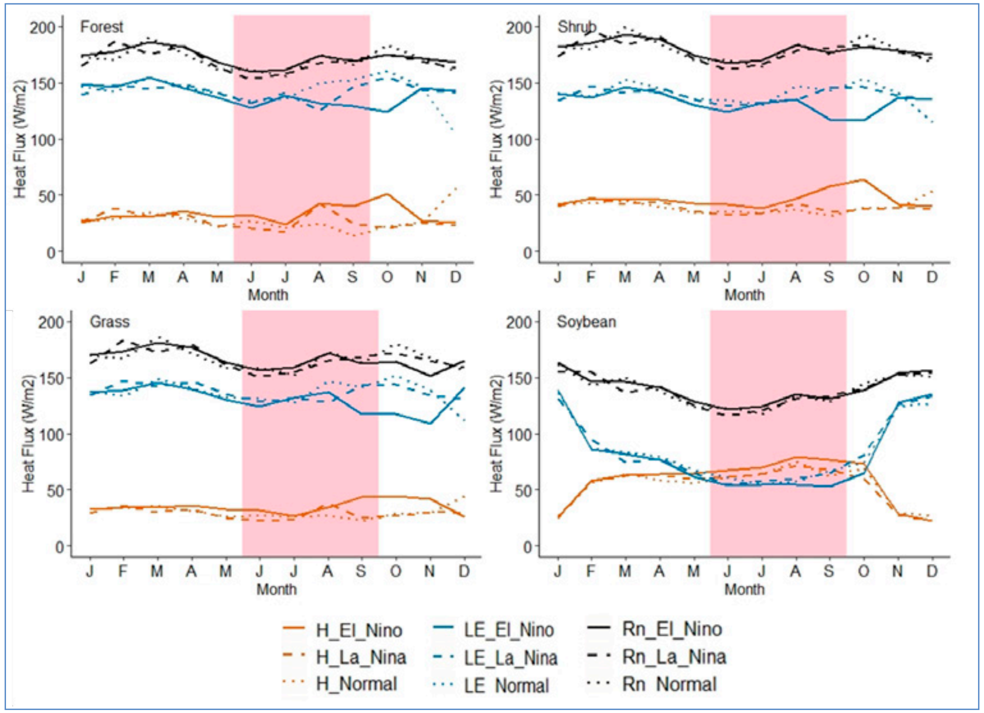


Figure 47. Comparing surface energy balance partition in forests and oil palms (simulated using CLM).



sensible heat flux H and latent heat flux LE between forest and oil palm is high (Fig. 47). A few years after planting, as plant become larger and has a higher LAI, LE increases and H decreases in oil palm. The value of LE (indicating evapotranspiration) remains larger in forest remain than in oil palm and other land uses (Figs. 48A and 48B), resulting in a lower Bowen ratio.

The Spatial distribution of H and LE (data from ECMWF) shows that in the lowlands, both H (Fig. 49) and LE (Fig. 50) have decreased, which could be from the increasing albedo due to land use changes that have reduced net radiation, and hence LE and H.

Changing surface energy balance partition will affect evapotranspiration and rainfall formation. The spatial distribution of annual rainfall from 1990 to 2020 shows a decrease in areas with high rainfall and an increase in areas with low rainfall (Fig. 51). Overall, there is a decreasing trend in annual rainfall in Jambi (Fig. 51) over the period 2000-2021 (data from NASA.gov.us).

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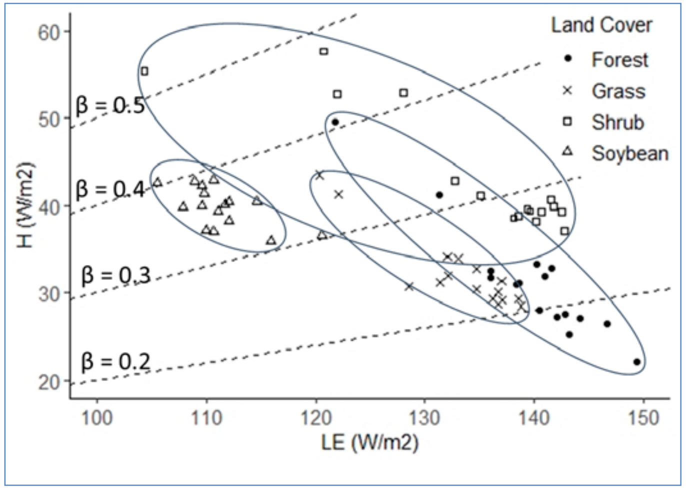

Figure 48A. Comparing surface energy balance partition in forest shrub, grass and soybean (simulated using CLM) showing sensible heat fluxes (H), latent heat fluxes (LE), and net radiation (Rn) in El Nino, La Nina, and Normal years. Pink shaded area denote dry season period.

Figure 48B. Annual average sensible and latent heat fluxes in Forest, Grass, Shrub and Soybean simulated using CLM in Jambi Province. Dash line show the value of Bowen ratio.

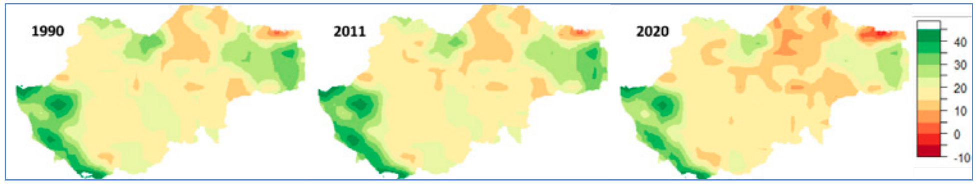

Figure 49. Average monthly sensible heat fluxes in Jambi (from ECMWF data).

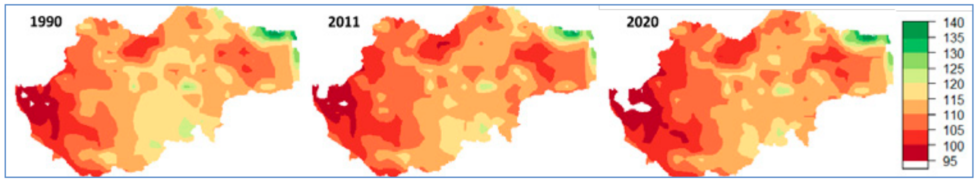

Figure 50. Average monthly latent heat fluxes in Jambi (from ECMWF data).

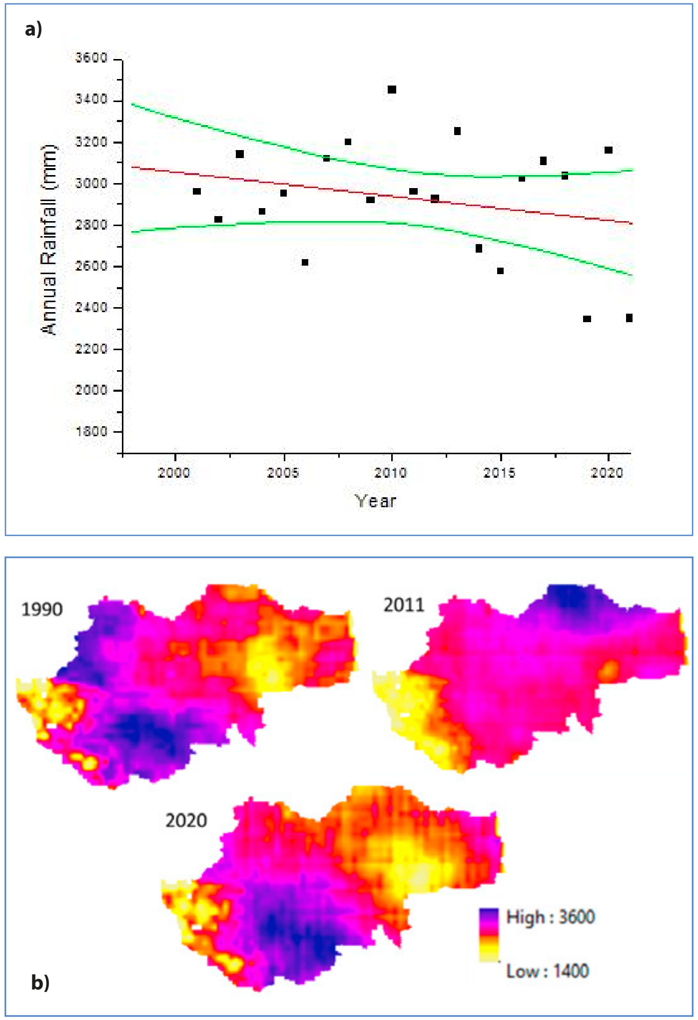

Figure 51. Average annual rainfall (a) (Time Series, Area-Averaged of Merged satellite-gauge precipitation estimate NASA) and its spatial distribution 1990 and 2020 (CHRIPS data) (b)) in Jambi Province.

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Windra Priawandiputra, Damayanti Buchori	**B09**	Development of a method to capture stingless bees for increasing human livelihood and improving biodiversity assessment

Background and Objectives

Global decline of bees has been reported in some countries, particularly in countries where honey bees are widely used for industrial purpose (Biesmeijer *et al.* 2006; VanEngeldorp *et al.* 2008). Although these drivers have also become a concern in Indonesia, data on the decline of bees and their populations in Indonesia are not available. Gratzer *et al.* (2019) shared that beekeepers in Indonesia are mainly managing local species (*Apis cerana*) and some stingless bees, although there are also a few beekeepers, which manage *Apis mellifera*. The number of beekeepers has recently increased in Indonesia, especially for stingless bee species (Buchori *et al.* unpublished). Stingless bees beekeeping could improve economic and human livelihood in Indonesia, especially in suburban areas (Cortopassi-Laurino *et al.* 2006; Pratiwi *et al.* 2020; Priawandiputra *et al.* 2020).

Some hunters of stingless bees in Indonesia usually find the wild nests on trees in natural habitats and cut them down. This method can be successfully used to collect stingless bees in the wild, although it has many consequences, such as the death of tree, loss of plants, loss of stingless bee habitat, costly in time and labor (Oliviera *et al.* 2013). Another method, nest traps, has been commonly applied in Brazil to collect stingless bee colonies in the wild (Oliviera *et al.* 2013). Although nest traps are a good potential alternative to the method used so far, they have not yet been not studied, tested and applied in Indonesia. Stingless bees are commonly found in forest area (Sakagami *et al.* 1990), while some species can also be found in various agricultural and urban habitats. We can utilize nest traps to monitor the existence and population status of various stingless bee species in natural and human-modified land uses. However, if nest traps could be successfully applied for stingless bee keeping in Indonesia, they would be a good solution for sustainable collection of wild stingless bees, improving human livelihoods, and a tool for monitoring bee population biodiversity. We also applied the grafting technique to propagate the stingless bees colonies, so the method could be applied in the wild. Therefore, this study aims to: (1) confirm the effectiveness of trapping and grafting methods in Indonesia; (2) investigate the effect of different land use composition on the success of trapping methods; (3) discover the most suitable material for capturing stingless bees; (4) assess stingless bees diversity using different trapping methods. In addition, the prospects for using trapping and grafting methods for human livelihood advantages, biodiversity assessments and conservation of stingless bees were investigated.

Methods

The study was conducted at IPB University, Dramaga Campus, Bogor, Indonesia. The area on Dramaga Campus designated as green campus was randomly selected for 21 plots (Fig. 52). A total 126 traps (63 made of bamboo and 63 made of plastic) were placed on the Dramaga Campus.

Figure 52. Traps location in Dramaga Campus IPB University.

We used two local common materials to construct traps such as plastic containers and bamboos (Picture 44). We choose 1.5 L plastic containers traps since they are easy to find and abundant in number. Internode of bamboo 30-40 cm long were selected for the traps. Each internode was perforated for the entry of stingless bees. Raw propolis and honey from stingless bees were used as attractants. Both attractants were sprayed into the entrance of the traps.

Picture 44. Traps that were made from bamboo (a) and plastic were placed nearby.

We also prepared the grafting techniques using different component of grafting boxes such as acrilic, wood, bamboo, and plastic (Picture 45). Three replicates were prepared for all grafting boxes. Each grafting box was connected to the hives of stingless bees. The weight and occupancy of the hives when moved to the new grafting box were measured. ImageJ was used to measure the cerumen, brood cell, honey and pollen pot, and occupation percentages. The grafting techniques were not installed until late August 2021. The grafting box served as a corridor between the colony in the sources box and the outside of the box. It takes 4 months for them to move their nest into the grafting box.

Picture 45. Grafting box were made from acrylic (a), wood (b), bamboo (c) and plastic (d).

Mining data was also collected from youtube videos related to trapping and grafting techniques for stingless bee colonies. We analyzed the percentages of video that already used grafting and trapping techniques to collect the stingless bees.

Results and Conclusion

Although the traps had been in place for 6 months, only two bamboo traps were occupied by colony of stingless bees (Picture 46). Meanwhile, 15 bamboo and 7 plastic traps were occupied by ants. In this case, this technique was not really effective to collect stingless bees in natural habitats. Some trap treatment need to be modified based on other video literatures, such as adding burning bamboo and propolis.

Picture 46. Bamboo traps were occupied by stingless bees (a) and ants (b)

The grafting techniques using different box materials showed different weight developments and occupation percentages (Fig. 53). The colony of stingless bees can occupy the new boxes made from wood, acrilic, and bamboo material (0.1, 0.13, 0.06 gr, respectively). Honey and pollen pot were established in wood, acrilic, and bamboo materials. Plastic materials were hardly colonized by stingless bees. Some batumen and cerumen were constructed in all type of boxes. The brood cell was only made in wooden box.

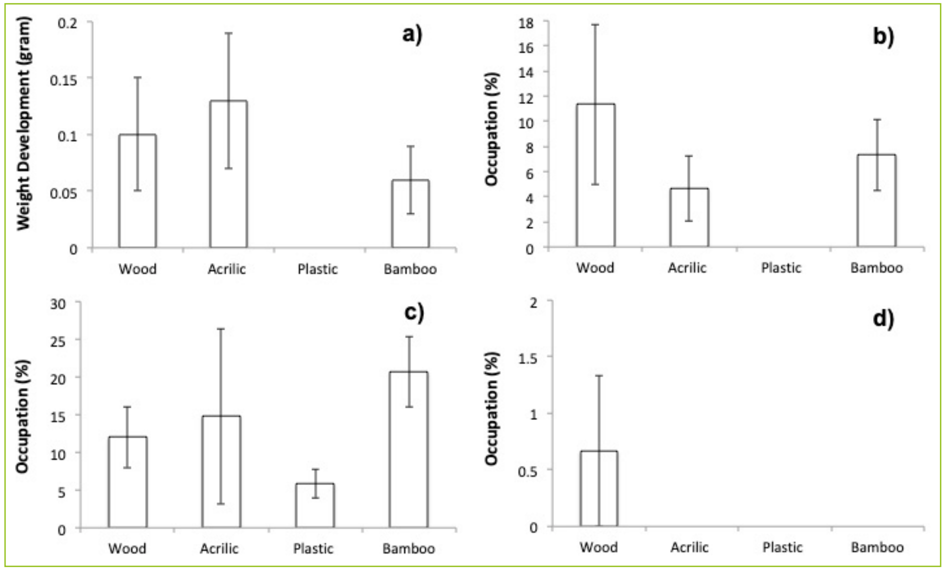

Figure 53. The weight development and percentages occupation of grafting boxes in different types: a) weight, b) honey and pollen pot, c) the cerumen, and d) brood cell.

Based on youtube video, many Indonesians have already tried the techniques of grafting and nesting trap techniques. We have seen 31 videos related to the grafting and trapping techniques for collecting stingless bees colonies in natural habitats. Some videos showed the different materials used to collect the stingless bees colony. Most Indonesians used wooden boxes and plastic bottles for grafting and trapping techniques, respectively (Fig. 54).

The nesting traps and grafting techniques were used to collect the colony of stingless bees in Indonesia based on youtube video. These grafting and trapping techniques could be effective and efficient to capture wild stingless bees for beekeeping. However, only grafting may be succesful in relocating the stingless bees colony, while the effectiveness of trapping needs to be re-evaluated. The different land use composition had no clear effect on the collection of stingless bee colony. Based on grafting result, wood box, acrilic and bamboo can be effectively used to collect stingless bees colonies. Plastic bottles can be used to collect stingless bee colonies in natural habitats based on video analysis, but our results shows that bamboo is more effective than plastic to collect the colony of

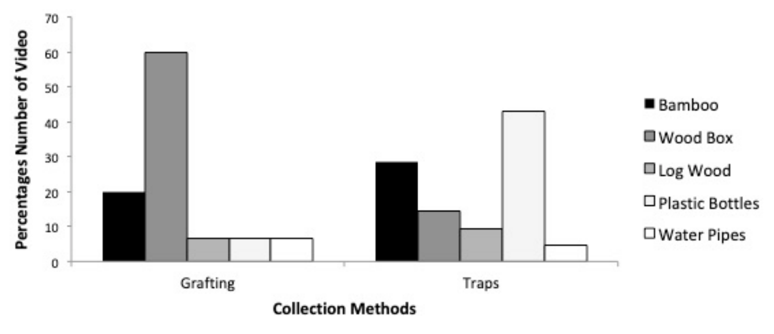

Figure 54. The percentages number of video (N=31) related with different collection method of stingless bees colonies.

stingless bees. Ants can be also trapped in the nesting traps. Collecting stingless bees can be more sustainable and environmentally friendly using these two techniques, althought it takes more time to reap the benefits. It can be implemented in Hutan Harapan, Jambi, as a follow-up project.

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Major Outcomes:

Hayati Journal of Biosciences, Biodiversitas, or Jurnal Entomologi Indonesia (JEI)

Iskandar Z. Siregar, Sri Rahayu, Ulfah Juniarti Siregar, Essy Harnelly, Fifi Gus Dwiyanti, Bambang Irawan, Muhammad Majiidu	**B14**	Genetic diversity of forest reproductive materials (FRM) produced from seeds (*Archidendron pauciflorum* Benth.) and clone (*Peronema canescens* Jack.)

Background and Objectives

The success of ecosystem restoration through a variety of planting activities can be influenced by several factors, one of which is the planting material. The genetic diversity of seed or other reproductive materials needs to be studied since it is crucial to determine success rate of plantation. Jalonen *et al.* (2017) found that about 40 % of forest plants reproductive materials originated from fragmented populations with insufficient quality. Considering the importance of trees growing in the *EFForTS-BEE* plots as future seed sources, we studied the reproductive materials from two species as examples. High quality Jengkol seeds and Sungkai clones are needed with adequate genetic diversity for future use in ecosystem restoration. This objective of this study is to determine the genetic diversity of Jengkol and Sungkai on *EFForTS-BEE* experimental plots.

Methods

Novel microsatellite markers (SSR) were developed based on short read sequence data. The following step of SSR analysis: i) DNA extraction by the CTAB Method (Doyle & Doyle, 1990), ii) SSR primer amplification (Ide *et. al.*, 2014), and iii) Fragment analysis based on ABI Genetic Analyzer 3500.
DNA from Sungkai and Jengkol were successfully extracted using the CTAB method. The DNA band in the gel electrophoresis is shown in figure 55a. The DNA concentration of Sungkai was 405 ng/µL and had a purity of 1.797 for A260/280 and 1.519

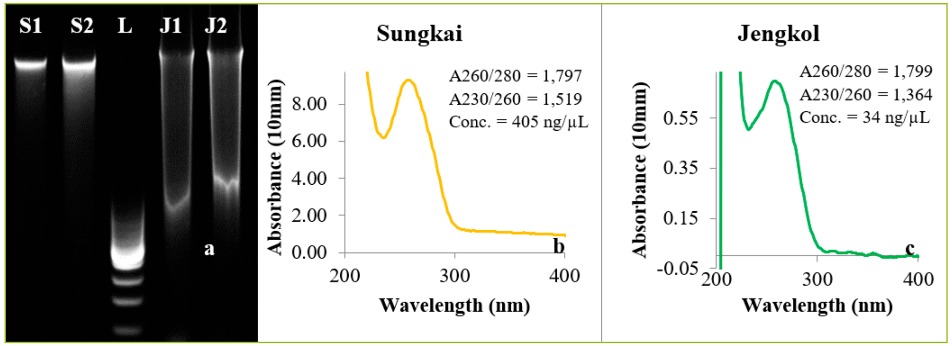

Figure 55. DNA extraction results. DNA electrophoresis (a); DNA quantity and quality of Sungkai (b); DNA quantity and quality of Jengkol; Sungkai (S); Jengkol (J); DNA Ladder 100 bp (L); Concentration (Conc.)

for A230/260 as shown in figure 55b, respectively. In contrast, The DNA Jengkol concentration was lower, 34 ng/µL, and had a purity of 1.799 for A260/280 and 1.364 for A230/260 as presented in figure 55c, respectively. It is sufficient for SSR-PCR Amplification. The specific SSR primers of Sungkai and Jengkol were designed using whole-genome data sequences.

Short read sequences

Data analysis resulted in sequence information as shown in tables 4 and 5.
According to table 4, 10.055 SSR primer candidates were founded in 9.460 sequences of Jengkol, while for Sungkai, more SSR primer candidates included 42.728 in 32.121 sequences. Of these candidates, we tested 20 loci for Sungkai and 20 loci for Jengkol using the PCR amplification assay as shown in figures 56 and 57.
Figure 56 shows that almost all SSR primer candidates of Sungkai were successfully amplified, and only one locus failed to be amplified. On the other side, all SSR primer candidates of Jengkol were successfully amplified at an annealing temperature of 60 °C. These SSR primers can be used for polymorphism testing on the respective FRMs.

Table 4. Sequence data information of Jengkol and Sungkai

Species	N of sequences examined	N of examines sequences (bp)	N of identified SSRs	N of SSR containing sequences	N of sequences containing more than 1 SSR	N of SSRs present in coumpound formation
Archidendron pauciflorum	389.266	168.548.255	10.055	9.640	394	205
Peronema canescens	151.448	231.541.369	42.728	32.121	7.736	1.865

Table 5. SSR candidates ofJengkol and Sungkai

	Species	Unit size					
		2	3	4	5	6	7
Number of SSRs	*Archidendron pauciflorum*	3.771	5.403	763	62	42	14
	Peronema canescens	27.732	11.427	2.742	590	352	65

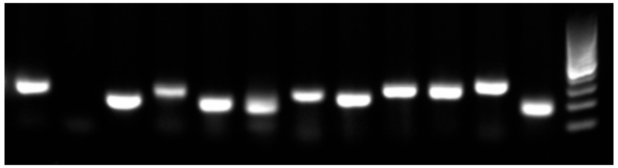

Figure 56. PCR amplification test of Sungkai. DNA Ladder 100 bp (L); locus (1-20).

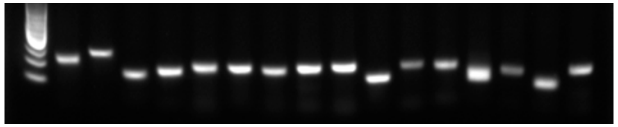

Figure 57. PCR amplification test of Jengkol. DNA Ladder 100 bp (L); locus (1-20).

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Ulfah Juniarti Siregar	**B14**	Assembling chloroplast genome sequences of petai, jengkol, sungkai and leprosula using both short-read and long-read sequencing: WP1: Generating raw sequences of four species from short read and long read sequencing

Background and Objectives

Jengkol (*Archidendron pauciflorum* of Fabaceae), Petai (Parkia scpeciosa of Fabaceae), Jelutung (*Dyera* spp of Apocynaceae), Sungkai (Peronema canescens of Apocynaceae) and Leprosula (*Shorea leprosula* of Dipterocarpaceae) are well known and widely distributed in Indonesia due to their economic value to the local population, however, very little basic genetic information is available on these species. The lack of such information has resulted in some planted species being less successful in surviving and adapting to the new planting environment. The families of those tree species, especially Apocynaceae and Fabaceae, are among the best studied in the world because of their importance for human beings. This research aimed to assemble the chloroplast genomes of the four tree species mentioned above. The chloroplast genome has been subject of evolutionary studies in plants due to its small size and conservative nature. The chloroplast genome also contains important genes related to physiological mechanisms for adaptation and stress.

Methods

DNA was extracted from leaf samples of four species, i.e. Jengkol, Petai, Jelutung and Sungkai, then subjected to shotgun sequencing using Illumina NovaSeq 6000, through Genetika Science Co. (representative of BGI in Indonesia). Short-read sequences data analysis was performed in Maser platform (*https://cell-innovation.nig.ac.jp*). Quality control was conducted using FASTQC and Filter FASTQ. Data with quality score (Q) > 30 were further assembled de novo due to lack of reference genome for each species using Platanus (Kajitani *et al.* 2019), SOAPdenovo (Li *et al.* 2010), and Ray (Boisvert *et al.* 2010). The draft genome from the assembly was run in BUSCO v3.0.2 (Genome assembly [nucleotide]) (Seppey *et al.* 2019). Results from Platanus assembler was annotated for chloroplast genes using GeSeq and visualized by OGDraw which is available in MPI-MP CHLOROBOX (*https://chlorobox.mpimp-golm.mpg.de/geseq.html*).

Major Results and Conclusion

From the three assembler software used, only SOAPdenovo and Ray provided good results when run in BUSCO (Table 6). Only partially annotated chloroplast genes could be assembled, and further attempts are needed to find as many genes as possible to assemble the entire chloroplast genomes of the four species.

Table 6. Results of BUSCO analysis from SOAPdenovo and Ray assemblers

Assembler	Species	Complete and Single Copy BUSCOs (S)		Complete and duplicated BUSCOs (D)		Fragmented BUSCOs (F)		Missing BUSCOs (M)	
		n	%	n	%	n	%	n	%
SOAP-denovo	Jengkol	27	8.9	0	0	11	3.6	265	87.5
	Sungkai	36	11.9	0	0	15	5	252	83.2
	Jelutung rawa	11	3.6	0	0	4	1.3	288	95
	Petai	32	10.6	0	0	17	5.6	254	83.8
Ray	Jengkol	33	10.9	0	0	7	2.3	263	86.8
	Sungkai	52	17.2	1	0.3	4	1.3	246	81.2
	Jelutung rawa	11	3.6	0	0	5	1.7	287	94.7
	Petai	42	13.9	2	0.7	12	4	247	81.5

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Rina Mardiana, Soeryo Adiwibowo, Endriatmo Soetarto	C02	Key elements of sustainable forest governance: An empirical experience from customary forest in Jambi

Background and Objectives

The decision of the Constitutional Court No.35/PUU-X/2012 (MK35) is a milestone in the end of the state forestry regime over customary forest (Fig. 58). With the MK35 stipulation, customary forest is not part of the state forest, but forest owned by indigenous people.

The recognition of customary forest by the state was carried out by President Jokowi for the first time on December 30, 2016 for 9 customary forests with a total area of 13.100 hectares, covering 5.700 House Holds (HH). In Jambi, as many as 5 customary forests are recognized by the state, namely Rantau Kermas, Bukit Sembahyang, Bukit Tinggi, Tigo Luhah Permenti Yang Berenam, and Tigo Luhah Kemantan. While the other 4 locations are located in the provinces of South Sulawesi, Central Sulawesi, Banten, and North Sumatra.

By 2022, Jambi is the area with the highest number of customary forests recognition, 29 customary forests with a total area of 7.984 ha covering 10.837 HH. This study aims to reveal two things, first, the impact of customary forests recognition (2016–2021) on socio-cultural, economic, and ecological sustainability conditions in Rantau Kermas-Jambi. Second, based on empirical experience of customary forest management in Rantau Kermas-Jambi, it aims to identify what key elements determine sustainable forest governance.

Methods

This research employs qualitative methods. Data was collected through secondary data (research reports, journals, and various information disseminated on the internet), and primary data (in-depth interviews and Focus Group Discussions). The interviewees included traditional leaders, village officials, regional government, village enterprises, and the NGO (WARSI). Field research was conducted in 2017, 2018, and 2019. Researchers continue to follow developments in the management of Rantau Kermas customary forest until January 2022 through internet-based communication. The collected data were then analyzed descriptively.

Results and Conclusion

Impact of Rantau Kermas customary forest recognition (2016–2021) on socio-cultural, economic, and ecological sustainability aspects.

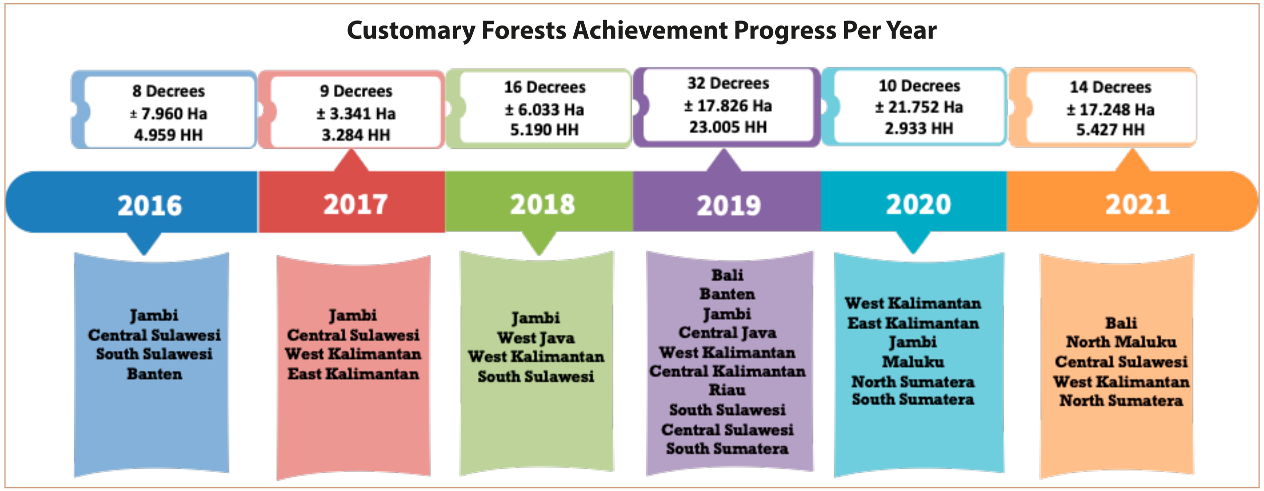


Figure 58. Ministry of Environment and Forestry, January 2022.

Picture 47. Village Owned Enterprises (Badan Usaha Milik Desa-BUMDes), Customary Forest Management Group (Kelompok Pengelola Hutan Adat-KPHA), Ecotourism Management Youth Group, Coffee Management Women's Group, Micro Hydro Power Management Group (PLTMH).

Socio-cultural aspect

Strengthening various village socio-economic institutions along with strengthening socialization and enforcement of customary rules (Picture 47)

Economic aspect

- Women get additional income from coffee processing from beans to packaging.
- Village income from PLTMH which is used for village development.
- Village income from "Adopted Trees" in customary forest is Rp. 200.000/person/tree/year

Ecological aspect

In 2019, the Rantau Kermas customary forest received the Kalpataru Award, for their efforts to protect and save the environment. They also won the 3rd place in the 2021 Indonesia Enchantment Award in the field of ecotourism.

Key elements of sustainable forest governance

During the five years of customary forest management in Rantau Kermas-Jambi, 11 key elements have been identified (Fig. 59) that are crucial to the sustainability of community-based forest governance,.

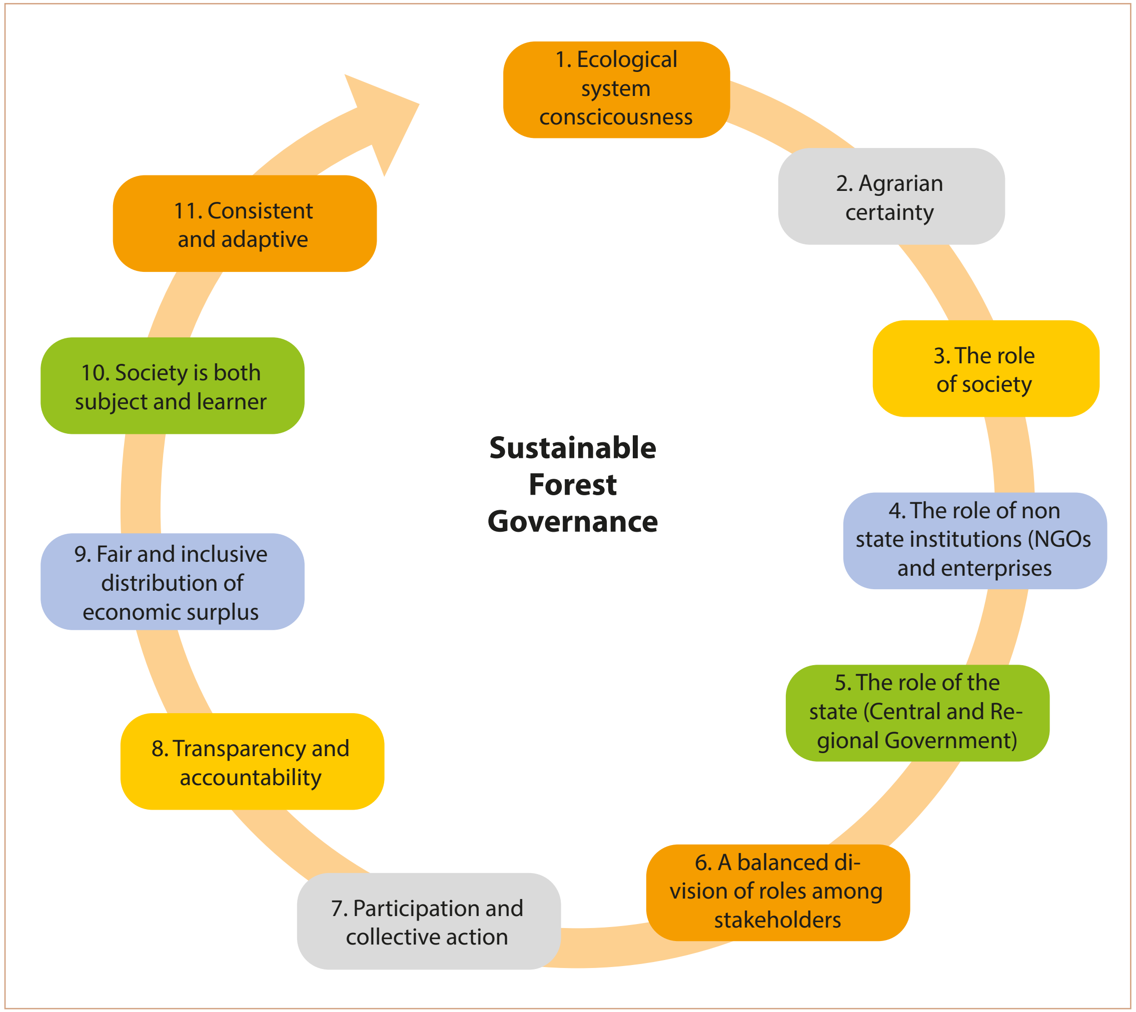


Figure 59. Key elements of sustainable forest governance

Dodik Ridho Nurrochmat	Z01	Policy studies and model development of agro-foresty in Jambi, Sumatra

Background and Objectives

Agro-forest management policy is one of the most trending issues in Indonesia under the dynamics circumstances of regional autonomy. Regional autonomy has been recognized in the formal government system of the Republic of Indonesia through Regional Governance Law 5/1972. The existing Regional Governance law has shifted all authorities in forest management from the regency to the province and associated with the new established Law 11/2020 on job creation that introduced a single liaison of multi-purpose forest utilization, which included agroforestry that would potentially reduce deforestation and improve the community welfare. This study evaluates the key elements of local development goals, risks and barriers, and the basic capitals for agro-forest management.

The study aims to identify and understand the transformation of agro-forest management policies as a consequence of local development goals, risks and barriers as well as basic capitals for agro-forest management after two decades of regional autonomy in Tebo Regency, Jambi Province in Indonesia

Methods

In this study, the Interpretive Structural Modelling technique is applied. The technique is used to evaluate interrelated elements associated to complex issue. In the second stage, three categories for agro-forest management are discussed in focus group discussions (FGDs) in the Tebo Regency. The FGDs were attended by six key participants (experts) representing institutions related to agro-forest management, namely Jambi Provincial Forestry Service, Tebo Regency Development Planning Agency, Jambi Natural Resources Conversation Unit, East Tebo forest management unit, Jambi University and a Jambi forestry observer.

Results and Conclusion

Research began by finding relevant documents and consulting relevant experts. FGD were conducted to list the local development goals, risks and barriers, and basic capitals for agro-forest management. Interpretive Structural Modelling technique were then used to identify the key elements of the local development goals, risks and barriers, and basic capitals for agro-forest management. From those discussion, figures were derived showing the hierarchy of levels of the elements of interest, with the lowest level representing the key elements. Figure 60 shows that the increased environmental quality (A12), increased stability of public order, legal, and political awareness (A13); and increased social and community protection (A14) are the key elements.

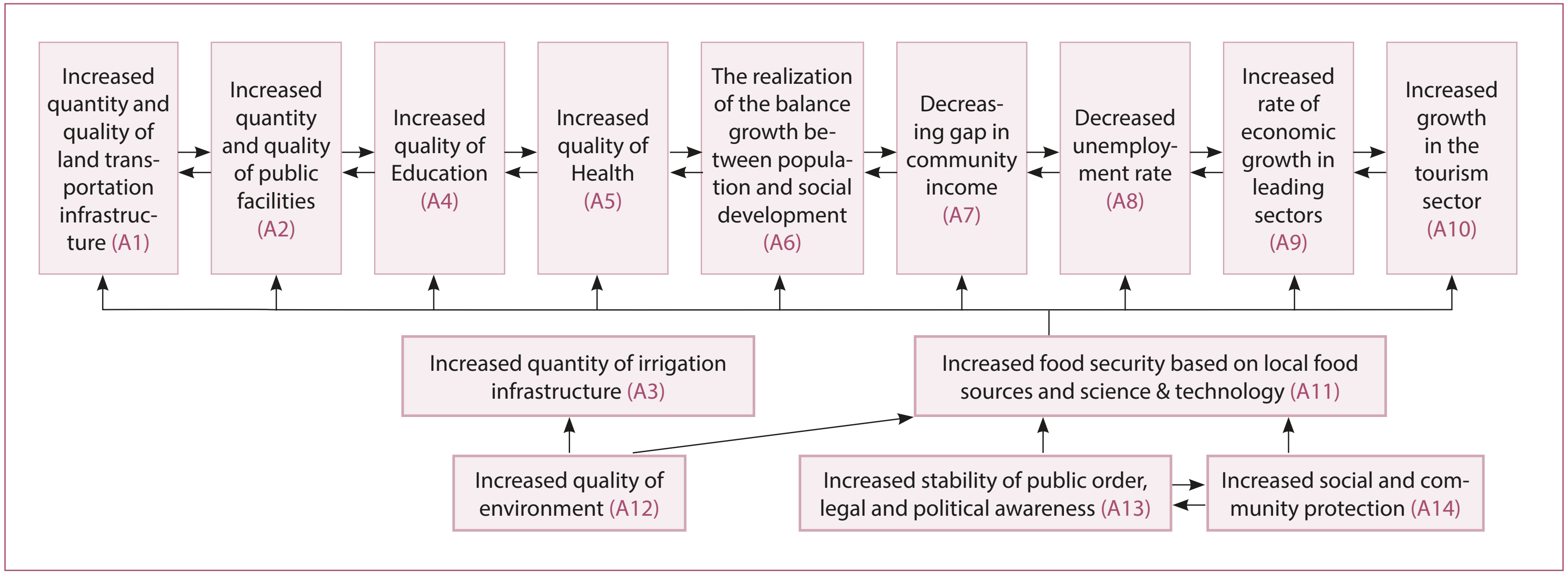


Figure 60. Diagram of local development goals

This study concludes recommendations to address issues pertaining local development goals, risks and barriers to forest management and provisions of basic capitals. All the recommended solution were summarized in table 7:

Table 7. Recommendation to address the issues.

Local development goals (LD)	Risks and barriers to forest management (RB)	Basic capitals (BC)
1. Improve the environment quality	1. Assess the need and quality of human resources for managing the forest areas	1. Education and human resources
2. Increase the stability of public order, political and legal awareness	2. Strengthen coordination beteween relevant institutions and groups	2. Effective leadership role
3. Improve social and community protection	3. Enhance communication between stakeholders	3. Improve social capital
	4. Improve forest management financing	4. Governance including rule of law and mulit-stakeholder engagement
	5. Increase public awareness and understanding of the importance of forests	5. Partnerships

From an ecological perspective, the financial feasibility of oil palm monoculture plantation and oil palm agroforestry was analyzed (Table 8). The data on costs and revenue were obtained from the interviews with key persons. Both the financial analysis are shown in table 9 and table 10 respectively.

Table 8. Financial feasibility analysis of monoculture oil palm plantation

Indicators	Result)
NPV	IDR 62,644,836 (US$ 4,476.84)
BCR	1.39
IRR	20,77%

Table 9. Financial feasibility analysis of oil palm agroforestry

Indicators	Result)
NPV	IDR 209,221,212 (US$ 14951.76)
BCR	1.79
IRR	24,42%

In general, oil palm agroforestry is more profitable compared to monoculture-oil palm cultivation. The selection of agroforestry intercrops is an important factor in increasing the likelihood of successful implementation. Table 10 below provides recommendations for croppin g pattern to achieve financial feasibility.

Table 10. Comparison of the financial feasibility with income and profit potential of each cropping pattern

Financial Feasibility Critieria					
Pattern	Plant combination	BCR	IRR (%)	Potential Income (IDR (US$))/ hectare/ month)	Potential Profit (IDR (US$))/ hectare/ month)
I	Oil Palm monoculture	1.39	20.77	2,371,069 (168.60)	986,874 (70.17)
II	Oil Palm and *jengkol*	2.01	25.83	6,022,434 (428.24)	3,861,744 (274.60)
III	Oil Palm with *petai*	1.56	22.94	3,763,134 (267.59)	2,161,076 (153.67)
IV	Oil Palm and *durian*	1.65	23.5	5,364,493 (381.45)	3,119,061 (221.79)
V	Oil Palm and *sungkai*	1.33	19.2	3,008,877 (213.95)	1,668,908 (118.67)
VI	Oil Palm and *meranti*	1.21	17.94	2,367,420 (168.34)	1,035,996 (73.67)
VII	Oil Palm with *jelutong*	1.34	19.73	2,826,627 (200.99)	1,342,595 (95.47)

In the implementation, table 10 shows a comparison of the financial feasibility with income and profit potential of each cropping pattern. The table shows that all oil palm agroforestry patterns are financially feasible. All financial criteria (NPV, BCR, and IRR) meet the threshold of financial feasibility where NPV > 0, BCR>1, and IRR >i.

Leti Sundawati, Adisti PP. Hartoyo, Fitta Setiajiati	PR	Agroforestry for higher education in Indonesia: Status and future development

Background and Methods

Agroforestry (the practice of growing trees and crops in interacting combinations) is recognized worldwide as an integrated approach to sustainable land use. Agroforestry also plays an essential role in reducing forest degradation in Indonesia. As a science, agroforestry is a complex science due to its many applications in the field. Although agroforestry is taught in many universities in Indonesia, an assessment of the status and impact of the course is needed, since the higher education curriculum tends to develop top-down, while agroforestry is carried from the bottom (field). Therefore, an online questionnaire survey was conducted among 20 universities that are members of the Indonesian Forestry Higher Education Leadership Forum, 210 forestry extension agents (both apparatus and non-apparatus staff) from 27 provinces, 58 farmers/practitioners of agroforestry, as well as literature review with a descriptive analysis in qualitative and quantitative terms.

Objective

The objectives were to 1) analyze the agroforestry curriculum's status in Indonesia and compare it with advanced universities/institutions in other countries; 2) identify user needs related to agroforestry at the field level and the gap between the user needs and the current agroforestry curriculum in Indonesia.

Approach

A mixed-method approach was applied for data collection. A questionnaire survey and in-depth interview were conducted by the online system. The data were analyzed descriptively in quantitative and qualitative terms: problem analysis and gap analysis.

Results and Conclusion

Agroforestry has been offered as a course in Indonesian higher education institutions from about 10 years to more than 30 years ago. The survey results show that the agroforestry is taught not only in the faculty of forestry but also in the faculty of agriculture. This is related to the nature of agroforestry as a multidisciplinary science. Most universities (90% of respondents) implemented agroforestry as an independent course. Only 5% integrated agroforestry into other courses and 5% implemented agroforestry as a study program. As an independent course, agroforestry is offered for 2-3 credits/semester. Most Indonesian higher education institutions have implemented agroforestry as a compulsory course (67%).

All respondents from universities perceived that the implementation of agroforestry courses in the future should be synchronized with the program of the Ministry of Education, Culture, Higher Education and Research such as program of MBKM (*Merdeka Belajar Kampus Merdeka*) or Free Learning Campus Free program in which a student could take about 20 credits until 40 credits or one to two semesters outside their study program, or their faculty and even outside their universities to broaden their knowledge and skills. Furthermore, agroforestry courses should also be better adapted to the needs of users, most of whom are involved in the Social Forestry program. The Indonesian government program in which people living surrounding the state forest area are given access (permission) to managed a portion of state forest area sustainably. Agroforestry as a land-use that integrated perennial woody plants with agricultural crops and/or livestock, is considered a very suitable land-use model for the implementation of the Social Forestry Program. Some universities also planned to emphasize agroforestry practices more than theory and focus more on local agroforestry practices that are different from other agroforestry practices in other areas.

On the other hand, agricultural and forestry extension workers also play an important role in developing agroforestry practices in Indonesia. They are tasked with assisting and empowering the community to improve their performance and achieve better socio-economic and ecological results in agriculture and forestry. However, they found that the budget for extension activities was limited and the scope of the work area was very large. In general, the working area of 1 extension staff was more than 5 villages with limited human resources in terms of both quality and quantity, limited facilities and infrastructure, inadequate transportation and communication accessibility. In one month, they only spent less than 25 hours in one village or less than four working days conducting activi-

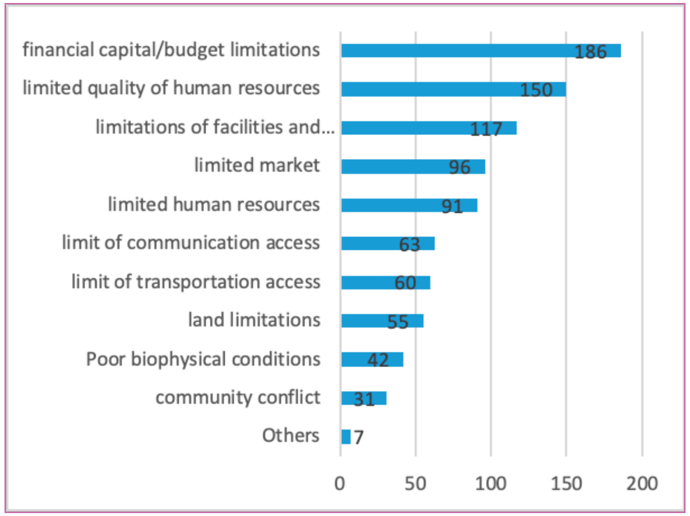


Figure 61. Obstacles in extension

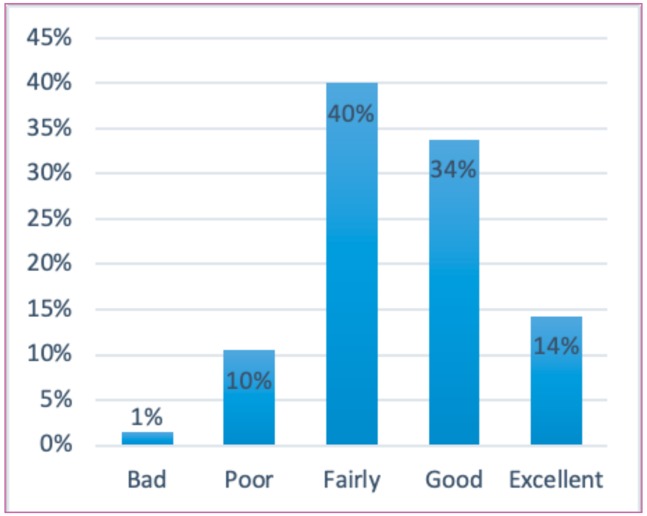


Figure 63. Performance of agroforestry practice

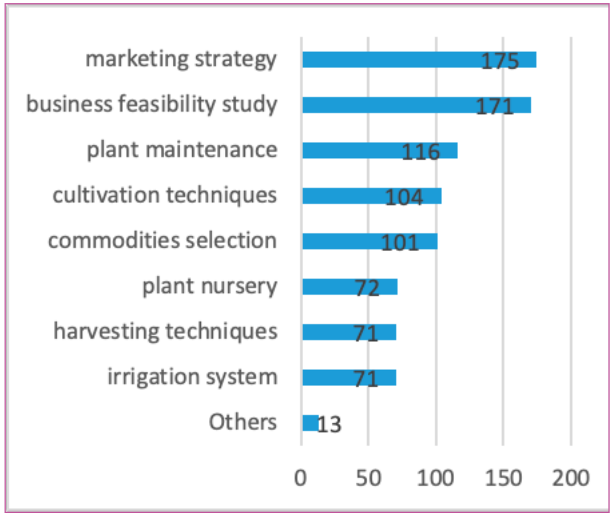


Figure 64. Subjects of agroforestry that need to be taught in higher education

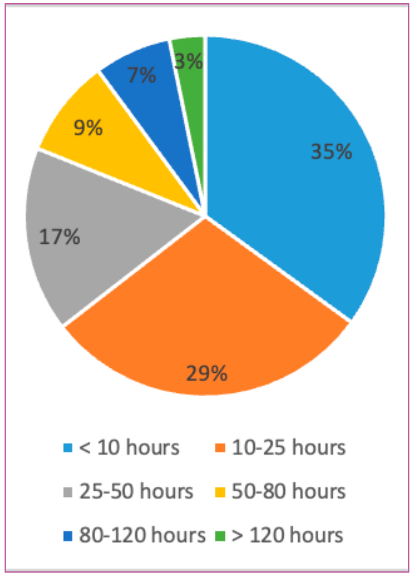


Figure 62. Visiting hours in a village in a month

tes in the field. The staff had already provided some materials to farmers, but they also admitted that they did not fully understand and lacked knowledge about the material. Their knowledge of irrigation techniques is poor, so the material has been delivered to farmers on a limited basis. They also suggested that materials on marketing strategies and business feasibility studies should also be included in agroforestry courses. In general, agroforestry courses taught technical aspects such as planting, plant maintenance, and harvesting. These technical aspects remains important and are also needed by extension staff, especially due to technological developments and increasingly dynamic market demands.

6The extension staff revealed that the budget for extension activities was limited and the scope of the work area was very large. In general, the working area of 1 extension staff was more than 5 villages with limited human resources both quality and quantity, limited facilities and infrastructure, inadequate transportation and communication accessibility (Fig. 61), so that in one month they only carried out counseling in the field is less than 25 hours per month in a village (Fig. 62) or less than four workdays in a month.

Some of these obstacles caused the conditions and performance of agroforestry practices to be not optimal (Fig. 63). The practitioners including farmers showed and expected some topics (especially marketing strategy, plant maintenance, and business feasibility) are delivered in the university to develop the agroforestry practices (see Fig. 64). This means that not only the technical aspect of biophysics, but also the socio-economics studies are essential to be taught in the agroforestry course.

As conclusion, future education of agroforestry at the higher education institutions level should be better adapted to the needs of extension workers as well farmers and support the government program on social forestry. This mean that ongoing evaluation of the agroforestry course curriculum is very important to develop agroforestry as a science that can be linked to policy and practice.

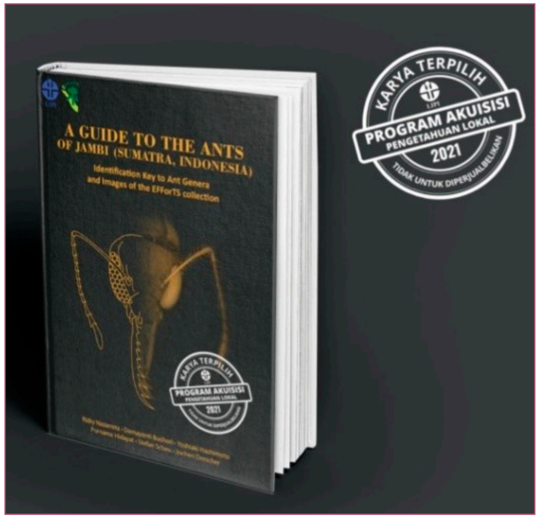
Damayanti Buchori, Purnama Hidayat, Rizky Nazarreta	**Z02**	Arthropods collection and identification books

Background and Objectives

Arthropods are the most numerous and diverse group of animals. Tropical rainforests are important habitats that ensure the existence of a wide variety of arthropods, especially insects. Currently, there have been major changes in the lowland tropical rainforest ecosystem. The rapid changes associated with changing human lifestyles have transformed lowland tropical rainforests into agricultural land, industrial forests and mining areas. Within the framework of *EFForTS* project, we collected arthropods from the canopy in a nested design in four land-use systems (i. e. rainforest, jungle rubber, rubber and oil palm plantation) in Jambi Province, Sumatra. Studies on insect diversity and responses to land use change in forest areas are still limited, so more research is needed on a regular basis to document various community parameters of insect diversity for conservation and sustainable management efforts. Based on this study, we made an updated key identification for ants "A Guide to the Ants of Jambi (Sumatra, Indonesia): Identification Key to Ant Genera and Images of the *EFForTS* collection", a field guide of butterflies "The Butterflies of Eastern Jambi", a field guide of coleopterans "Guidebook of Beetles and Weevils of Jambi, Sumatra, Indonesia (Chrysomelidae, Curculionidae, Elateridae Staphylinidae)", and a scientific popular book (Keanekaragaman Serangga di Hutan Hujan Tropis Dataran Rendah di Provinsi Jambi, Sumatra: Dampak dari Perubahan Penggunaan Lahan). All of those books are a collection of the results of collaborative research through the *EFForTS* project and focused as a book that can provide information about the important value of insect biodiversity, increase scientific knowledge about insect ecology and the most up-to-date dichotomous key identification of ants.

Results and Conclusion

- Nazarreta R, Buchori D, Hashimoto Y, Hidayat P, Scheu S, Drescher J (2021) A Guide to the Ants of Jambi (Sumatra, Indonesia): Identification Key to Ant Genera and Images of the *EFForTS* Collection. e-Publishing, Penerbit BRIN

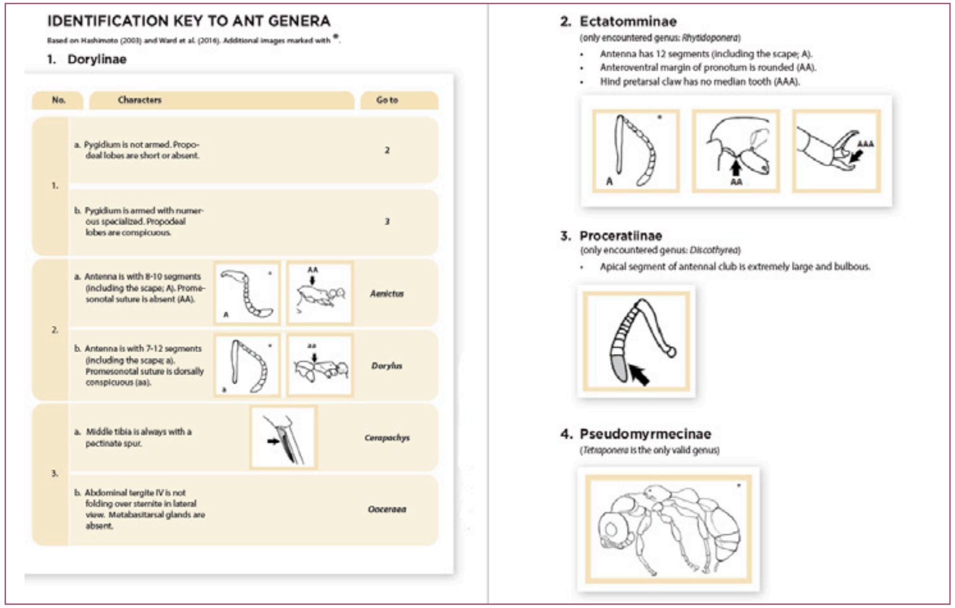


Picture 48. A guide to ants of Jambi.

This guide (Picture 48) documents more than 300 ant species that were found in rainforests and agroforestry of Jambi Province, Sumatra, and also includes a recently updated identification key to the ant genera of Southeast Asia.

The identification keys provided in this guide are designed to identify workers caste only (Picture 49).

The reason is that workers ants have morphological characters that allow differentiation be-



IDENTIFICATION KEY TO ANT GENERA

Based on Hashimoto (2003) and Ward et al. (2016). Additional images marked with *.

1. Dorylinae

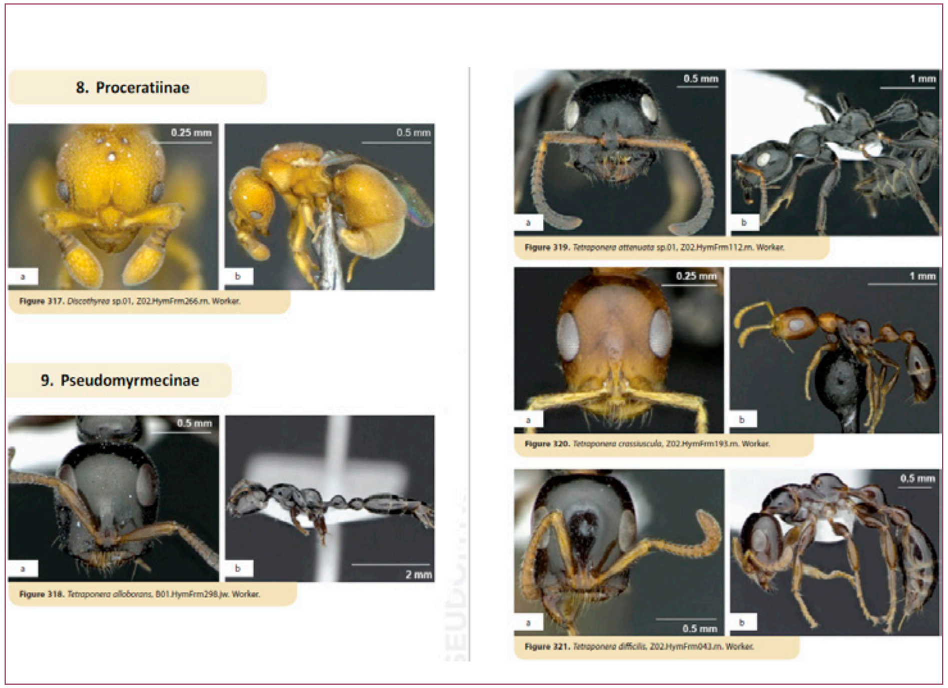
No.	Characters	Go to
1.	a. Pygidium is not armed. Propodeal lobes are short or absent.	2
	b. Pygidium is armed with numerous specialized. Propodeal lobes are conspicuous.	3
2.	a. Antenna is with 8-10 segments (including the scape; A). Promesonotal suture is absent (AA).	*Aenictus*
	b. Antenna is with 7-12 segments (including the scape; a). Promesonotal suture is dorsally conspicuous (aa).	*Dorylus*
3.	a. Middle tibia is always with a pectinate spur.	*Cerapachys*
	b. Abdominal tergite IV is not folding over sternite in lateral view. Metabasitarsal glands are absent.	*Ooceraea*

2. Ectatomminae
(only encountered genus: *Rhytidoponera*)
- Antenna has 12 segments (including the scape; A).
- Anteroventral margin of pronotum is rounded (AA).
- Hind pretarsal claw has no median tooth (AAA).

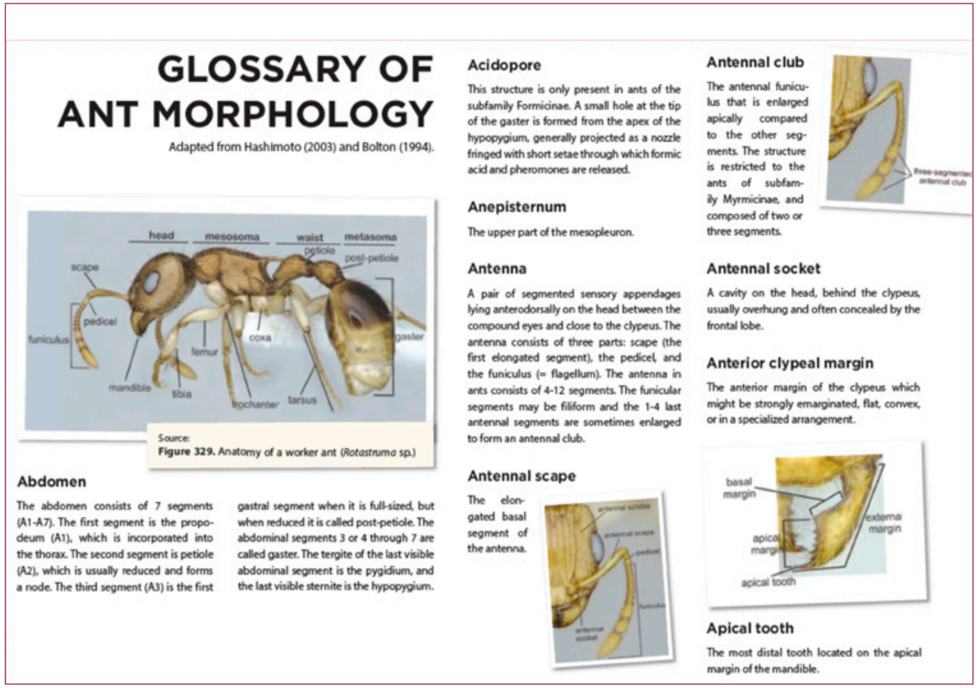
3. Proceratiinae
(only encountered genus: *Discothyrea*)
- Apical segment of antennal club is extremely large and bulbous.

4. Pseudomyrmecinae
(*Tetraponera* is the only valid genus)

Picture 49. Identification key to ant genera.



Picture 50. Images of the *EFForTS* ant collection.



GLOSSARY OF ANT MORPHOLOGY

Adapted from Hashimoto (2003) and Bolton (1994).

Source:
Figure 329. Anatomy of a worker ant (*Rotastruma* sp.)

Abdomen

The abdomen consists of 7 segments (A1-A7). The first segment is the propodeum (A1), which is incorporated into the thorax. The second segment is petiole (A2), which is usually reduced and forms a node. The third segment (A3) is the first gastral segment when it is full-sized, but when reduced it is called post-petiole. The abdominal segments 3 or 4 through 7 are called gaster. The tergite of the last visible abdominal segment is the pygidium, and the last visible sternite is the hypopygium.

Acidopore

This structure is only present in ants of the subfamily Formicinae. A small hole at the tip of the gaster is formed from the apex of the hypopygium, generally projected as a nozzle fringed with short setae through which formic acid and pheromones are released.

Anepisternum

The upper part of the mesopleuron.

Antenna

A pair of segmented sensory appendages lying anterodorsally on the head between the compound eyes and close to the clypeus. The antenna consists of three parts: scape (the first elongated segment), the pedicel, and the funiculus (= flagellum). The antenna in ants consists of 4-12 segments. The funicular segments may be filiform and the 1-4 last antennal segments are sometimes enlarged to form an antennal club.

Antennal scape

The elongated basal segment of the antenna.

Antennal club

The antennal funiculus that is enlarged apically compared to the other segments. The structure is restricted to the ants of subfamily Myrmicinae, and composed of two or three segments.

Antennal socket

A cavity on the head, behind the clypeus, usually overhung and often concealed by the frontal lobe.

Anterior clypeal margin

The anterior margin of the clypeus which might be strongly emarginated, flat, convex, or in a specialized arrangement.

Apical tooth

The most distal tooth located on the apical margin of the mandible.

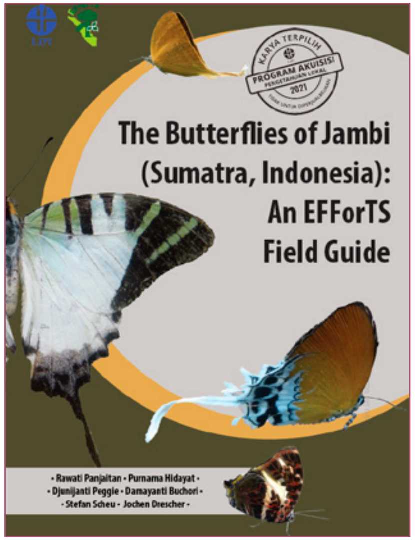
Picture 51. Glossary of ant morphology.

tween species, while those characters are often obscure in queen or males. The main part of this guide consists of images of our collection of (morpho-) species (Pictures 50 and 51).

In the current version, we include 335 (morpho-) species from 71 genera and 10 subfamilies in 629 images. For non-taxonomists and taxonomists alike, the photographs displayed in the image section shows the variety of morphology of the ants we have found. This will hopefully be helpful in determining ants to genera, or possible even (morpho-)species. Studying this book will bring you closer to our planet's fascinating diversity, and the little things that run our world. This book is an excellent starting point for those who want to know more about the ants of Southeast Asia, as well as a valuable resource for scientists and students studying ants in this part of the world. All in all, this book is a compendium of the ants of Jambi, Sumatra, and embodies a starting point for further ant research in Indonesia.

- Panjaitan R, Hidayat P, Peggie D, Buchori D, Scheu S, Drescher J (2021). The Butterflies of Jambi (Sumatra, Indonesia): An *EFForTS* field guide. e-Publishing Penerbit BRIN

Butterflies are probably the most attractive insects among the arthropods. For centuries, both professional scientists and amateur enthusiasts have collected, catalogued and scientifically described butterflies from all over the world. Unsurprisingly, they belong to the most well-known insect groups in terms of taxonomy and global species record completeness. More than 17,500 described species are distributed throughout the entire world, with the exception of Antartica. As butterflies are among the species facing population decline due to climate changes, the need to document them is more urgent than ever. Our data are based on 6,653 captured and/or observed butterfly individuals that we identified to 209 species from 106



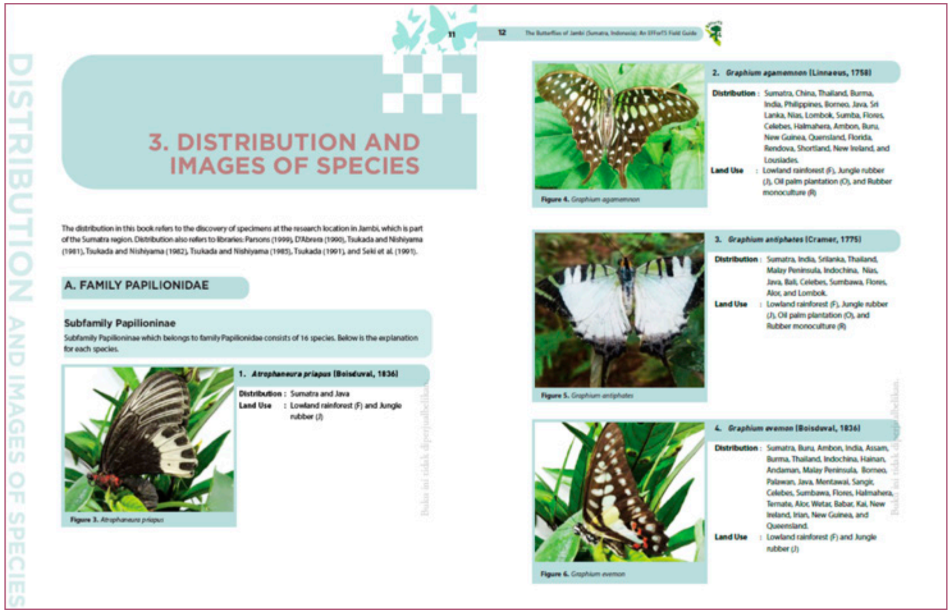
genera, 19 subfamilies and 5 families. This guide includes a checklist and images of all 209 species observed and collected. It provides scientists working in the region with an easy to use reference, and will be updated regularly. Moreover, this book also offers complete and detailed information on each butterflies name, habitat, distribution and image (Pictures 52 and 53).

Picture 52. The butterflies of Jambi.

- Hidayat P, Siddikah F, Amrulloh R, Anggraitoningsih W, Hiola MS, Kasmiatun, Najmi L, Nazarreta R, Scheu S, Buchori D, Drescher J (2022). Guidebook of Beetles and Weevils of Jambi, Sumatra, Indonesia (Chrysomelidae, Curculionidae, Elateridae, Staphylinidae). e-Publishing Penerbit BRIN, accepted and in copyediting.

Beetles are the largest and most diverse insects in the world, about 40% of all the insects and 30% of all animals are beetles. About 350.000 described species of beetles are spread around the world (Grimaldi and Engel, 2005). About 25.000 individuals of beetles have been collected by

Picture 54. A guidebook of beetles and weevils of Jambi.



DISTRIBUTION AND IMAGES OF SPECIES

11 12 The Butterflies of Jambi (Sumatra, Indonesia): An EFForTS Field Guide

3. DISTRIBUTION AND IMAGES OF SPECIES

The distribution in this book refers to the discovery of specimens at the research location in Jambi, which is part of the Sumatra region. Distribution also refers to libraries: Parsons (1999), D'Abrera (1990), Tsukada and Nishiyama (1981), Tsukada and Nishiyama (1982), Tsukada and Nishiyama (1985), Tsukada (1991), and Seki et al. (1991).

A. FAMILY PAPILIONIDAE

Subfamily Papilioninae

Subfamily Papilioninae which belongs to family Papilionidae consists of 16 species. Below is the explanation for each species.

1. *Atrophaneura priapus* (Boisduval, 1836)
Distribution : Sumatra and Java
Land Use : Lowland rainforest (F) and Jungle rubber (J)

Figure 3. *Atrophaneura priapus*

2. *Graphium agamemnon* (Linnaeus, 1758)
Distribution : Sumatra, China, Thailand, Burma, India, Philippines, Borneo, Java, Sri Lanka, Nias, Lombok, Sumba, Flores, Celebes, Halmahera, Ambon, Buru, New Guinea, Queensland, Florida, Rendova, Shortland, New Ireland, and Lousiades.
Land Use : Lowland rainforest (F), Jungle rubber (J), Oil palm plantation (O), and Rubber monoculture (R)

Figure 4. *Graphium agamemnon*

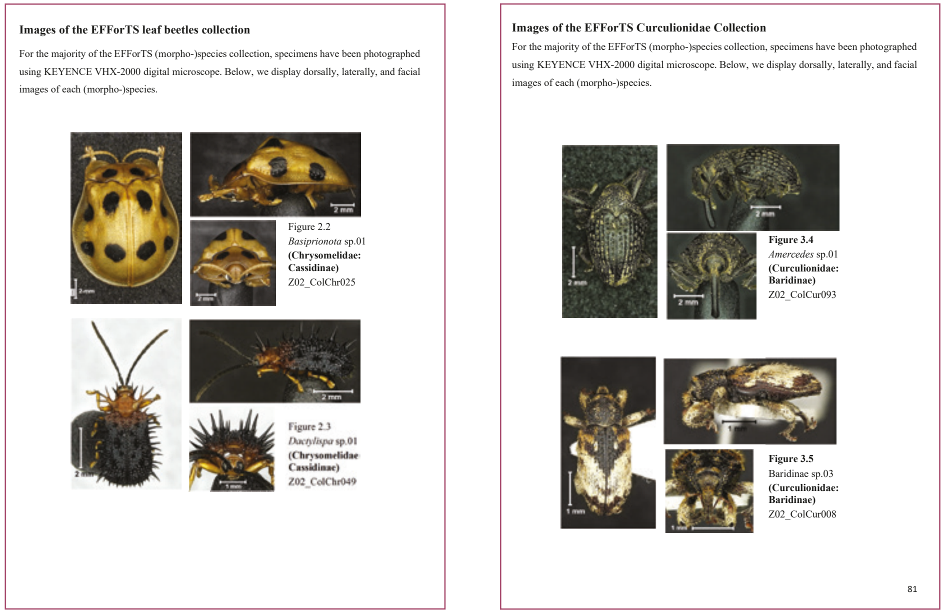
3. *Graphium antiphates* (Cramer, 1775)
Distribution : Sumatra, India, Srilanka, Thailand, Malay Peninsula, Indochina, Nias, Java, Bali, Celebes, Sumbawa, Flores, Alor, and Lombok.
Land Use : Lowland rainforest (F), Jungle rubber (J), Oil palm plantation (O), and Rubber monoculture (R)

Figure 5. *Graphium antiphates*

4. *Graphium evemon* (Boisduval, 1836)
Distribution : Sumatra, Buru, Ambon, India, Assam, Burma, Thailand, Indochina, Hainan, Andaman, Malay Peninsula, Borneo, Palawan, Java, Mentawai, Sangir, Celebes, Sumbawa, Flores, Halmahera, Ternate, Alor, Wetar, Babar, Kai, New Ireland, Irian, New Guinea, and Queensland.
Land Use : Lowland rainforest (F) and Jungle rubber (J)

Figure 6. *Graphium evemon*

Picture 53. Distribution and images of species



Images of the EFForTS leaf beetles collection

For the majority of the EFForTS (morpho-)species collection, specimens have been photographed using KEYENCE VHX-2000 digital microscope. Below, we display dorsally, laterally, and facial images of each (morpho-)species.

Figure 2.2
Basiprionota sp.01
(Chrysomelidae: Cassidinae)
Z02_ColChr025

Figure 2.3
Dactylispa sp.01
(Chrysomelidae Cassidinae)
Z02_ColChr049

Images of the EFForTS Curculionidae Collection

For the majority of the EFForTS (morpho-)species collection, specimens have been photographed using KEYENCE VHX-2000 digital microscope. Below, we display dorsally, laterally, and facial images of each (morpho-)species.

Figure 3.4
Amercedes sp.01
(Curculionidae: Baridinae)
Z02_ColCur093

Figure 3.5
Baridinae sp.03
(Curculionidae: Baridinae)
Z02_ColCur008

81

Picture 55. Images of the *EFForTS* beetles and weevils collection.

EFForTS, four major groups (families) with the highest number of species and individuals have been identified, i.e. Elateridae (click beetles), Staphylinidae (rove beetles), Curculionidae (true weevils), and Chrysomelidae (leaf beetles). A total of 4,295 individuals of Elateridae belonging to 7 subfamilies, 27 genera, and 80 (morpho-)species; 4,089 individuals of Staphylinidae belonging to 13 subfamilies, 13 genera, and 74 (morpho-)species; 3.544 individuals of Curculionidae belonging to 12 subfamilies, 34 genera, and 214 (morpho-)species; and 1697 individuals of Chrysomelidae belonging to 6 subfamilies, 69 genera, and 154 (morpho-)species. Many of the (morpho-)species are still unknown to science, and therefore need further taxonomic (and biological or ecological) investigation. We hope that this guidebook will be of interest to both taxonomists and ecologists, and may represent a first step in exploring the diversity of beetles in tropical Indonesia (Pictures 54 and 55).

- A scientific popular book: Keanekaragaman Serangga di Hutan Hujan Tropis Dataran Rendah di Provinsi Jambi, Sumatra: Dampak dari Perubahan Penggunaan Lahan). *https://penerbit.brin.go.id/press/catalog/book/280*

Authors: Buchori D, Hidayat P, Nazarreta R, Ardiyanti RM, Siddikah F, Amrulloh R, Azhar A, Kasmiatun, Scheu S, & J Drescher

Summary:
This book in Bahasa Indonesia summarizes the work of the Department of Plant Protection (Buchori) in the *EFForTS* framework. It focuses mainly on the results achieved within *EFForTS*-Z02, but also on several ABS projects.
The target audience is the general, interested public in Indonesia (Pictures 56, 57, 58).

Picture 56. Keanekaragaman Serangga di Hutan Hujan Tropis Dataran Rendah di Provinsi Jambi, Sumatra.

Picture 57. (top) Ants transporting food.
Picture 58. (bottom) Parasitoid wasps.

Purnama Hidayat	**Z02**	Monitoring arboreal arthropods communities across four different land-use systems

Background and Objectives

Tropical rainforest harbor much of the world's biodiversity, including arthropods. However, it is threatened by massive forest conversion to monoculture, particularly rubber and oil palm, over the last decade. In the present study, we compare the diversity of arboreal arthropods along different rainforest transformation system gradients, i.e., forest, jungle rubber, rubber, and oil palm plantation. The different land use systems represent the transition from natural habitat (forest) to extensively managed agriculture (jungle rubber) and intensively managed monoculture (rubber and oil palm plantation). This study is a follow-up research conducted since 2013 (Drescher *et al.* 2016). It is essential to conduct a long-term monitoring of arboreal arthropods diversity, which could be useful to monitor population dynamic of arboreal arthropod along land-use transformation gradients over times.

Methods

Sampling was conducted in four different land use types, i.e., forest, jungle rubber, rubber, and oil palm plantations in Harapan and Bukit Duabelas landscape. For each land use type, four plots were selected as replicates, giving a total of 32 plots. In addition, a total of 12 plots were established for riparian site of forest, rubber, and oil palm plantation. The arboreal arthropods were collected by canopy fogging (Drescher *et al.* 2016). Data analysis was performed using R v 4.0.3 (R Core Team 2020) and visualized using ggplot2 (Wickham 2016). The arboreal arthropod abundance between land use types was analyzed using glm by Gaussian family with the log link function. The same analyses were also conducted to compare canopy arthropod abundance between upland and riparian sites.

Results and Conclusion

In total, we collected 78,744 of arboreal arthropods specimens. Hymenoptera was the most abundant arthropod order found in this study with 16,628 individuals, followed by Collembola (14,311 individual), Coleoptera (9,628), and Diptera (8,010 individual) (Fig. 65). This study was in accordance with our expectation, since Hymenoptera was known to be one of the major insect order with its trait as social insect, the other beings Coleoptera, Diptera, and Lepidoptera (Goulet and Huber 1993).

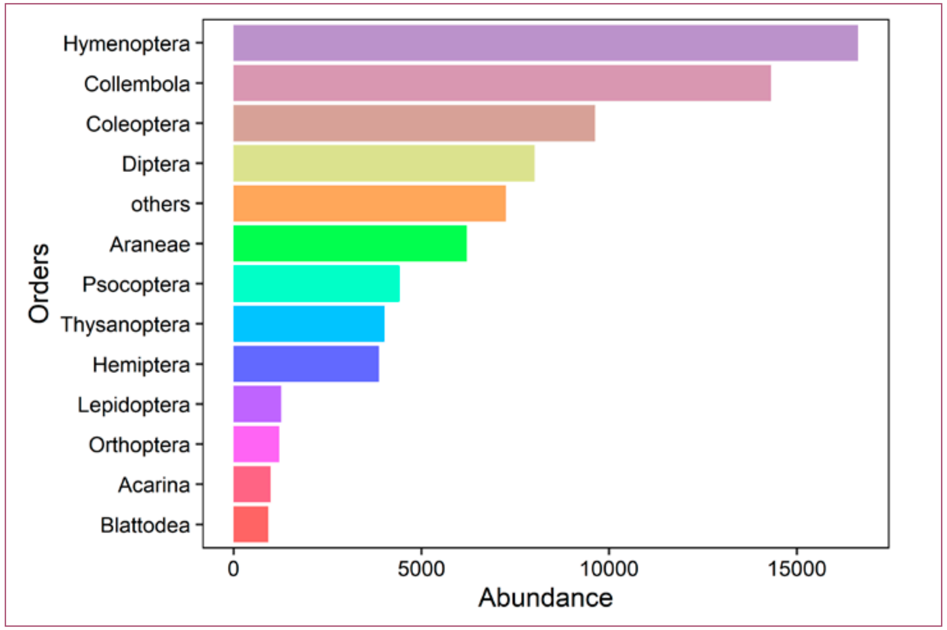


Figure 65. Canopy arthropod abundance which collected in four land use types

Abundance of arboreal arthropod differed among land use types (F40,43= 7.43; P<0.01). Surprisingly, the abundance was slightly higher in rubber jungle than forest and was highest compared to rubber and oil palm monocultures (Fig. 66). This result differs from 2013 results for many taxa, such as ants, butterflies, and parasitoid wasp, which were found highest in forest than other land use type (Grass *et al.* 2020). However, further in-depth analyses using the 2017 data in some specific taxa may produce the same result with the 2013 data, as some taxa respond differently to the occurrence of rainforest transformation. The lowest abundance in monoculture, both rubber and oil palm plantation, indicates that rainforest conversion to monoculture leads to a decline of arboreal arthropod.

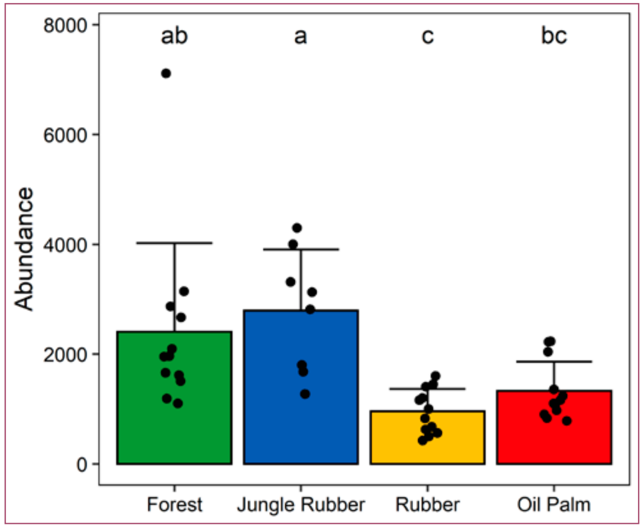


Figure 66. Arboreal arthropod abundance in four different land-use system. Different letters above the bar indicate significant differences of arboreal arthropods abundance between the land use systems.

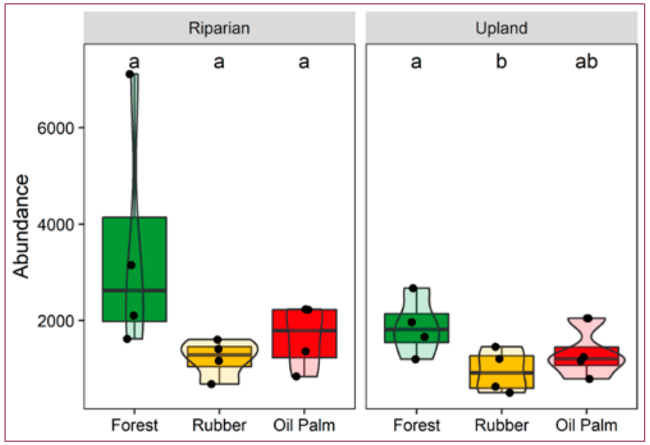


Figure 67. Arboreal arthropod abundance in different land-use system between riparian and upland site. Different letters above the bar indicate significant differences abundance between the land use systems.

The analysis of arboreal arthropod in upland and riparian sites showed that abundance was significantly different in different land use types ($F_{1,21}= 4.67$; $P=0.02$). The highest abundance of arboreal arthropod was found in forest and the lowest in rubber plantation. The abundance in riparian sites was marginally different compared to upland habitat ($F_{1,20}= 4.27$; $P=0.05$). The abundance of arboreal arthropod at each site showed different patterns. There is no difference in arthropod abundance between land-use system in riparian site. Nevertheless, there was a difference in upland sites where forest was most abundant, followed by oil palm and rubber plantation (Fig. 67).

This study found that forest and jungle rubber, representing agroforestry, had the highest abundance of arboreal arthropod than monocultures of rubber and oil palm plantations. This pattern was also evident in the upland site of land use system. Upland and riparian site did not give significant differences of arboreal arthropods abundance. Future in-depth analyses of some dominant and specific taxa, such as ants, hymenopteran parasitoid, and Coleoptera need to be conducted to investigate their response to conversion of natural habitats to rubber and oil palm plantations.

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Research projects of counterparts funded at UNJA

Name	Counterpart	Title
Asmadi Saad, Kurnia Irvanda, Dwiana Ocviyanti	**A01**	Physical characteristics of peat in various land use in Bram Itam Raya Village, Bram Itam District – Jambi

Background and Objectives

The area of peatland in Indonesia is estimated at around 14.95 million ha, spread over the islands of Sumatra, Kalimantan and Papua, and a small portion in Sulawesi (Wahyunto *et al.*, 2013). Thick peat deposits accumulate as a result of conditions such as low topographical support, high biomass production and rainfall as well as tidal influences.

Incorrect water management is the main cause of peatland degradation (Masganti *et al.*, 2014). This degradation is mainly related to the conversion of peatland for agriculture, such as oil palm plantations, mixed garden and other plantation crops, the depletion of the peat layer by drainage activities, and the destruction and depletion of the peat layer by fire events (Kurnain, 2006).

The characteristic physical property of peat is its very low volumetric weight compared to mineral soils. Peat can absorb water up to 13 times its weight. When the water content is <100%, the peat loses its ability to absorb water (irreversible drying) and becomes dry organic matter that is not suitable for use as a planting medium and loses its function as soil (Agus and Subiksa, 2008). Peatlands are very fragile soils and their productivity is very low.

This study aims to investigate the relationship between the physical characteristics of the soil peat and ash content in several land uses in Bram Itam Raya village, Tanjung Jabung Barat District Jambi

Material and Methodology

The research was conducted in the village of Bram Itam Raya whose area includes the Bram Itam Peat Protected Forest, Tanjung Jabung Barat Regency, Jambi Province (Fig. 68). The research was conducted from May to November 2021. Observation were conducted at three locations, namely Bram Itam Raya 1 (BIR1), Bram Itam Raya 2 (BIR 2) and Bram Itam Raya 3 (BIR3) with sequential land use Oil palm, mixed plantations and Forest (Picture. 59).

Soil samples were collected using a soil Auger (Core). Soil weight volume (W/V), soil moisture, ash content and C-organic were analyzed every 10 cm. Volume weight and water content were analyzed by gravimetry, while the ash content and C-organic were analyzed by combustion – LoI (furnace).

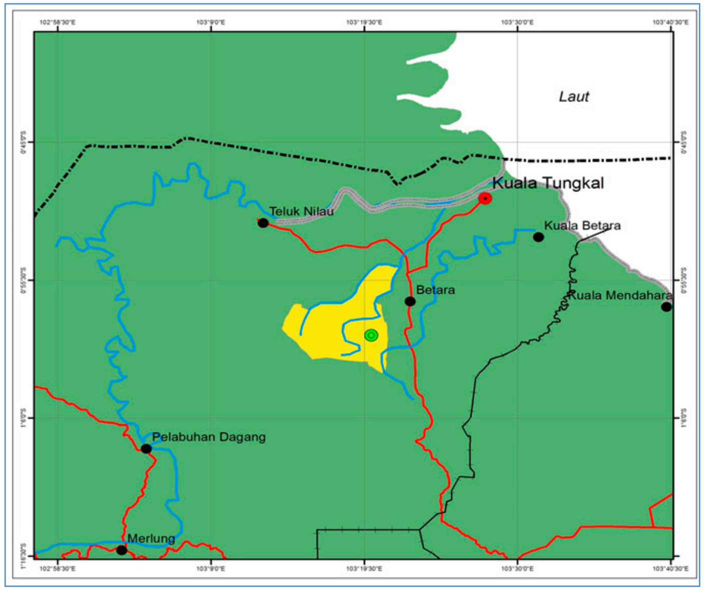

Figure 68. Map of Location Bram Itam Raya

Result and Discussion

The value of the weight volume (W/V) of soil at the Bram Itam Raya location varies slightly. The highest value is at the BIR01, followed by BIR02 and BIR03 (Fig. 69). It can be concluded that the other three locations, namely oil palm land use, mixed plantations and forest have slightly different characteristics since they are located in the transition zone of peat to minerals and near the river. This is an indication that the peat is mature (sapric) and the composition of the peat is mixed with sand/clay grains due to flooding and the

Picture 59. Field work activities

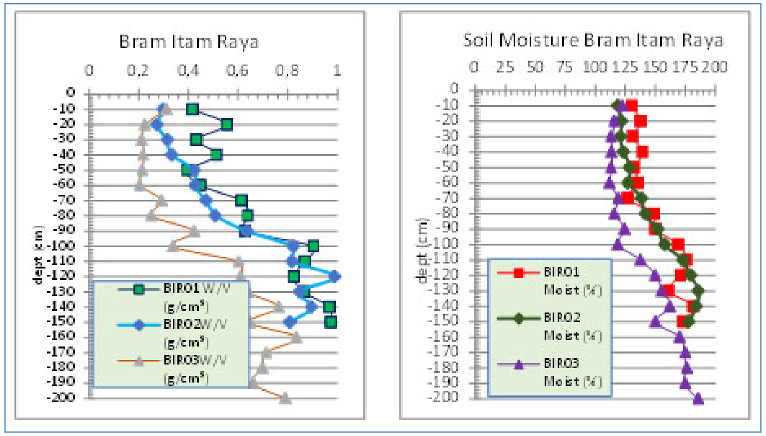

Figure 69. W/V (gr/cm³) and Soil Moisture (%)

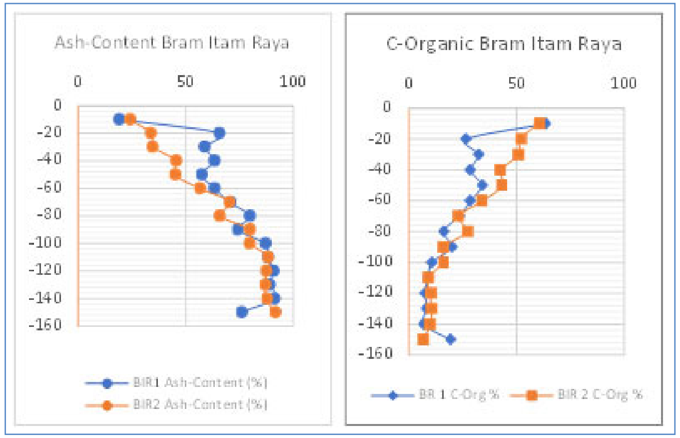

Figure 70. Ash content (%) and organic C (%)

influence of tides. Soil moisture more than 100 % indicates water level influenced by tides twice a day (diurnal).
A high ash content shows that peat is mixed with sand/clay grains due to flooding from river and tides (Fig. 70).

Conclusion

Physical characteristics of peat in various land use in Bram Itam Raya Village influenced by mixed of sedimentation from flooding and tides. W/V higher at oil palm than mixed garden and forest.

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Damris Muhammad, Nurzeni Fitri	**A05**	The effects of modified biochar on greenhouse gas emission from soils of palm oil plantations in Jambi

Background and Methods

The conversion of tropical rain forest to palm oil plantation not only causes above ground carbon loss but also carbon stock in the forest soils. Thus, the greenhouse gas emission from the converted land come not only from the decomposition of above ground biomass, but also from the carbon stock in the soils. However, the question of how to reduce the greenhouse gas (GHG) emission from soils to the atmosphere and how to stabilize the most unstable fraction of soil carbon in the form of dissolved organic carbon (DOC) in the soil is not well understood. Biochar as a pyrolysis product of organic wastes under limited oxygen environment (Oliveira *et al.*, 2018) was used and added to the soil of palm oil plantation in a lab incubation study, which then used to estimate and quantify the amount of GHG flux reduction and stabilisation of DOC in the palm oil plantation soils. The GHG emission were analyzed by HCl titration and DOC by UV-VIS spectrophotometer. The biochar was characterized using FTIR and SEM.

Objective

The objectives of this study were to estimate and quantify the GHG emission and DOC stabilisation in biochar-enriched soils of palm oil plantation, as a strategy to mitigate of GHG emission from palm oil plantation.

Approach

Ten soil samples (0–30 cm) were randomly collected from smallholder palm oil plantations in Muaro Jambi District. Samples were air dried and grained to pass 2 mm sieve. Approximately 750 g of soil was placed to a 1000-ml amber bottle and coffee husk biochar (5 and 10 % w/w) was added, with the water content was adjusted to 75 %. The weight of the mixture is recorded. The bottles were kept open for one week for conditioning and the weight was adjusted with water if necessary. Samples were stored in the dark for 10 weeks and the gas released from the bottles was collected in a 0.1 M NaOH solution. A small portion of the solid from the bottle was collected for DOC extraction. After collection of the gas and solids, the bottles were opened to ensure that oxygen was not a limiting factor of organic carbon mineralization. The soil samples in the bottle were re-weighted to ensure no loss of weight. This process is repeated for 10 weeks. The concentrations of CO_2 and DOC were determined by HCl titration and UV-VIS spectrophotometer, respectively. Soil properties such as pH, particle size distribution, minerals, total carbon content, water holding capacity, and density were also determined in this study. The biochar used in this study was modified with acid (HNO_3), alkaline (KOH) and ethanol, and characterized by FTIR and SEM. All experiments were performed in triplicate.

Result

The effect of biochar amendment on CO_2 emission

Carbon dioxide emission from incubation of the biochar-enriched soil measured over 30 days are shown in figure 71. It shows that the addition of biochar to the soil affects CO_2 emission to the atmosphere. Both organic and mineral soils produced higher CO_2 emission compared to the control (without biochar addition), which was measured at the 5th day. The variation of biochar addition (5 % and 10 %) to the soils resulted in a decrease in CO_2 emission. Soil amended with 5 % biochar reduces CO_2 emission from organic soil (7.01 to 6.30 mg g-1) and mineral soil (4.50 to 4.00 mg g-1) by about 10 %. While the soil enriched with 10 % biochar resulted in a greater reduction in CO_2 emission.

The effect of biochar amendment on N_2O emission

Nitrous oxide (N_2O) emissions from biochar-enriched soil are shown in figure 72. It appears that the biochar-enriched soils affect the N_2O emission from the oil palm plantation measured over 30 days. The variations of biochar additions affect the N_2O emission released from the biochar-enriched soils. The control soil (without biochar addition) resulted in higher N_2O emissions for both organic and mineral soils measured at day 5 of incubation. The addition of 5 % and 10 % (w/w) biochar to the soil resulted in a decrease in N_2O emissions. The addition of 5 % biochar reduced N_2O emissions by 27 % and 10 % for organic and mineral soils, respectively. However, the 10 % addition

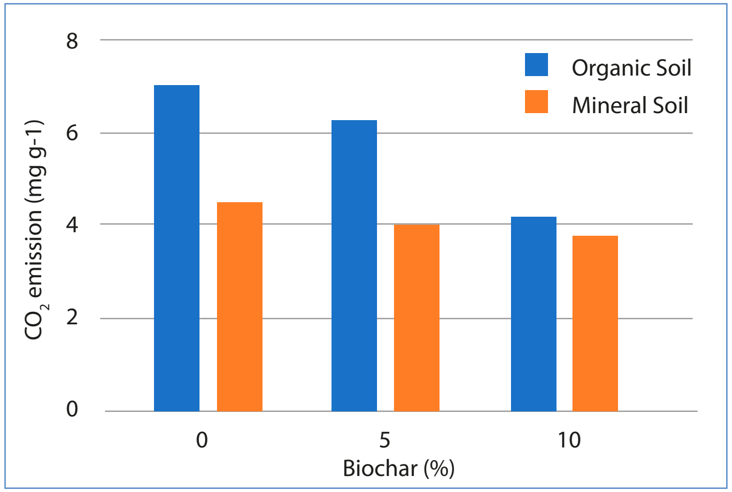

Figure 71. the effect of biochar addition to organic and mineral soils on the CO_2 gas emission

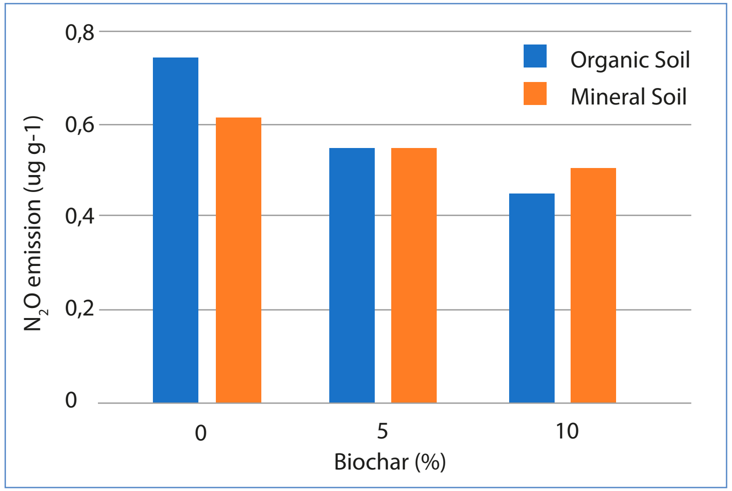

Figure 72. the effect of biochar amendment to organic and mineral soils on the N_2O gas emission measured at the 5th day of incubation

did not result in a proportional reduction in N_2O emissions, as shown in figure 72. The 10 % addition measured on the 5th day of incubation reduced N_2O emissions by 40 % and 18 % for organic and mineral soil, respectively.

The addition of biochar to the organic and mineral soils of smallholders of palm oil plantation resulted in the decrease of greenhouse gas emission (CO_2 and N_2O) released from the studied soils in a laboratory experiment with 0 day of incubation. This approach appears to be promising strategy to mitigate greenhouse gas emissions from the palm oil plantation.

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RevisAsra, Joko Ridho Witono, Izu Andry Fijridiyanto	**B14**	Sex identification of Jernang (*Daemonorops draco* (Willd.) Blume) using ISSR markers

Background and Objectives

Jernang (*Daemonorop draco*) as a synonym of *Calamus draco* (Baker 2015) is one of rattans which produces resin called dragoon's blood that has economic value as a medicine and natural dye (Gupta *et al*. 2007). This species belongs to the Palmae family, which is found in Sumatra and Kalimantan (Purwanto *et al*. 2005). In Sumatra, Jernang is distributed from West Sumatra, South Sumatra, Jambi, Riau to Lampung (Rustiami *et al*. 2004).

The resin is harvested from the fruit collected in the forest. The presence of *D. draco* in wild is rare (BKSDA Jambi 2010), and cultivation of this species is still rare (Asra and Farid 2016). Meanwhile, habitat destruction of *D. draco* for oil palm and rubber plantations is also causing a decline in the population of this species (Asra *et al*. 2014). Cultivation and conservation programs are needed to prevent the extinction of this plant in natural forest. Jernang is a dioecious plant. It is difficult to distinguish male and female plants based on vegetative characters. The sex of jernang can be determined by the structure of the inflorescence. Male plants produce inflorescences with fertile male flowers and female plants produce inflorescences with fertile female flowers and sterile male flowers. It takes 4–5 years for jernang to produce its first inflorescence (Asra *et al*. 2012).

In cultivation programs, it is desirable to grow as many female plants as possible to produce fruit containing dragoon's blood. In conservation programs, an equal (1:1) ratio of male and female plants is usually found in natural populations (Rottenberg 1998). It is essential to be able to identify male and female plants at the seedling stage. Therefore, it is important to find another method to distinguish male plants and female plants of jernang at the vegetative stage. The easiest and most reliable method for sex determination in plants is the use of sex-specific DNA markers. Such markers have been developed for many dioecious plants. In most cases, sex specificity was associated with the male sex (Aleksandrov *et al.* 2011). Among the molecular markers, inter-simple sequence repeat (ISSR) markers have been used to detect variations among plants and also to determine sex in various dioecious plants (Milewicz & Sawicki 2013; Grewal & Goyat 2015).

The Objective of this study is to develop genetic markers from ISSR analysis of male and female plants of *C. draco* to allow sex determination at seedling or vegetative stage in its life cycle.

Methods

Plant materials and Genomic DNA extraction

Leaf samples of 5 male, 5 female mature individuals and 10 seedlings of *D. draco* from Sepintun (Sarolangun Regency) in the Province of Jambi, Indonesia, were randomly collected and placed in silica gel prior to extraction. Total genomic DNA is extracted from silica gel-dried leaf tissues. DNA was isolated using Quick-DNATM plant/seed MiniPrep Kit (Zymo Research) according to manufacturer manual. DNA samples of each plant was analysed individually to detect sex determination markers.

PCR (Polymerase Chain Reaction)

PCR amplification was performed in 16 µL reaction, and the reaction mixture contained 8 µL KOD One ™ PCR Master Mix-Blue (TOYOBO), 2 µL ISSR primer (10 pmol mL-1), 1 µL of DNA template and 5 µL of nuclease-free water. The DNA amplification was performed in a PCR instrument (TaKaRA PCR Themal Cycler Dice) for about 30 cycles. PCR procedures were performed in the following order: (1) one cycle of denaturation at 98 °C for 3 min: (2) 30 cycles of 98 °C for 10 s (denaturation), 60 °C for 3 s (annealing), 68 °C for 1 s (extension); and (3) final extension 68 °C for 7 minutes followed by soaking at 4 °C.

Electrophoresis

An initial screening revealed 26 ISSR primers from previous studies in some species of palms, of which 14 primers were successfully amplified (Table 11). PCR results generated by ISSR marker were processed by electrophoresis with 5 µL of the standard DNA, 100 bp DNA ladder of 1.5 % agarose gel in TBE 1X as the buffer solution. The agarose gel was then run on an electrophoresis device (Mupid ™ – exu Submarine) with 100 V for 90 minutes at room temperature. The resulting amplified bands were observed using gel documentation Gel Doc™ EZ Imager (BIO RAD). The band that was present in corresponding male or female samples and absent in the alternate sex samples was recognized as a potential sex-linked marker. The primers showing unique bands were further used with separate male and female seedling samples.

Table 11. ISSR Primers were used in this study

No.	Primer Code	Oligonucleotide name	Sequence	Tm (0C)	Reference	PCR Products
1.	IS A02	(GA)9C	5'-GAGAGAGAGAGAGAGAGAC-3'	60	Al-Ameri *et al.* 2016	Amplified
2.	IS A71	(CA)8RG	5'-CACACACACACACACARG-3'	60	Al-Ameri *et al.* 2016	Amplified
3.	RT28	(CT)8G	5'-CTC TCT CTC TCT CTC TG-3'	60	Sarmah *et al.* 2017	Amplified
4.	RT29	(CA)8A	5'-CAC ACA CAC ACA CAC AA-3'	60	Sarmah *et al.* 2017	Amplified
5.	HB 9	(GT)6GG	5'-GTGTGTGTGTGTGG -3'	60	Younis *et al.* 2008	Amplified
6.	HB 11	(GT)6CC	5'- GTGTGTGTGTGTCC -3'	60	Younis *et al.* 2008	Amplified
7.	HB 12	(CAC)3GC	5'- CACCACCACGC -3'	60	Younis *et al.* 2008	Amplified
8.	814	(CT)8TG	5'- CTC TCT CTC TCT CTC TTG -3'	60	Younis *et al.* 2008	Amplified
9.	844A	(CT)8AC	5'- CTC TCT CTC TCT CTC TAC -3'	60	Younis *et al.* 2008	Amplified
10.	Clo 2	(CT)7YC	5'- CTCTCTCTCTCTCTCC -3'	60	Sarmah & Sarma 2011	Amplified
11.	ISSR2	(AAG)5 GC	5'- AAGAAGAAGAAGAAGGC -3'	60	Sarmah & Sarma 2011	Amplified
12.	UBC 807	(AG)8 T	5'-AGAGAGAGAGAGAGAGT-3'	60	Asra *et al.* 2014	Amplified
13.	UBC 808	(AG)8 C	5'- AGAGAGAGAGAGAGAGC-3'	60	Asra *et al.* 2014	Amplified
14.	UBC 834	(AG)8 YT	5'-AGAGAGAGAGAGAGAGYT-3'	60	Asra *et al.* 2014	Amplified

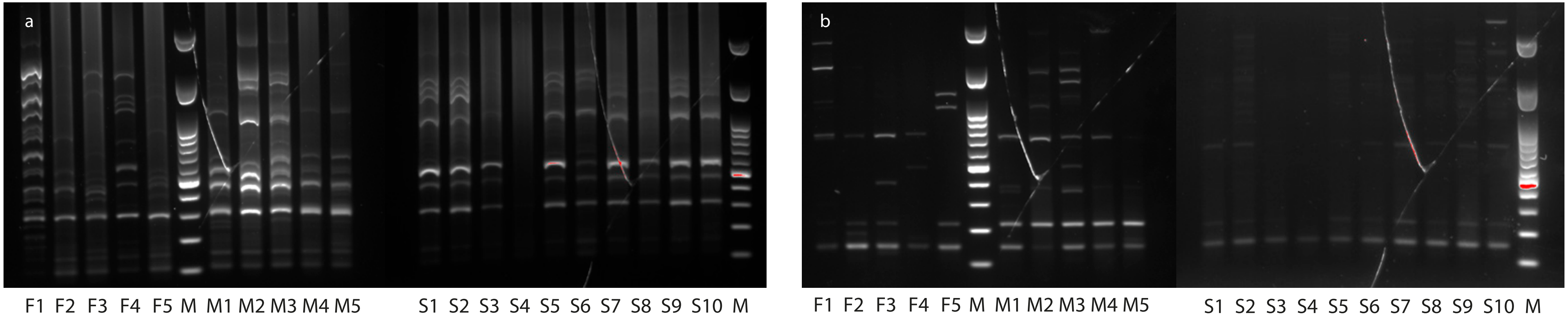

Figure 73. ISSR banding patterns of male, female and seedling (undetermined sex) individuals of *Calamus draco* obtained from 2 primers: (a) HB 9 and (b) HB 11. M = 100 bp ladder; F1-F5 = female individuals, M1-M5 = male individuals, S1-S10 = seedlings (undetermined sex).

Results and Conclusion

Based on the PCR results using 26 ISSR primers, 14 primers of which were successfully amplified of 100-3000 bp with clear bands, whereas the other primers were not amplified or amplified with smear bands (Table 11). Some examples of successful PCR results are shown in figure 73.

Of all 14 primers tested and observed, only one primer, 844A [(CT)8AC] showed sex specificity in bulk analysis. The primer produced a unique 270 bp fragment (yellow arrow) in male bulk DNA, and this band was absent in female bulk DNA. Several other bands were also generated in both male and female samples in 340 bp and 800 bp (red arrow) (Fig. 74). Then the primer was presented to 5 seedling individuals (S6-S10) with similar banding patterns as in the male individuals (blue arrow). It could be concluded that seedling of S6-S10 are male individuals.

In natural stands, sexually mature plants are usually present, but flowering and fruiting occurs only between April and June. Based on this study, PCR-based DNA markers such as ISSR markers can be successfully used for sex identification at the seedling stage. However, designing and exploring other ISSR markers are necessary for gender determination of *C. draco* in the future.

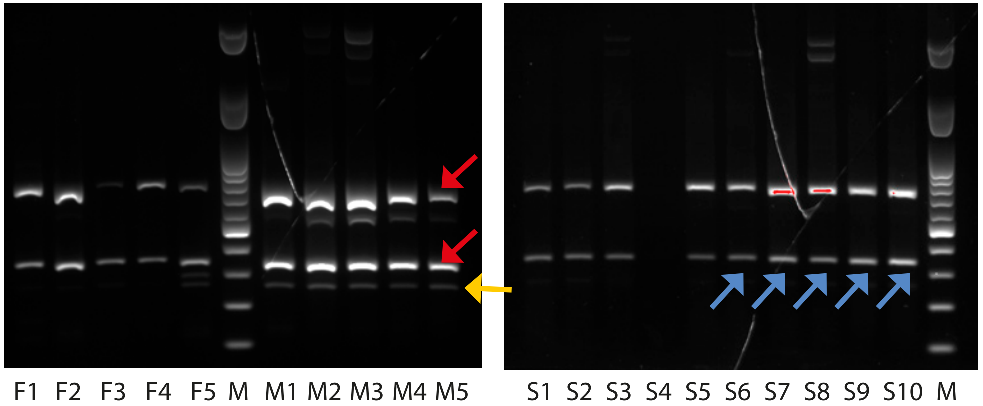

Figure 74. ISSR banding patterns of male, female and seedling (undetermined sex) individuals of *Calamus draco* produced by primer 844A [(CT)8AC]. M = 100 bp ladder; F1–F5 = female individuals, M1–M5 = male individuals, S1–S10 = seedlings (undetermined sex).

As a conclusion, of all the 26 ISSR primers tested and observed, only one primer, namely 844A [(CT)8AC] showed sex specificity in bulk analysis. Designing and exploring other ISSR markers are necessary for gender determination of *C. draco* in the future.

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Bambang Irawan, Yabes God Anugrah Panjaitan	**B14**	De novo whole genome sequencing of Bulian (*Eusideroxylon zwageri* Binn & Teijsm) using millenial technology MinION Oxford Nanopore

Scientific Background and Method

Ironwood (*Eusideroxylon zwageri* Teijsm. et Binn., synonymous to *Bihania borneensis* Meissner and *Eusideroxylon lauriflora* Auct.) is known by several common names (e.g. bulian/ulin/belian/onglen) and belongs to the family of Lauraceae (tribe Cryptocaryeae, subtribe Eusideroxylineae) (Kostermans 1957). In nature it is distributed in Sumatra, Kalimantan and some small islands such as Tawi–Tawi (Philippines), Banka and Billiton.

E. zwageri is one of the most important species for construction wood in Indonesia. The wood is used to make furniture, windows and door frames, heavy constructions, roofs, bridges, railway sleepers, marine pillings, boat constructions, fence posts, heavy duty industrial flooring, shingles and vehicle body work. Seed extracts can be used as a skin medicine (Irawan 2005). The most valuable characteristic of *E. zwageri* is that it is not susceptible to termites and other ubiquitous tropical wood-eating insects and fungi. For this reason, the wood is in great demand for construction throughout Indonesia (Peluso 1992). Martawijaya *et al.* (1989) stated that the physical characteristics of *E. zwageri* are excellent. It has very high strength and durability (class one) and is very hard with a specific gravity of 0.88–1.19. In addition, Wong *et al.* (1996) found that *E. zwageri* is very resistant to fungi in a fungal decay test. Sampling of heartwood poles in Sarawak revealed only surface biodeterioration after 20 years of operation and ground-contact. Furthermore, although impermeable to preservatives, the wood can be used in highly decay-prone environments (burial in the ground).

Variability based on morphological structures (see Van Lijnden and Groll 1851; Teijsmann 1858; Teijsmann and Binnendijk 1863; Heyne 1927; Koopman and Verhoef 1938; De Wit 1949; Kostermans *et al.* 1994), as well as genetic variation based on DNA marker had been reported in several publications. Knowledge of genetic variation among *E. zwageri* varieties and populations is very important for the conservation and sustainable utilization of its genetic resources.

On the other hand, populations of *E. zwageri* are intensively decreasing in nature in parallel with the demand for this species. The decline in population is caused by overexploitation. Recently, *E. zwageri* has been excluded from the list of protected plant species in Indonesia, which may lead to further decline of natural population. The natural regeneration of *E. zwageri* in overlogged forests is limited. To date, the species has been planted on a small scale due to insufficient supply of seeds and seedlings and slow growth compared to more commonly planted trees (Oldfield *et al.* 1998). In Jambi, *E. zwageri* can be found in several remnant forest areas, namely Senami forest, Sengkati, Durian Luncuk I and II, and several small forest areas in Sungai Kandang, Batanghari (Harapan Rainforest), District VIII Conservation area of PT, Wirakarya Sakti, Mandiangin. Rimbo Bulian in Batanghari and some other regions in the eastern part of Jambi, namely Muaro Jambi in Kumpeh region and Muara Sabak, Tanjung Jabung Timur District. *E. zwageri* is also found in South Sumatra, including one stand of *E. zwageri* in PT REKI (Restorasi Ekosistem Indonesia). Considering the resilience of bulian, fundamental research is needed that requires sufficient genomic information to understand genetic diversity, mating systems, planting stock quality etc.

Samples were collected in Jambi Province in four villages, namely Bulian baru, Durian Luncuk, Belanti Jaya, and Muara Kilis. The method in general included (1) sample collection using tea bag method to preserve the leaf sample; (2) DNA isolation using modified CTAB method; (3) Quantity and quality check using electrophoresis and nanophotometer; (4) DNA sequencing using MinION Oxford Nanopore and associated softwares. In particular, for DNA isolation, modification was conducted on the grinding methods, namely i) DNA isolation with nitrogen in pestle, ii) sample grinding with CTAB in pre-chilled mortar and iii) sample grinding in tube with tips.

Objectives

The objective of this study is to sequence the whole genome of bulian as baseline information for subsequent genetic analysis using portable MinION ONT sequencer (Picture 60).

Picture 60. Collection of samples in the field.

Picture 61. Genetic analysis using portable MinION ONT sequencer.

Approach

The samples were collected from Jambi Province which spread from four villages meanly Bulian baru, Durian Luncuk, Belanti Jaya, and Muara Kilis villages. The collected sample were obtained from leaves and preserved directly in the field using tea bag method by drying the leaves with silica gell (Picture 61). The DNA sequencing using MinION oxford nanopore as the data will be used to establish the whole genome sequence of bulian. Previously, the genetic study of bulian was conducted using RAPD marker, but this study did not provide whole genome information, but only focused on the genetic diversity of bulian. Whole genome sequencing information is important for analyzing SNP location, *Copy Number Variation* (CNVs), structural variation (SVs), SNP annotation and enrichment analysis of SNPs that has no synonym (Mei *et al*. 2016).

Results Leaf sample collection

Leaves from a total of 38 individual trees were collected as presented in table 12.

Table 12. Number and location of sample taken

No.	Location	Number of Sample (trees)
1	Muara Kilis Village	11
2	Bulian Baru Village	8
3	Durian Luncuk Village	10
4	Belanti Jaya Village	0
		38 (Total)

DNA Isolation

The DNA extraction and electrophoresis results were presented in figure 75. Based on the results of figure 75, the modified grinding methods had an effect on the DNA yields. The results of the nanophotometer as shown in table 13 were generated using samples with clear DNA bands.

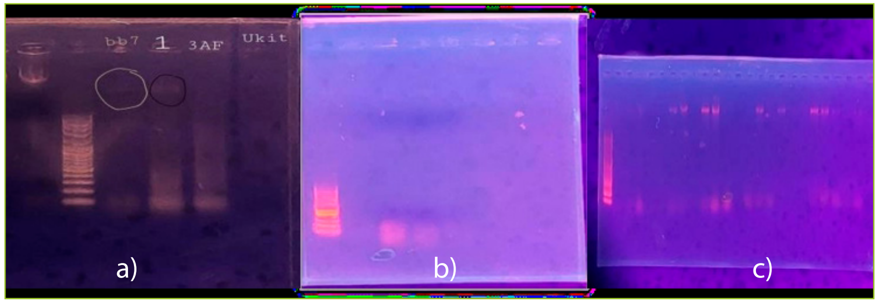

Figure 75. (a) DNA isolation with nitrogen in pestle (b) Sample ground withCTAB in pre-chilled mortar (c) sample ground in tube with tips.

Table 13. Nanophotometer results

No.	Name	Concentration (µg/ml)
1	D1	114,30
2	BB7	106,65
3	D10	145,15
4	BJ9	237,05
5	B3B5	86,400

In general, the results are still preliminary, and further analysis is necessary to ensure that the samples have passed the quality check before sequencing.

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Mirawati Yanita	**C01**	Economic production model of independent smallholder oil palm cultivation in Batanghari Regency

Background and Objectives

Oil palm is the most important commercial crop worldwide (Byerlee, 2017; Qaim *et al.*, 2020). Many agricultural and nonagricultural households in the tropics depend on oil palm cultivation and employment for their livelihoods. Oil palm has significantly improved rural poverty and malnutrition (Qaim *et al.*, 2020). The introduction of oil palm allowed these rural households to have a good income independent of the seasons. The many benefits of palm oil make the demand for palm oil to increase. Therefore, efforts to increase oil palm production are continuing to increase the area under cultivation. Thus, oil palm cultivation is developing quite rapidly, and oil palm production is continuously increasing yearly. The development of oil palm production also extends to the island of Sumatra, especially Jambi Province. The development of oil palm in Jambi Province has continued to increase over the past five years (2014–2018) with an average growth of 3.78 % per year and an average growth of oil palm production of 4.17 %. As a result, oil palm plantations are one of the leading plantation sectors in the Batanghari Regency. Muara Tembesi District has the lowest productivity among other districts, 3.06 tons/ha (Plantation Division, 2018) It is believed that the low productivity due to the influence of production factors used by farmers. Therefore, this study aims to: 1) Know the description of independent Oil Palm cultivation in Muara Tembesi District, Batanghari Regency 2) Analyze the effect of production factors (land area, number of stems, plant age, fertilizers, herbicides, and labor) on production yields.

Methods

The number of research samples obtained is 54 people with a proportional distribution of 23 people in Jebak Village, 20 in Ampelu villages, and 11 in Ampelu Mudo villages (Picture 62). The method of data analysis used is descriptive and quantitative. The picture of independent smallholders farmers cultivate oil palm in Muara Tembesi Subdistrict is explained descriptively. Quantitative analysis is used to analyze the influence of palm oil production factors. Regression analysis is used to predict causal relationships between independent and dependent variables. Furthermore, regression analysis can be used to build a model of production functions that can be mathematically described: Where: Y is Palm oil production (Kg/Year), A is Constanta, X_1 is Land Area (Ha/Year), X_2 = Number of Plant (stems). Next, X_3 is Age of the Plant (Year), X_4 is fertilizer (Kg/Year), X_5 is Herbicides (Liter/Year), X_6 is Manpower (HOK/Year), $b_1 \ldots b_6$= Variable regression coefficient X_1-X_6, and e is an error term (2,71828). To examine whether the factors of production used simultaneously affect oil palm production, an F- test and a partial test using the T-test are used.

Results and Conclusion

The respondents in this study were smallholders farmers who worked on oil palm cultivation in Jebak Village, Ampelu, and Ampelu Mudo Muara Tembesi Subdistrict, with a sample size of 54 farmers. The identity of the farmers interviewed is described in table 14.

Table 14. Average Identity of Oil Palm Smallholders in Research Area

No	Identity of smallholders	Amount/degree
1	Age of the Farmer (tear)	47
2	Level of Education)	Junior High School
3	Number of Family Members	5
4	Experience of cultivation (year)	19

Source: Primary data processed.

The implementation of the mature crop in the research area is carried out in several stages, ranging from maintenance, fertilization, spraying and harvesting. The first stage of soil maintenance consist of cleaning the plates and gates. Farmers routinely perform this maintenance activity at least once a month. Next, farmers must perform fertilization activities. This activity is usually performed 1-3 times a year, with urea fertilizer oftenly used by farmers. Spraying or administering herbicides, including activities that farmers rarely do, is usually done only 1-2 times per year. Finally, harvesting activity includes fruit harvesting, fruit transportation, and pruning (cutting). Smallholders usually harvest within 14-20 days, depending on the condition of the fruit.

Analysis using factors of production to determine the extent of the influence of the use of factors of production can be seen in table 15.

Picture 62. Overview of Palm Oil Cultivation in Research Areas (a), and Interview process (b and c)

Table 15. Results of Estimated Production Function of Cobb-Douglas Oil Oil palm cultivation in Research Area

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_X1_Land	0.502649	0.203522	2.469752	0.0172
LN_X2_Number of Bars	-0.152788	0.177118	0.862634	0.3927
LN_X3_Age of plants	0.095015	0.030081	3.158636	0.0028
LN_X4_Fertilizer	0.112097	0.034057	3.291494	0.0019
LN_X5_Herbicides	0.087406	0.041618	2.100220	0.0411
LN_X6_ labor	0.466680	0.167341	2.788797	0.0076
C	7.350125	1.181233	6.222416	0.0000
R-squared	0.985835	Mean dependent var		10.56661
Adjusted R-squared	0.984026	S.D. dependent var		0.419677
S.E. of regression	0.053042	Akaike info criterion		-2.915060
Sum squared resid	0.132230	Schwarz criterion		-2.657229
Log likelihood	85.70661	Hannan-Quinn criter.		-2.815624
F-statistic	545.1634	Durbin-Watson stat		1.844974
Prob(F-statistic)	0.000000			

Source: Eviews 8, 2021

The simultaneous use of the production factors of land, age of crop, fertilizers, herbicides and labour has a real effect on oil palm production with an Adjusted R-squared value of 0.984026. While for the production factor of the number of stems simultaneously has no real effect on palm oil production. Partially, the production factor has a real effect on oil palm production with a sign of 10%. Therefore, oil palm smallholders in Muara Tembesi District are expected to pay more attention to the existing production factors to optimize their production. The local government is expected to provide incentives in the form of fertilizer subsidies to smallholder farmers by both the provincial government and the regency government to help farmers in conducting their oil palm cultivation activities and capital formation.

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Rosyani, Fuad Mukhlis, Fazriyas, Nurhikmah Mila	C02	Community's perception and poverty threaten the preservation of Grand Forest Park (Tahura)"Orang Kayo Hitam" in Muaro Jambi District, Jambi Province, Indonesia

Background and Objectives

The sustainability of the Taman Hutan Rakyat (Tahura) Orang Kayo Hitam (OKH) is threatened. There has been an observation conducted by the community covering an area of 902 hectares. There were forest fires covering an area 7,984.78 hectares and illegal logging has occurred against OKH Tahura (Picture 63). Meanwhile, Tahura OKH is a protected peat swamp forest with the area of 18,140.77 hectares (Picture 64). This area contains specific types of flora and fauna.

There are several villages bordering Tahura OKH. The people living around Tahura OKH are poor. Low perceptions and poverty cause the community to encroach the OKH Tahura.

The objectives of this research are: 1) By providing books on conservation of OKH Tahura, it can increase community perceptions of the conservation function of OKH Tahura. 2) By doing a demo-video about OKH conservation it can increase people's perceptions. 3)By providing seeds to be planted at utilization zones through a partnership pattern can increase additional community income.

Methods

The stages carried out in this study are summarized in figure 76:

- Inquired initial data on respondents' perceptions(T0)
- Given reading books about the functions and regulations of the OKH Tahura (T1) to respondents
- Conducted and shown videos about Conservation of Tahura and the importance of Tahura OKH (T2) To respondents FGDs
- Given seeds to respondents, then to be partner with Tahura OKH in the utilization zone (T3)
- Interviewed the respondents after three months (Picture 65). The data is obtained whether there is a change in perception and additional income of the respondent

Respondents are people within the three villages closest to Tahura. Namely Sungai Aur Village (528 families), Jebus Village (256 families) and Sungai Bungur Village (603 families). Total population of 1,387 household (Forestry Service, 2020). The sample size are 93 respondet.

Picture 63. Peat Location After the Tahura Fire in 2015.

Picture 64. Picture of Tahura Location at the Time of Research in 2019.

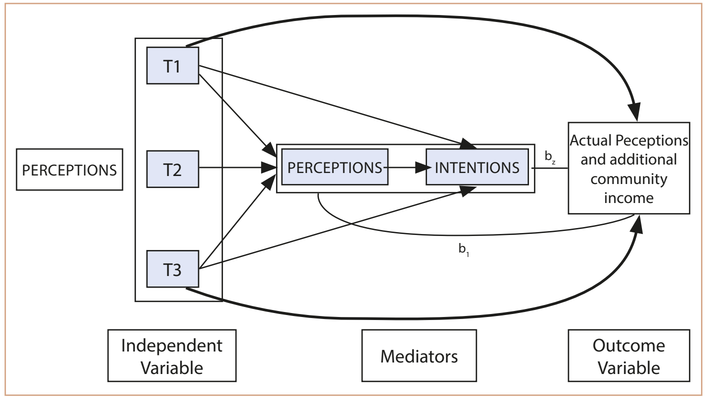

Figure 76. Research framework used. Community perception of Tahura OKH after treatment.

Picture 65. Overview of Local community activities

Table 16. Trial Test Before And After Being Given a Reading Book About Tahura OKH

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	11.24	93	2.123	220
	After	14.85	93	531	055

Table 17. Trial Test Before & After Showing Video about Tahura OKH

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	10.40	93	2.202	228
	After	13.73	93	1.438	149

Table 18. Trial Test Before & After Giving Plant Seeds

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	11.34	93	2199	228
	After	14.18	93	988	103

The method of analysis used in this research is the pre-test and post-test facto, a method that can describe changes in community perceptions after being given training, on preservation of Tahura OKH. This method is effective in describing the pre-test and post-test training (Tables 16–18). Further data from survey results are cross-tabulated and analyzed using T-test (Sugiyono, 2017).

Results and Conclusion

The analysis method used in this research is the pre-test and post-test factor. This method can describe the changes that occur in community's perceptions after being given training, books, demo-video and seedling. The results of this study have shown the knowledge perception of community and their income have changed after three of action training.

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Dompak MT Napitupulu, Mirawati Yanita, Karina Rahma	C06	Independence Smallholder Oil Palm Replanting: An Analysis of Income Inequality

Background and Objectives

Oil palm plantation has multiplied since 2000 until 2021 (6.83 % / year). this has resulted in this commodity becoming a significant source of income for several communities in rural areas. Oil palm plantations, either owned either by the state, large private companies or smallholders, are now widespread in Sumatra and Kalimantan, as well as in parts of the Sulawesi and Papua Islands. Oil palm plantations have developed well and have become one of the leading regional commodities, especially in Jambi Province. Therefore, it has an opportunity to become a profitable commodity. However, the acceptance of oil palm farmers depends on the costs incurred in farming, the production at each harvest and the prevailing price of fresh fruit bunches. Therefore, the replanting of oil palm is induced to improve quality and secure farmers' incomes. Replanting with high-yielding seeds, sustainable cultivation technology, and expansion of cultivated areas also contribute to increase the income of oil palm farmers. Ngadi (2019) found that the number of Household working members and the land area significantly affect the income of oil palm farmer households. Oil palm replanting was conducted in Pelepat Sub-district, specifically in Mulia Bhakti Village. This study is aimed to analyze farmers' income and income distribution of smallholders in that area

Methods

This research was conducted using a survey method in Mulia Bhakti Village, Pelepat District, Bungo District, Jambi Province. This location was purposively selected, considering that the oil palm smallholders in Mulia Bakti Village were successful and were the first to replant oil palm in Pelepat Subdistrict. Therefore, the oil palm farmers who had replanted their old oil palms were the subject of this study. In 2021, the number of oil palm farmers was 385 people distributed in 11 farmer groups. 10% of each farmer group members, represented by one farmer from each group, were randomly selected to be the respondent sample. The total number of oil palm farmers interviewed was 39. Farmers' income was counted by summing farmers' income from on-farm, off-farm, and non-farm. The Gini Ratio approach was used to analyze income distribution. The Gini Index indicates the degree of income or wealth inequality of the population in an area (Dib *et. al.*, 2018). Mathematically, the Gini Index is calculated based on the Lorenz curve, which describes the cumulative proportion of the total income owned by the population on the Y-axis with the cumulative proportion of the population in the area on the X-axis. The greater the cumulative number of people who have a low cumulative income, the more unequal the population's income in the area. Uneven increased occurred due to only a small number of people have a significant cumulative income. Picture 66 shows that the area of triangle ABC that is not coloured becomes smaller as the coloured area becomes larger. If a coloured curve completely covers the area of the triangle, it means that the Gini Index becomes 0 and the total area of the ABC Triangle is equal to 1 (one). If this is the case, it means the income of the population in this area will be perfectly unequal. On the other hand, if the cumulative population follows evenly the cumulative percentage of the population's income, the Gini ratio index will be 1, which means that the population's income is perfectly and equally distributed.

Picture 66. Replanting Area at Pelepat Sub District, Mulia Bakti Village.

Picture 67. Land Area No. 2 For Household Living During Replanting.

Results and Conclusion

Oil palm farmers who had replanted their old oil palm plantations (Picture 67) in Mulia Bhakti Village obtained a less optimal average income. This is because their replanted plants are not yet producing optimally. The income of smallholder households in this study is calculated by adding three income sources: on-farm (oil palm plantation), off-farm, and non-farm income. On-farm income is the money from selling the oil palm production from the smallholders own plantation area. The total FFB produced during the Year 2021 is multiplied by the average price received in the same year. Off-farm income is the total money earned by a whole family member from agricultural activities other than oil palm production on his or her farm. Finally, non-farm income is the amount of money earned by all family members from off-farm activities, such as civil servants or other productive work or services. The overview of oil palm farming can be seen below (Table 19).

Data showed that the average area of oil palm plantations cultivated by smallholders at the research location was 4.15 ha, with the oil palm age varies from 3 to 21 years. Several farmers have a plant age of 3–4 years due to the replanting program. These Immature oil palm plants still produced somehow small FFB called buah pasir. As a result, the average productivity is still lower than the average productivity of PPKS standards. Therefore, farmers income from oil palm farming is not yet optimal.

Assuming that the family members of smallholder farmers, including the farmer himself, are five people per Household, and the minimum income assumption is IDR 30,000 or US$ 2 per capita per day (BPS), in order for average farmer to overcome the poverty line needs to raise IDR 54,750,000.00 (Chrisendo, *et al.*, 2021). The amount of income needed is still above farmers' income if they only rely on oil palm farming. This means that farmers still need to be supported by activities outside of oil palm farming to live outside the poverty line, particularly during replanting periods.

Respondents who are relatively homogeneous in this research, should be evenly distributed based on average annual income. The results show that the Gini Ratio coefficient value of oil palm smallholders in Mulia Bhakti Village is classified as

Tabe 19. Household Smallholder Income in Mulia Bhakti Village, Pelepat District, Bungo Regency, the Year 2021

Indicators	Vallue
Average Area (Ha)	4,15
Average Tone/Ha	1,16
Average Tone/Month	5,08
Price per Kg	1.181,47
Revenue/Ha/Month	1.475.631,60
Revenue/Farm/Month	5.895.384,62
Revenue/Farm/Year	70.744.615,38
Cost/Farm/Year	20.298.244,00
On-Farm Earning/Farm/Year	50.446.371,38
Off-Farm Earning/Farm/Year	584.996,44
Non-Farm Earning/Farm/Year	8.940.000,00
Total Household Income (IDR)	59.971.367,82

"unequal income distribution", where the poorest 20 % of respondents only control the accumulated income of 2.90 %. In comparison, 20 % of the highest income group controls the accumulated income of 34.89 %. Therefore, the Gini Ratio Index (GR) is 0.63 or classified as high unequal income distribution. One of the reasons for the high inequality in the income distribution of smallholder oil palm farmers in the research area is the disproportionate distribution of newly planted oil palm. Some farmer who replant larger areas might suffer from the low productivity of FFB. In the early years of the replanting program, some oil palms were still produced small size and immature FFB, and they had not been able to contribute to the income of smallholders optimally. In addition to the oil palm area, which is still dominated by the replanting of palm oil, some farmers also engaged in farming outside of oil palm. Some other farmers work in the service sector, both as civil servants and with other productive service activities. The field of work outside of oil palm farming, although not very large, can also be used as an additional income source during the replanting period. The income of non-oil palm and non-agricultural farmers in the research location is IDR 584,996.44 and IDR 8,940,000.00, respectively. By generating household income from the service sector and other productive activities, the minimum needs of farming families can be covered. The non-optimal productivity of oil palm has resulted in an uneven distribution of the average income of oil palm smallholders in the study area. This implicitly shows the need to open other business fields outside the agricultural sector for oil palm farmers in the replanting periods

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Ngadi (2019). Income Inequality of Oil Palm Plasma Farmers in South Sumatra, Indonesia. Asian Journal of Agriculture and Development Vol. 16 No. 2 |

Zulkifli Alamsyah, Gina Fauzia, Mirawati Yanita	C07	The economic performance of non-plasma smallholder oil palm plantations based on plantation management practices in Muaro Jambi District of Jambi Province

Background and Objectives

Oil palm plantation in Indonesia, including in Jambi Province, can be divided into three categories, namely large private plantations, state plantations and smallholder plantations. Smallholder plantations can be divided into plasma plantations and independent plantations. Some studies have captured the poor governance problem in the plasma scheme (Suharno *et al.*, 2015; Abram *et al.*, 2017; Li, 2018). Therefore, some plasma farmers are trying to repay loans immediately in order to break away from ties to their partner companies. For both ex-plasma and independent smallholders, hereinafter referred to as non-plasma smallholders, the problem that arises is when plantation management is carried out by farmers with various backgrounds and diverse understandings of good agricultural practices, leading to variations in plantation management. The purpose of this study is to investigate the management practices and the economic performance of non-plasma oil palm smallholder and to compare the economic performance based on management practices of non-plasma oil palm smallholder

Methods

The research was conducted in Muaro Jambi Regency as the main producer of palm oil in Jambi Province. Samples of non-plasma farmers were taken from 2 sub-districts, namely Sungai Bahar District and Kumpeh Ulu District with a total of 114 farmers. Plantation management was examined and measured based on cultivation techniques. These include the use of seed type, spacing, plant age, application of fertilizers and agricultural chemicals, and weeding intensity. The economic performance was assessed from the net margin which is calculated from revenue (gross margin) and operational costs. To compare economic performance based on plantation management, the Kruskal-Walis test was used, in which farmers in the sample were grouped into 3 clusters according to how well they implemented good plantation management.

Major Results and Conclusion

Based on the plantation management score, the farmers in the sample were categorized into 3 clusters, namely Cluster-1, Cluster-2 and Cluster-3. The higher the score reflects the better plantation management implemented by the farmers. The number of farmers, the scores obtained and a description of the plantations covering land area, plant age and production in each cluster is presented in table 20.

Table 20. Management plantation score, plantation area, plant age, and productivity based on plantation management clusters

Plantation conditions	Plantation Management Clusters		
	Cluster-1	Cluster-2	Cluster-3
Range of Management Score	16 - 20	12 - < 16	< 12
Average of Management Score	16,89	13,40	8.56
Number of respondents (total 114)	38	40	36
Plantation area (ha)			
- Range	1.0 – 7.0	1.0 – 6.0	1.0 – 6.0
- Average	2.6	3.0	3.1
- Coef. of variations	56.1	45.6	47.5
Plant age (year)			
- Range	5.0 – 19.0	5.0 – 18.0	5.0 – 18.0
- Average	10.0	10.9	11.9
- Coef. of variations	33.5	28.6	27.6
Productivity (ton FFB /ha/yr)			
- Range	16.35 – 33.75	13.45 – 33.95	11.75 – 29.93
- Average	22.25	20.08	15.82
- Coef. of variations	20.71	24.36	22.11

The highest score in plantation management also has an impact on the productivity produced by farmers in cluster-1, which is the highest compared to the other 2 clusters. In addition to having an impact on increasing productivity, good plantation management also has an impact on FFB prices and net margins received by farmers. This condition is presented in table 21.

Table 21. FFB price, revenue, operational cost, and net margin based on plantation management clusters.

FFB Price, Revenue, and Costs	Plantation Management Clusters		
	Cluster-1	Cluster-2	Cluster-3
FFB Price (Rp/kg)			
- Range	2,000 – 2,500	2,000 – 2,500	2,000 – 2,500
- Average	2,300	2,199	2,132
- Coef. of variations	6.39	8.78	7.48
Revenue (Rp.Million/ha/yr)			
- Range	36.78 – 73.70	27.00 – 84.88	25.89 – 62.86
- Average	50.97	44.76	34.53
- Coef. of variations	19.37	30.11	23.02
Operational cost (Rp Million/ha/yr)			
- Range	5.92 – 10.76	4.87 – 9.34	2.71 – 10.76
- Average	7.78	7.17	6.86
- Coef. of variations	17.44	16.94	30.83
Net Margin (Rp Million/ha/yr)	43.19	37.59	27.67

In line with the increase in productivity in better plantation management, the net margin received by farmers in Cluster-1 is also the largest compared to the other 2 clusters. Statistically, it can be proven that there are significant differences in net margin among clusters, as shown in figure 77 and table 22.

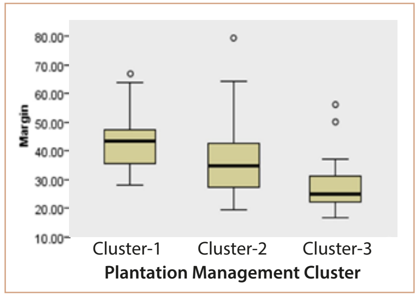

Figure 77. Kruskal-Wallis Test Results of Differences in Net Margin in Three Plantation Management Clusters

Table 22. Pairwise Comparisons Test of Each Plantation Management Clusters
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sides tests) are displayed. The significance level is .05.

Sample 1 – Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
Cluster-3 – Cluster-2	28.411	7.593	3.742	.000	.001
Cluster-3 – Cluster-1	47.302	7.687	6.153	.000	.000
Cluster-2 – Cluster-1	18.891	7.487	2.523	.012	.035

Based on the results of this study, it can be concluded that the better the level of management of oil palm plantations by farmers, the better their economic performance will be. This is evidenced by the increase in productivity, the price of FFB produced, and the net margin obtained by farmers.

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Edison, Ira Wahyuni	C08	The analysis of a replanting model on smallholders oil palm in Muaro Jambi District, Jambi Province

Background and Objectives

Muaro Jambi is a district with the largest oil palm plantation area in Jambi Province (91,206 ha, Picture 68) with a total production of 535,337 tons in 2019. The smallholder's oil palm plantation in this district has been operating since the 1980s. Therefore, most of the smallholder oil palm trees are currently in the final stages of the production cycle, so it is necessary to plan the replanting activities (Anonymous, 2020) (Picture 69). The oil palm plantations of smallholders in Muaro Jambi district have a much larger area than the other two plantations. However, the problem is that the productivity of smallholder oil palm plantations cannot compete with the government and private plantations. This condition is due to various factors, both internal and external to the management actors, in this case, the farmers or planters (Edison, 2020). The status of conventional and under-planted smallholder oil palm cultivation in Muaro Jambi District varies in terms of the yield of fresh fruit bunches (FFB, Picture 70) produced in 2021. This result is due to the fact that the number of plants and the age of the plants affect the amount of oil palm production and the farmer's profit (Edison and Wahyuni, 2020). Choosing the right replanting technique to provide farmers with an alternative income during replanting. The objective of this research is to (1) analyze the feasibility of replanting oil palm plantations by smallholders based on investment criteria, and (2) analyze the sensitivity of replanting oil palm plantations by smallholders in case of changing output and input prices.

Picture 68. Oil palm plantation in Muara Jambi District.

Picture 69. Replanting activities for the next production cycle.

Picture 70. Fresh fruit bunches produced from the oil palm plantations.

Methods

The study was conducted in Muaro Jambi District. Research data was obtained through interviews using questionnaires in the Muaro Jambi District. As many as 60 purely independent smallholder farmers replanting oil palm were obtained by snowball sampling. Methods of data analysis used criterion investment using NPV, IRR, Net B/C, PP, and sensitivity analysis.

Results and Conclusion

Feasibility criteria analysis was conducted for replanting using conventional techniques and underplanting techniques. The financial feasibility criteria were Net Present Value (NPV), Internal Rate of Return, Net Benefit Ratio (Net B/C), and Payback Period. The discount factor used in this study is the prevailing interest rate of 4.5 %. The value of NPV, IRR, Net B/C Ratio, and payback period for replanting conventional techniques and underplanting techniques can be seen in table 23.

Table 23. The value of NPV, IRR, Net B/C Ratio, and *Payback Period* of conventional techniques and underplanting techniques

No	Criteria	Conventional techniques	Underplanting techniques
1	NPV (IDR)	356,612,925	83,750,145
2	IRR (%)	56,24	19,38
3	Net B/C Ratio	136,28	59,85
4	Payback Period (Year)	6,42	5,35

The results of the study showed that oil palm planting by smallholders is feasible through both conventional replanting and underplanting. The results of the sensitivity analysis showed that both types of replanting oil palm plantations are feasible if the input price increases by 15% and the selling price of FFB is kept constant, or if the price of FFB decreases by 15% and the input price remains the same. Changes in FFB prices are more sensitive to changes in standard investment values than changes in input prices.

The smallholder oil palm plantation replanting model, both the conventional and underplanting models, is suitable for farmers. The investment criteria for the two models of oil palm replanting are that the NPV, Net B/C, IRR, and Payback Period values are quite profitable for farmers. It is better to use the conventional model for oil palm replanting because it provides higher productivity and more efficient plantation management than the underplanting model. The response to changes in the value of NPV, Net B/C, IRR, and the payback period is more sensitive to changes in FFB prices compared to increases in production factor prices. The increase in the values of NPV, Net B/C, IRR, and the payback period is very large when there is an increase in FFB prices for both the conventional replanting model and the underplanting model. The conventional model responds stronger than the underplanting model when there is an increase in FFB prices.

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Bambang Irawan, Gindo Tampubolon, Hasbi Hasibuan	**Z01**	Ecosystem reclamation after coal mining and silviculture of forest plantation in PT. Nan Riang

Background and Objectives

The main problem that occurs after coal mining is the deterioration of soil quality (soil degradation), e.g. due to deterioration of chemical properties, environmental changes, and changes in soil morphology and topography. Referring to these changes, reclamation measures must be implemented. However, the problems that occurred are a limiting factor in the growth rate of plants to be planted during reclamation activities. For this reason, plants that have considerable potential and are adapted to the environment are needed for reclamation activities, especially in the former coal mining area. The plants used in this study were sengon solomon (*Paraserianthes mollucana*), calliandra (*Calliandra calotyrsus*) and jati (*Tectona*

grandis). These plants has advantages over other plants such as fast growth, adaptability to extreme environments, and a fairly high economic and ecological value (Setiowati *et al*., 2017 and Hendrati *et al*., 2014). However, to support the growth of these plants, special treatment is required to improve the condition of the soil. One of these measures is the provision of organic material as soil enhancers, namely humic acid, boiler ash and poultry manure and dolomitic lime. In addition, NPK fertilizer is administered to provide primary macronutrients to the soil to promote plant growth.
The purpose of this research was to investigate the soil chemical properties and the growth of sengon solomon and calliandra due to the application of NPK fertilizer, NPK fertilizer with humic acid, boiler ash application, and dolomitic lime application with poultry manure, evaluate the growth of jati plants and investigate the effect of soil chemical properties on the growth of jati.

Methods

The research was conducted using an experimental method with a Randomized Block Design (RAK). In the NPK fertilizer experiment, there were 5 levels with 5 replicates, the NPK fertilizer experiment with humic acid contained 9 treatment combinations with 3 replicates, in the boiler ash experiment there were 5 levels with 5 replicates and for the poultry manure experiment with dolomitic lime there were 9 treatment combinations with 3 replicates, for the jati study there are 4 experiments with 5 replicates. The observed plant variables were height, diameter, increase in height, increase in diameter, increase in the number of leaves, increase in the number of branches, root length, crown dry weight, root dry weight and number of root nodules. The observed variables of soil chemical properties were soil texture pH, Al-dd, K-dd and P_2O_5. The resulted data were analyzed statistically using Analysis of Variance (ANOVA) 5 % and Duncan's Multiple Range Test (DMRT) to determine the differences between treatments.

Major Results and Conclusion

The results showed that the interaction of NPK fertilizer and humic acid had no significant response on the growth of sengon solomon and calliandra and on some soil chemical properties. A single application of 100 g/plant NPK fertilizer had the best effect on Sengon plant growth and K-dd content. A single application of 20 g/plant of humic acid had the best effect on sengon solomon growth. A single application of 150 g/plant of NPK fertilizer had the best effect on calliandra plant growth and P_2O_5 content. A single administration of humic acid 30 g/plant had the best effect on the K-dd content, but no significant effect on calliandra growth. The interaction of dolomitic lime and poultry manure had no significant effect on the growth of sengon solomon. The single application of dolomitic lime 1 x Al-dd/plant hole had the best effect on the growth of sengon solomon and soil pH. Single application of poultry manure 2 kg/planting hole had the best effect on the growth of sengon solomon. The best effect on the growth of sengon solomon plants and soil pH was the administration of boiler ash (4 kg/planting hole). The percentage of living jati that were categorized successful was 86 %. The respective height and average diameter of jati plantations in the concession area of PT. Nan Riang is 6.26 m and 10.81 cm. The growth of jati plants was affected by clay content, but pH and C-organic content had no significant effect on the growth of jati plants because the range of soil acidity was relatively the same (very acidic) and C-organic content was relatively the same and classified as very low.

Major Outcomes

The main result of this research is a paper for the benefit of bachelor at Jambi University.

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Upik Yelianti, Raissa Mataniari, Dewi Komalasari	**Z01**	Exploration of orchid mycorrhizal fungus at Harapan Rain Forest (HRF), Jambi Province as a learning resource of a plant ecophysiology course

Background and Objectives

The existence of orchids in the Harapan Rain Forest Jambi Province is now threatened. This is due to the devastating forest fires in 2015 (Anonymous, 2021) that caused a great loss of germplasm or biodiversity, including trees as habitats for epiphytic plants (Ministry of Environment and Forestry Republic of Indonesia, 2018), such as orchids. Orchid is a plant that has an aesthetic value, so beautiful and very liked by the community, so that its occurrence in decreasing in nature, including Harapan Rain Forest Jambi Province. Orchid plants usually have a symbiotic relationship between mycorrhizal fungi and their roots, where mycorrhizal fungi help the orchids absorb water and nutrients (Brundrett, *et al.*, 2003; Taylor, *et al.*, 2004; Wu, *et al.*, 2010), while mycorrhizal fungi receive nutrients from the orchids. This fungus infects orchids through the roots, which are characterized by the presence of hyphae in the form of dense coils in the bark, called platoon (Ningsih, *et al.*, 2014). Therefore, it is necessary to conduct research on the Exploration of Orchid Mycorrhizal Fungus at Harapan Rain Forest (HRF) Jambi Province. This research aims to study the morphological structure of mycorrhizal fungi in symbiosis with the roots of orchid from the Harapan rain forest Jambi Province.

Methods:

The orchid is obtained from Harapan Rain Forest, Jambi Province and was maintained. The roots were collected, washed and cut about 1 cm and observed under a microscope for the presence of external hyphae. Isolation of mycorrhizal orchid came after the modified method of Manoch and Lohsomboon (1992). To observe the colonization structure of mycorrhizal fungi in the roots of orchid plants, observations were made by staining and observed under the microscope. In addition, the morphological structure of the mycorrhizal fungi was determined by growing them on PDA medium, then observing the shape, color, and structure of the fungal colonies under a microscope.

Result and Conclusion:

The results showed that there was colonization between mycorrhizal fungi and orchid roots as presented in figure 78.

The growth of mycorrhizal fungi on orchid roots on PDA medium after 2 days after incubation (dai) is presented in the figure 79.

In table 24, the characteristics of mycorrhizal fungi isolated from the roots of orchid plants grown on PA medium are presented.

Microscopic observations were made of the colony of mycorrhizal fungi that are in symbiosis with the roots of orchids (Figures 80a and 80b).

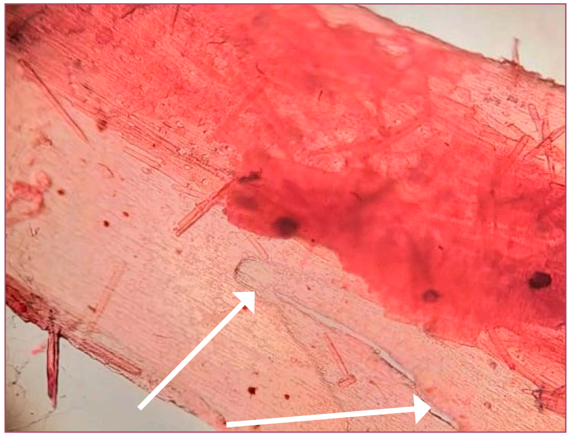

Figure 78. Hypha external mycorrhizal fungi on orchid roots.

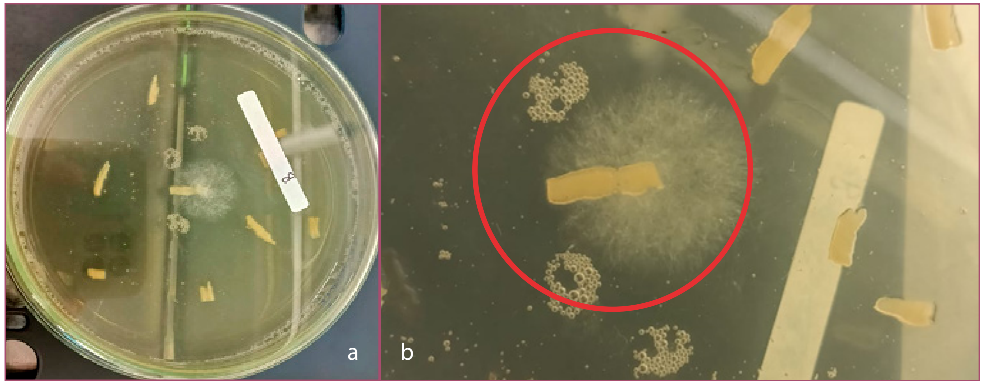

Figure 79. (a) The growth of mycorrhizae fungi orchids on PDA medium. (b) after the image in enlarged

Table 24. The characteristic of colony of orchids mycorrhizae fungi on PDA media

No.	Samples	Shape	Margin	Size	Elevation	Appearance	Optical property	Texture	Color
A	Colony 1	Circular	Entire	Moderate	Convex	Dull	Opaque	Velvet	Greyish
	Colony 2	Irregular	Undulate	Moderate	Convex	Dull	Opaque-Translucent	Velvet	Yellow
	Colony 3	Circular	Entire	Moderate	Flat	Dull	Opaque	Velvet	White
	Colony 4	Spindle	Entire	Moderate	Convex	Dull	Opaque	Velvet	Blackish
B	Colony 1	Circular	Undulate	Large	Flat	Dull	Translucent	Velvet	White
	Colony 2	Circular	Undulate	Large	Convex	Dull	Opaque	Velvet	White
	Colony 3	Circular	Entire	Large	Flat	Dull	Translucent	Velvet	White
	Colony 4	Irregular	Undulate	Large	Flat	Dull	Opaque	Velvet	White
C	Colony 1	Circular	Entire	Moderate	Raised	Dull	Opaque	Velvet	White
	Colony 2	Irregular	Undulate	Large	Convex	Dull	Opaque	Velvet	Greyish
	Colony 3	Irregular	Curled	Large	Flat	Dull	Opaque	Smooth	White
D	Colony 1	Irregular	Rhizoid	Large	Raised	Dull	Opaque	Cotton	Greyish
	Colony 2	Circular	Entire	Moderate	Convex	Dull	Opaque	Velvet	White
	Colony 3	Circular	Entire	Small	Flat	Dull	Opaque	Velvet	Greyish
	Colony 4	Filamentous	Rhizoid	Moderate	Raised	Dull	Opaque	Smooth	White

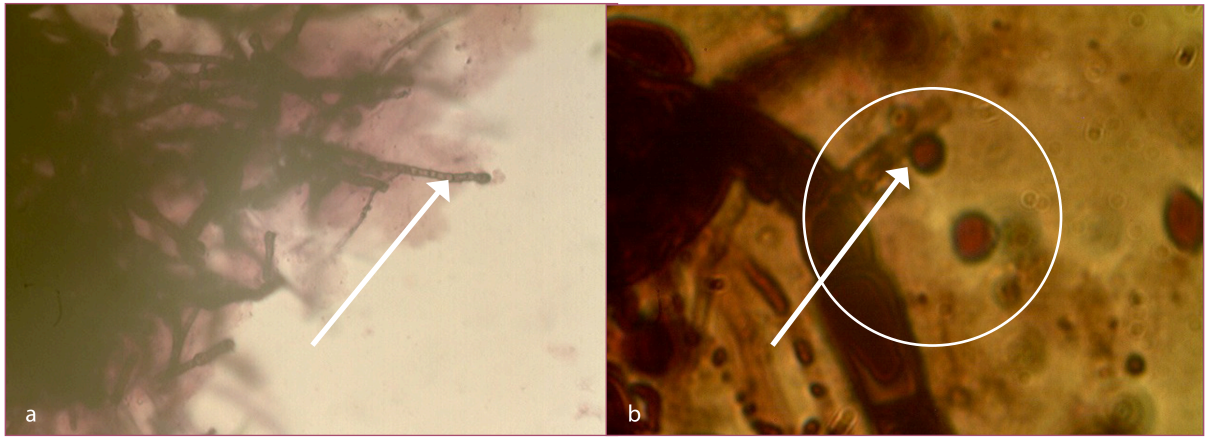

Figure 80. (a) Insulated hypha with conidia, and (b) the spores of mycorrhizal fungi on roots of orchids.

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Mohd. Zuhdi, Zuhratus Saleh	**Z02**	Building hyperspectral spectral signature of tropical lowland vegetation: Identification of vegetation state and condition using Hyperspectral Imagery

Background and Objectives

This study is addressing the use of hyperspectral imageries collected by CRC in 2020 and the ground survey to relate the hyperspectral reflectance of image and the vegetation variability (Nidamanuri & Zbell, 2011). Therefore, the goal is to observe how vegetation variability i. e.: species, stage of age, environmental condition and diversity influences the spectral pattern of the images, and to identify the spectral reflectance of tropical lowland vegetation (Papes *et al.*, 2013) in order to expand the library of spectral signature which is currently still lacking.

Method

The study was conducted from July to November 2021. Field data collection was conducted in areas covered by existing hyperspectral imagery, namely smallholder plantation areas in Batang Hari Regency and inside the REKI forests concession, Jambi Province of Indonesia (Fig. 81).

The equipment used for this study included: Emlid DGPS rover, motor cycle, digital camera, tally sheet, 16 GB RAM i7 Laptop, 1 TB external SSD, ArcGIS and Envi software (Marhaento & Mada, 2015). The main material was the available hyperspectral imagery data acquired from an aircraft from January to February 2020 using the HySpex VNIR 1600 sensor (Amigo *et al.*, 2015). The bandwidth is 3.26 nm, consisting of 186 bands and ranging from 400 nm to 1000 nm.

The study started with observation of existing hyperspectral data, identification of coverage area and comparison of land use maps and accessibility maps. During

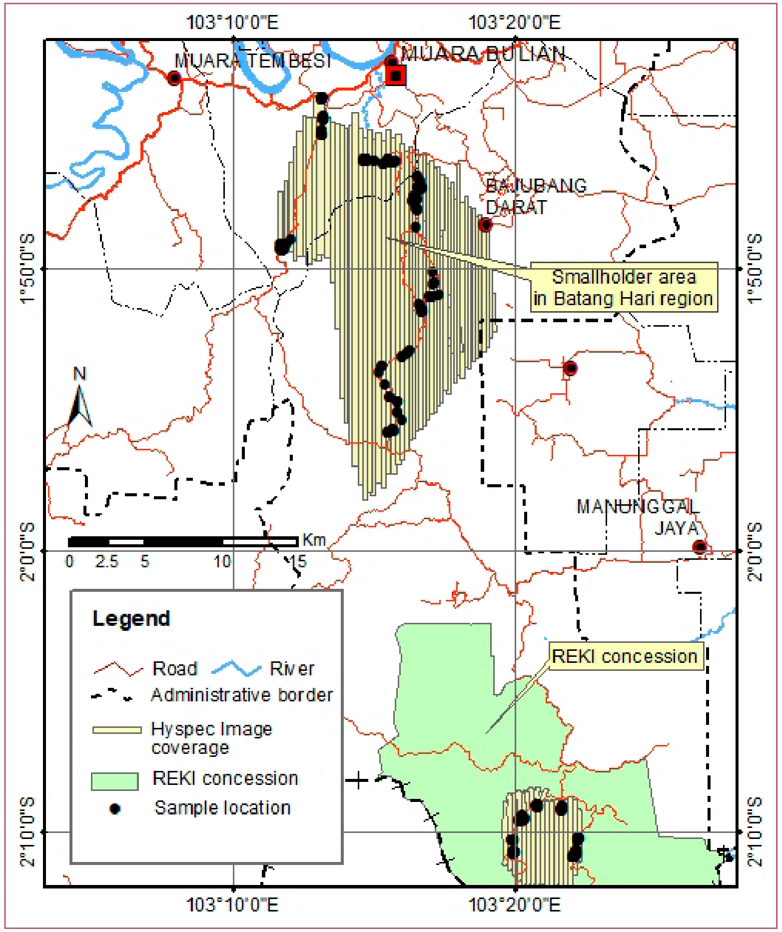


Figure 81. Research area in Batang Hari region and REKI forest concession

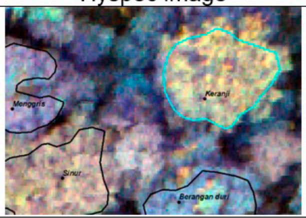
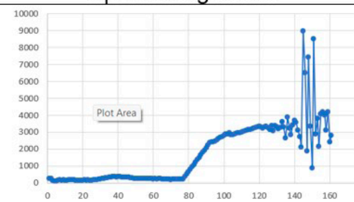
No	Hyspec image	Photo	Location:	Name:	Spectral signature	Dimension	Conditions
275			REKI 103° 22' 9.5" E 2° 10' 49.2" S	Local : Keranji Scientific: (*Dialium indum*)		Height : 34 m Diameter : 195 cm Crown width: 10 m, 8 m	Healthy, mature, growing in flat to undulating area

Figure 82. Example of collected vegetation from hyperspectral data.

the field survey, some activities were performed; 1) Measurement of position with DGPS rover with averaging method. 2) Species identification with the help of a taxonomist, 3) Recording the status of species, including age, height, crown diameter and health, 4) Recording environmental condition, including topography, drainage (moisture), density and shading. Each individual of known vegetation in the image is then delineated to create a zone boundary of statistical averaging of its reflectance value.

Results

This study has produced the collection of vegetation data of 350 points over the whole study area. Of these, 200 points are located in smallholder plantations consisting primarily of crop vegetations. The remaining 150 points are located in the REKI forest, which consist entirely of forest vegetation. They comprise a total of 188 species, 81 of which are forest vegetations, the rest are plantation crops. Example of the data collection is presented in figure 82.

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Research project of counterparts funded at Syiah Kuala University

Name	Counter-part	Title
Essy Harnelly	**B14**	Assembling chloroplast genome sequences of petai, jengkol, sungkai and jelutung using both short-read and long-read sequencing

Background

Since diversity is thought to be lower in oil palm plantations compared to primary and secondary forest, an enrichment planting experiment was recently conducted utilizing 6 tree species, including Durian (*Durio zibethinus* of Malvaceae), Jengkol (*Archidendron pauciflorum* of Fabaceae), Petai (*Parkia scpeciosa* of Fabaceae), Jelutung (*Dyera* spp of Apocynaceae), Sungkai (*Peronema canescens* of Verbenaceae) and Jelutung (*Dyera costulata* of Apocynaceae). Although all of these species are well known as favorite community trees and seemed to grow well throughout Indonesia, recent field observations showed that not all species were able to adapt and grow well in the experiment. The families of these tree species, especially Apocynaceae and Fabaceae, are among the best studied in the world. Those two families already have reference genomes, both nuclear and chloroplast genomes, deposited at NCBI, thanks to increasingly cheap NGS technology (Tang *et al*. 2014; Wang *et al*. 2018; Weitemier *et al*. 2019). Accurate genome assembly is the first key important step in genomic studies. It is well known that both short-read and long-read sequencing have their own advantages and limitations in the assembly process.

Objective

The objective of this research is to assemble the chloroplast genomes of four tree species commonly found among local community gardens in Indonesia, i. e., Jengkol (*Archidendron pauciflorum*), Petai (*Parkia scpeciosa*), Sungkai (*Peronema canescens*) and Jelutung (*Dyera costulata*).

Methods

Sample collection of Jengkol, Petai, Sungkai and Jelutung was conducted in *EFForTS-BEE* plots, PT Humusindo, Bugku, Jambi Province. The leaves samples were collected from three individuals for each species and extracted through a modified CTAB method. The DNA library preparation was followed the Nanopore Protocol for Native barcoding genomic DNA (with EXP-NBD104, EXP-NBD114, and SQK-LSK109), version NBE_9065_v109_revAC_14Aug2019. Sequencing was done in two rounds using two flowcells (FLO-MIN106). The sequencing run of genomic DNA samples was performed using the MinKnow v4.4.3.

Results

The data received from the sequencing process is in the form of FAST5. The high-accuracy basecalling mode was used to basecall the signal in FAST5 files and outputted FASTQ files. FASTQ files obtained from Jengkol, Petai, Sungkai, and Jelutung species were 1.2 Gb, 1.5 Gb, 1.3 Gb and 832 Mb respectively. All samples were uploaded to the usegalaxy websites for analyze (*https://usegalaxy.eu*). The reads quality and reads statistics were calculated using NanoPlot. After statistical analysis, all reads quality was filtered and assembled through Flye assembler. The draft assembly was then polished using medaka_consensus. The resulting polished assembly statistics was calculated using QUAST. Afterwards, completeness of the data would be checked by BUSCO. Jengkol species had 180,949 reads with 100 % reads quality >Q7 (nanopore default passed quality) (Fig. 83).

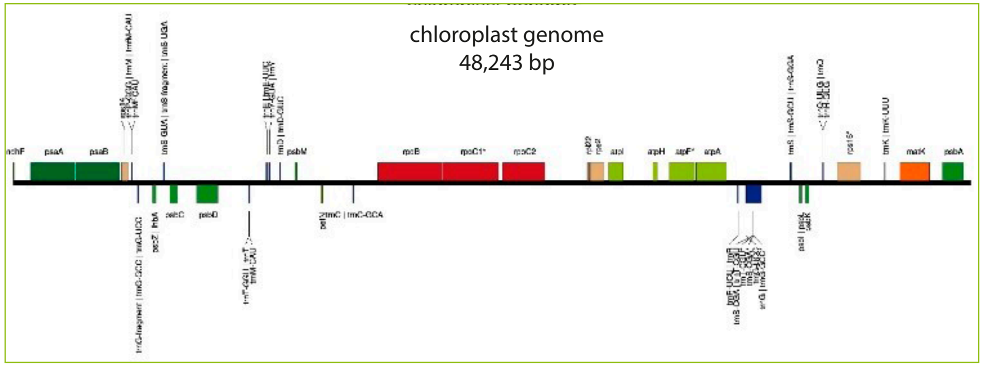

Figure 83. Gene annotation of jengkol species from long-read sequencing.

The contig was 492 (N50 43,210 bp, GC 37.42 %) and had 2 complete BUSCOs and 422 missing BUSCOs. For Petai species (Fig. 84), we obtained 320,291 reads with 100 % reads quality >Q7. The contig was 390 (N50 20.749, GC 35.06 %). Petai had only 1 complete BUSCOs and 423 missing BUSCOs.

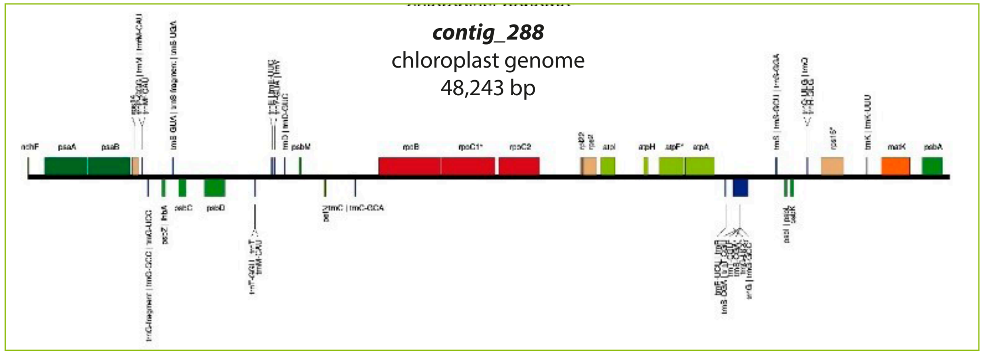

Figure 84. Gene annotation of Petai Species from long-read sequencing.

Furthermore, we acquired 256,699 reads with 100% reads quality >Q7 for Sungkai species (Fig. 85). The contig was 1,201 (N50 21,952 bp, GC 36.29%) and had 13 complete BUSCOs and 407 missing BUSCOs.

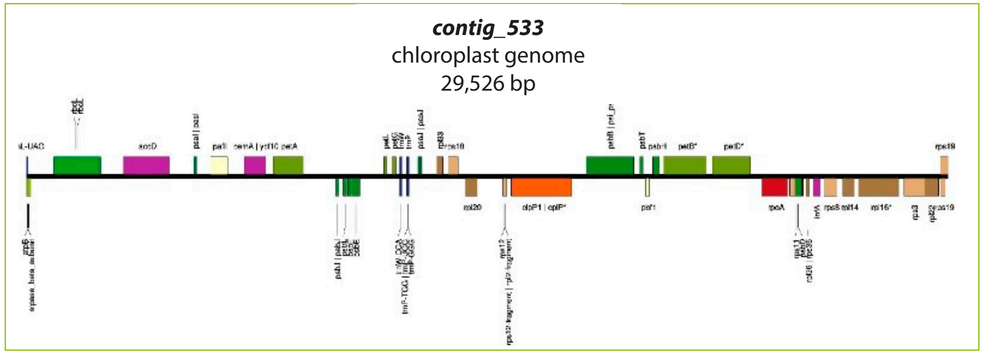

Figure 85. Gene annotation of Sungkai species from long-read sequencing.

Lastly, Jelutung species has 264,789 reads with 100% reads quality >Q7. The contig was 145 (N50 18,219 bp, GC 37.82%). Jelutung (Fig. 86) has no complete BUSCOs and had 425 missing BUSCOs.

The contig from medaka_consensus were then annotated by using GeSeq platform for Organellar Genomes, resulted in the GenBank annotation and their visualization.

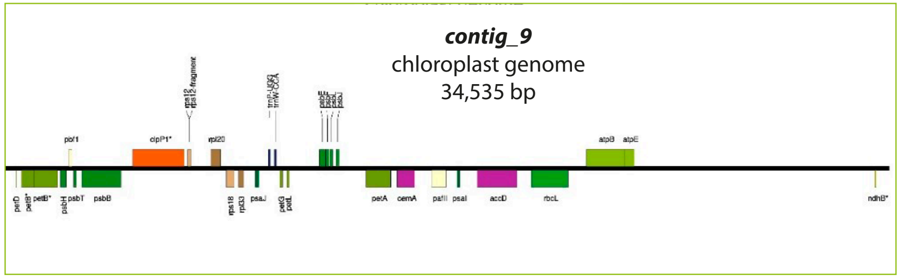

Figure 86. Gene annotation of Jelutung Species from long-read sequencing.

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Research projects of stakeholders funded at LIPI

Sri Rahayu, Iskandar Z. Siregar, Ulfah Juniarti Siregar, Essy Harnelly, Fifi Gus Dwiyanti, Bambang Irawan, Muhammad Majiidu	**B14**	Assessment of FRM quality produced from seeds (*Archidendron pauciflorum* Benth.) and clone (*Peronema canescens* Jack.)

Background and Objective

The term forest reproductive material, or FRM, encompasses seeds, plant parts (e.g., cuttings and scions) and plants grown using seeds or plants parts, including plants propagated in vitro (FAO, 2021a,b). FRM from jengkol are seeds from specific mother trees, while for sungkai are ramets (clones) for specific ortets. The asexual reproduction system has a higher risk due to decreasing genetic diversity, which needs to be considered when mass-producing FRM. Multiple provenances from difference sources assumed to reduce risks (Konnert *et al.*, 2015). The potential of FRM utilization in the *EFForTS-BEE* has not yet been evaluated considering future demands for quality seeds and clones in the near vicinity. This study aims to assess the quality of FRM regenerated from jengkol seeds and sungkai clones.

Methods

The fruits or seeds of jengkol were collected during fruiting seasons (August) and tested according to the protocol for seed testing (Sudrajat *et al.*, 2021). The activity includes the following steps: i) seed extraction, ii) measurement of seed physical properties (weight, moisture content), iii) measurement of seed germination parameters, and iv) seedling maintenance and seedling quality assessment. On the other hand, vegetative material that can be collected at any time (e.g., 15–20 cm cuttings) was used for testing sungkai clones. The activity consists of the following steps: i) cutting preparation, ii) plant media preparation in polybag, iii) treatment with rooting hormones, iv) maintenance of rooted cuttings, and v) evaluation of seedling quality (Sumiasri & Priadi, 2003)

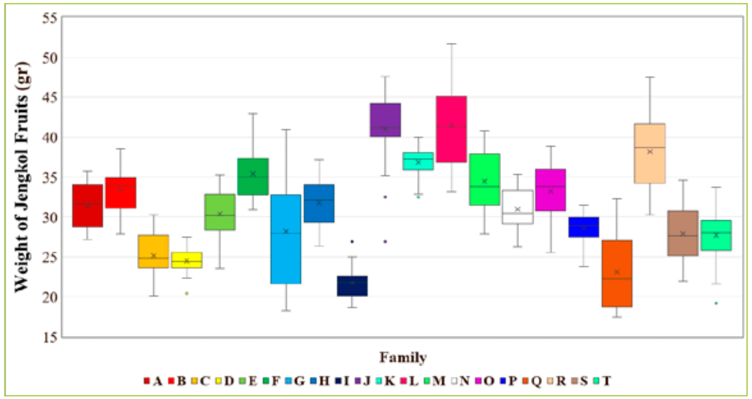

Figure 87 Variability of jengkol fruit weight.

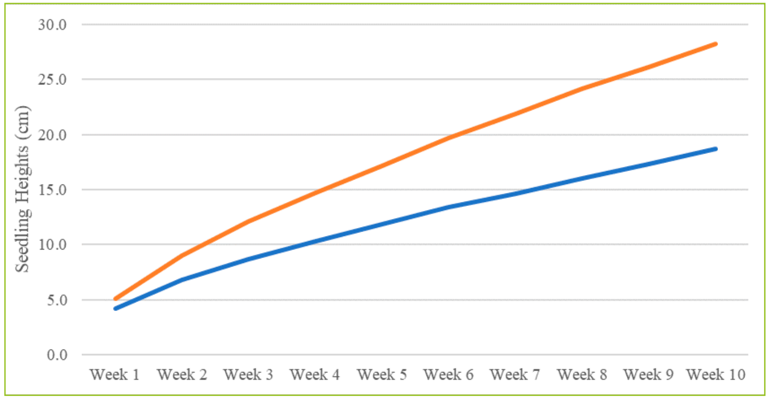

Figure 89 Growth of jengkol seedling (orange line is removed skin, blue line no removed skin).

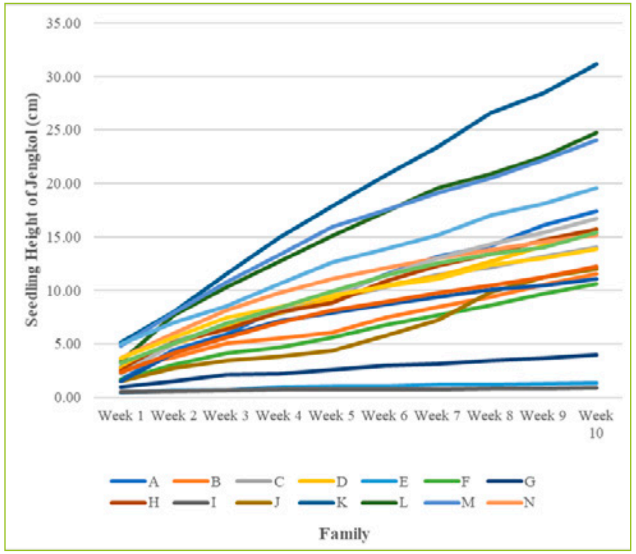

Figure 88. Growth of jengkol seedlings according to accession.

Results and Conclusion

FRM from seed (sexual reproduction) – represented by jengkol fruit

Firstly, we measure the fruit weight and size to differentiate each accession from each tree source. The fruit weight is presented at the figure 87.

The range of fruit weight is quite wide, ranging from 18 to 45 gr on average for each accession. We also noted skin color as an indication of fruit maturity. We have difficulty collecting enough samples at sufficient and uniform maturity since they are not available at the location. The fruit of Jengkol at the location was also consumed by squirrel and monkeys, which was very difficult to manage. We collected jengkol fruit as ripe as possible from each accession. The outer skin of the ripe jengkol fruit is dark brown, while the younger fruit has a green skin. Some of the fruits still had some green color on the dark brown skin. The lower weight (Fig. 87) also represented from the young (not ripe) fruit having a green skin. Every accession also had a different growth rate as shown in figure 88.

According to figure 88, acc. K, L, M, and Q have good seedling growth, while acc. G, E, and I have very slow seedling growth and mostly fail to germinate. This correlated with the weight and maturity of jengkol fruit/seeds, which are shown in figure 87. Fruit weight may be a response to the genetic traits of each accession, which will be seen from the genetic analyses. Fruits of acc. G, E, and I were mostly not mature enough for germination, as indicated by the green color of the outer skin and less fruit weight (Fig. 87). In general, each individual has a different genetic background, as indicated by the shape, color, and size of the jengkol fruits.

We made comparison between skinned and non-skinned seeds (still with the hard shell). Skin removal was performed on the mature seed and accelerate the seed germination as shown in figure 89 (the orange line).

The jengkol fruit has a hard, non-edible skin. The skin is removed for seed consumption, but usually the skin is retained for the seed germination. People in Sumatra and Jambi were not used to germinating jengkol seeds, and the jengkol tree grew spontaneously in the garden/orchard. Sometime, when they need to plant jengkol fruits, they just collect the spontaneously germinated fruit near the mother tree. Recently, as the demand for jengkol fruit increased, the germination of jengkol seed increased without removing the fruit skin. The gap between skinned and non-skinned was quite long, about 3-4 weeks.

FRM from clone (asexual reproduction) – represented by sungkai cuttings

The sample size was 21 clones which have different stem size diameter. The results is shown in figure 90.

Six clones showed good growth, that are acc. H, K, M, L, S, and P. Growth performance seems to correlated with cutting size, particularly from the stem diameter. The acc. H. K. M have larger stem diameter for cuttings. The correlation between growth performance, cutting size and genetic diversity of each clones is determined from molecular marker analyses.

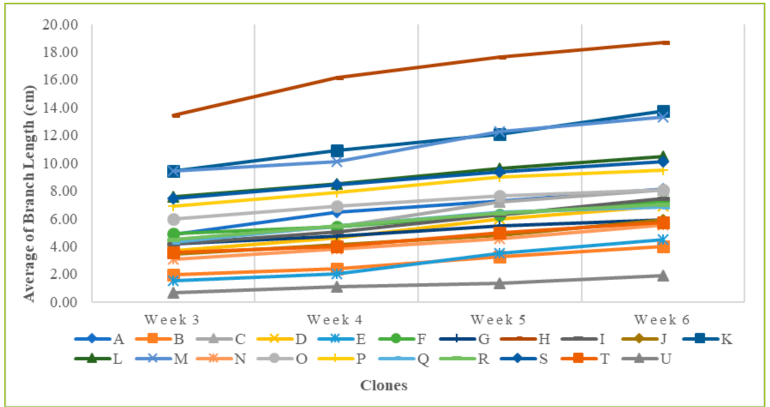

Figure 90. Growth of 21 clones of sungkai

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Research project of counterparts funded at Universitas Pendidikan Ganesha

Name	Counter-part	Title
I Nengah Suparta, Luh Mitha Priyanka, I Wayan Muderawan	PR	Developing Socio-Scientific Module Based on the Pros and Cons of Using Pesticides in *Citrus Nobilis* Cultivation for Enhancing Student's Awareness and Participation

Background and Objectives

The teaching materials used in an environmental science course still lack the use of contextual issues. It turns out that some students have difficulty in learning due to an unrelated problem. According to Manuel (2014), one of the best instructional materials to stimulate the learning experience is a module. A module is defined as a self-contained, independent unit of a planned series of learning activities, designed to help student achieve specific, well-defined goals. This module is based on socio-scientific issues, especially in environmental issues terms. Module-based on socio-scientific issues is expected to increase student's understanding of some common issues in their surroundings. This module is also designed to align with the educational approach of the *EFForTS* PR project by addressing a local problem in the *Citrus nobilis* cultivation to raise awareness in preventing agricultural land (*Citrus nobilis* landscape) from the negative effects of using pesticides. This issue is relevant to the *EFForTS* project in terms of ecological and socioeconomic.

Methods

Instructional design is a process that involves the creation or adaptation of instruction. Most research evidence concerning instructional theories relies on fundamental principles that address and respond to learning needs and goals). The basic goal is to identify conditions of instruction that optimize learning, retention and transfer of learning. The starting point is to consider an already useful approach to course design: Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Fig. 91).

Figure 91. ADDIE Model

Results and Conclusion

Module based on socio-scientific issue in Citrus nobilis cultivation in Kintamani was develop using this following stage.

Analyze Stage

The first stage was conducted by analyzing several things such as literature review, needs assessment, and student analysis.

Design Stage

The second stage of this developmental model is the design stage, in which the results of the analysis stage are used to plan a strategy for the development of a module with socio-scientific issues that align with the educational approach of the *EFForTS* PR project. The module is divided into four sections, mainly addressing the problematic issues in *Citrus nobilis* cultivation in Kintamani, Bali, based on a teaching model using SSI-TL. Using socio-scientific teaching and learning, the first section begins with identification of focus topics. Here, students learn about some ecological and socio-economic impact of *Citrus nobilis* cultivation. Students then learn about SWOT analysis in the use of chemicals in *Citrus nobilis* cultivation. In the second section, this module help students engage in three-dimensional learning related to *Citrus nobilis* cultivation. They will discover disciplinary core ideas, crosscutting concepts, and scientific practice in these socio-scientific issues. Then, students will learn to identify a possible pathway as the best solution related to using pesticide in *Citrus nobilis* cultivation issue (including evaluation and reflection) through *Citrus nobilis* Organic-Farm Management. The last section introduces the concept of sustainable development and discusses how *Citrus nobilis* Organic Farm Management relates to it. In every section, the module is completed with the learning objective, some information related to the issue, summary, and an evaluation. Figure 92 shows the cover design of this module using a citrus 'picture' from the farm.

PROS AND CONS OF USING PESTICIDES IN CITRUS NOBILIS CULTIVATION

Socioscientific Issue: Pros and Cons of using Pesticides in *Citrus Nobilis* Cultivation and its ecological and socioeconomic impacts

Focal Points of the Sections:

1. Encounter Focal Issue: Using Chemical in *Citrus Nobilis* Cultivation
2. Engage in Three Dimensional Learning: Cause and Effect of Pesticides in controlling the pest in *Citrus Nobilis Cultivation*
3. Synthesis Key ideas and Practice: *Citrus nobilis* Organic-Farm Management
4. Sustainable development through *Citrus nobilis* Organic-Farm Management

ECOLOGICAL AND SOCIO-ECONOMIC EFFECTS OF *Citrus nobilis* CULTIVATION

***Citrus nobilis* and Socio-Economic Effect**

Citrus is one of the horticultural crops which plays an important role in the world and domestic markets. Currently, Indonesia is the second-largest Citrus exporter in ASEAN after Malaysia, with the aim of exports are to Malaysia, Brunei Darussalam, and the Middle East. In 2019, citrus fruit production for Indonesia was 2.56 million tonnes which tended to increase through 1970 - 2019 period (Knoema, 2019).

Figure 1: Fresh fruit Citrus nobilis as Source of Vitamin C

Citrus production tends to increase caused by the increasing of these fruit consumption. Citrus is most commonly thought as a good source of vitamin C (Figure 1). However, like most other whole foods, citrus fruits also contain an impressive list of other essential nutrients including a variety of vitamins, minerals, fiber, and phytochemicals such as carotenoids, flavonoids, and limonoids, which appear to have biological activities and health benefits (Turner, 2013).

Because of this fact, citrus cultivation will be very profitable to increase people's income, job opportunities, consumption of fruit, and increase national export foreign exchange. Citrus is a horticultural commodity which growing rapidly in Bali. Alitawan (2017) said that Kintamani, Bangli is the highest central Citrus' production in Bali with citrus' land area which also tend to increase in 2015 (Figure 2).

Figure 2: Citrus' land area in Bali which tend to increase

Citrus' land in Bangli which tend to increase, make the total production of Citrus are 99.353 ton in 2015. It is also increases farmer's income. The area of citrus owned by farmers is directly proportional to the income earned. The wider the citrus' land, more income will also increase.

Figure 92. Design of SSI-TL Module

Based on the interview, using pesticides two to three times per month has negative impact. Pesticide residues and their persistence on or in food are an important and well-known concern for human health and environmental safety. When a pesticide is applied, it reaches not only the target but also other organisms in the ecosystem. Pesticides promise the effective mitigation of harmful bugs, but unfortunately, the risks associated with their use have surpassed their beneficial effects. Non-selective pesticides kill non-target plants and animals along with the targeted ones. In addition, some pests develop genetic resistance to pesticides over time. Because of the negative impact, pesticide residue analysis in citrus and soil is important to know how dangerous the pesticides are. The method used to analyze the residues in citrus and soil is extraction. Figures 93 and 94 showed the process of pesticides residue analysis and the result.

Figure 93. Extraction of Pesticides Residue

The analysis showed that pesticide residues in citrus and soil are quite high. The pesticides residue in citrus peel are 2–3 ppm. Meanwhile the residue in soil is also around 1–2 ppm. This fact gives some impact on the environment. The result of this analysis will be presented in the module to provide information on how dangerous the residue of pesticides to the environment and human health. Students are expected to find out a solution for this situation. *Citrus nobilis* organic farm management is one of the solutions shown in the module to overcome the issue. Modern organic farming was developed in response to the environmental harm caused by the use of chemical pesticides and synthetic fertilizers in conventional agriculture, and organic farming has numerous ecological advantages. Compared to conventional agriculture, organic farming uses organic fertilizer, biological control and fewer pesticides, reduces soil erosion, decreases nitrate leaching into groundwater and surface water, and recycles animal wastes back into the farm. With the help of this module, students will learn about Citrus nobilis organic farm management and how far this method relates to sustainable development.

Development Stage

Socio-scientific module on the advantages and disadvantages of using pesticides in Citrus nobilis cultivation, which has already been developed, needs to be reviewed by a panel of expert. The judges will review the module based on the design, content, and also language. This module (prototype 1) will be

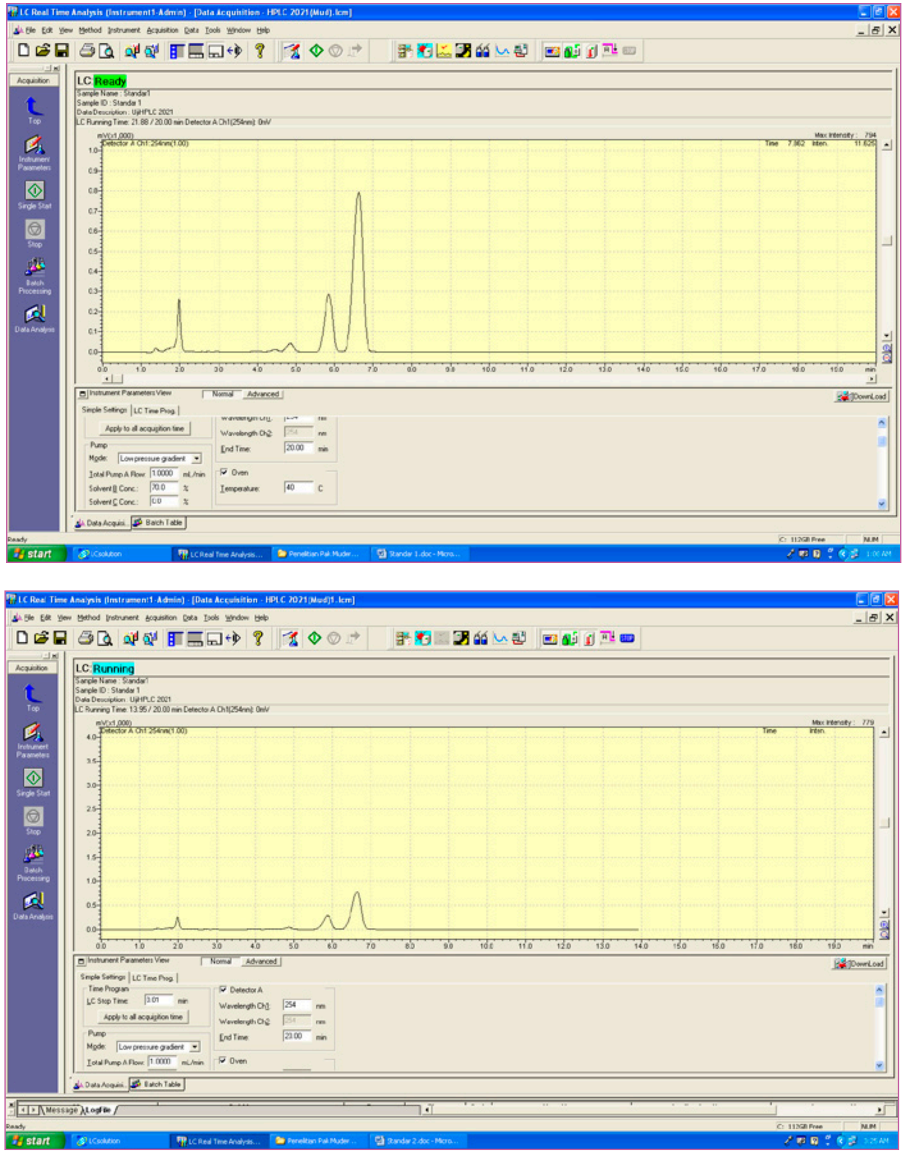


Figure 94. The Result of Pesticides Residue in Citrus and Soil

tested by three expert judges from physic, biology, and chemistry education department.

Some feedback from expert lecturers will be revised to become prototype 2. Some scientific data, photo and illustration will be attached in the module to prove that this issue occurs in Bali. In prototype 2, a questionnaire will be used as a non-test method, the expert will evaluate this prototype again to prepare the SSI module for implementation in the next semester. The result of second evaluation by three expert lecturers can be seen in the table 25 below.

Table 25. Validation Score from Expert Lecturers

Expert Lecturers	Score	Category
1	84.6	Good
2	92.3	Very Good
3	76.9	Good

The average score of prototype 2 from three expert lecturers is 84.6, which is in the "good" category. In the second evaluation, expert lecturers also give some feedback on the language and design of the SSI module for better improvement. In the development stage, after the feedback from the expert lecturers, this module is reviewed by 24 selected students as they will use this module in the next semester. The average score of the 24 students for the SSI module is 89.5 which falls into the "very good" category (Fig. 95).

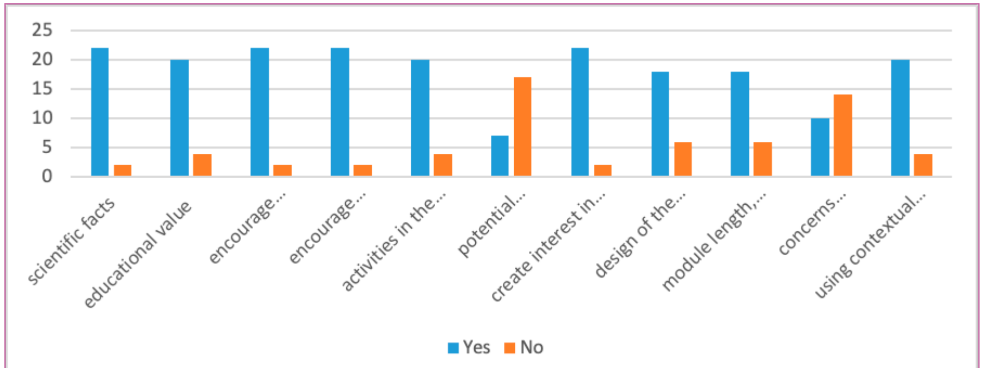


Figure 95. Evaluation by Students

The results of prototype 2 evaluation by expert lecturers and selected students shown that the SSI module which developed is suitable for use and ready to be implemented next semester.

The socio-scientific module is still in the developmental stage for some refinement and make it the final product. This module will be implemented next semester to help students become more engaged with the socio scientific issue surrounding them. By learning using contextual issue, students learn through experience rather than memorization. Contextual learning can encourage students to have a more positive attitude toward science learning. When students can relate the concepts, they have learned to real-life situations, it means that they have inserted the context they have learned into the actual situation and transformed it as life experiences.

2. ABS – SCHOLARSHIPS FOR EARLY CAREER RESEARCHERS OF COUNTERPARTS & STAKEHOLDERS

With begin of Phase 3, in 2020 and 2021, *EFForTS* extended 8 scholarships and awarded one new one.
Two doctoral researchers completed their dissertations in December 2020 and October 2021:

- Rawati Panjaitan – December 2020 at IPB University: Diversity and Abundance of Butterflies (Lepidoptera:Papilionoidea) in Four Land Use in the Bukit Duabelas and Hutan Harapan Landscape, Jambi, Sumatera. Supervised by Purnama Hidayat and Damayanti Buchori, both counterparts of Z02.
- Winda Ika Susanti – March 2022 at the University of Göttingen: Soil Fauna in the Lowland Rainforest and Agricultural Systems of Sumatra: Changes in Community Composition and Trophic Structure with Focus on Collembola. Supervised by Stefan Scheu / UGoe & Rahayu Widyastuti / IPB University (Picture 71 c). [*Link*]

Research summary – Winda Ika Susanti

In 2019 I started to investigate the community composition and trophic position of Collembola in the *EFForTS* core sites. Collembola are among the most abundant arthropods inhabiting the belowground system sensitively responding to changes in vegetation and soil conditions. However, parameters which are more closely linked to ecosystem functioning, such as trophic niches, received little attention. I used stable isotope analysis (^{13}C and ^{15}N) to investigate changes in the trophic structure and use of food resources by Collembola in four land-use systems (rainforest, rubber agroforest, rubber (*Hevea brasiliansis*) and oil palm (*Elaeis guineensis*) monoculture plantations. Overall, the results suggest that rainforest conversion into plantation systems is associated with marked shifts in the structure of trophic niches in soil and litter Collembola with potential consequences for ecosystem functioning and food web stability. Across Collembola species $\Delta^{13}C$ values were highest in rainforest suggesting more pronounced processing of litter resources by microorganisms and consumption of these microorganisms by Collembola in this system. Lower $\Delta^{13}C$ values, but high $\Delta^{13}C$ variation in Collembola in oil palm plantations indicated that Collembola shifted towards herbivory and used more variable resources in this system. Small range in $\Delta^{15}N$ values in Collembola species in monoculture plantations in comparison to rainforest indicated that conversion of rainforest into plantations is associated with simplification in the trophic structure of Collembola communities (Fig. 96).
Further, I investigated the response of Collembola communities to the conversion of rainforest into rubber agroforestry ("jungle rubber"), rubber, and oil palm plantations. Samples from litter and soil layer taken in 2013 and 2016

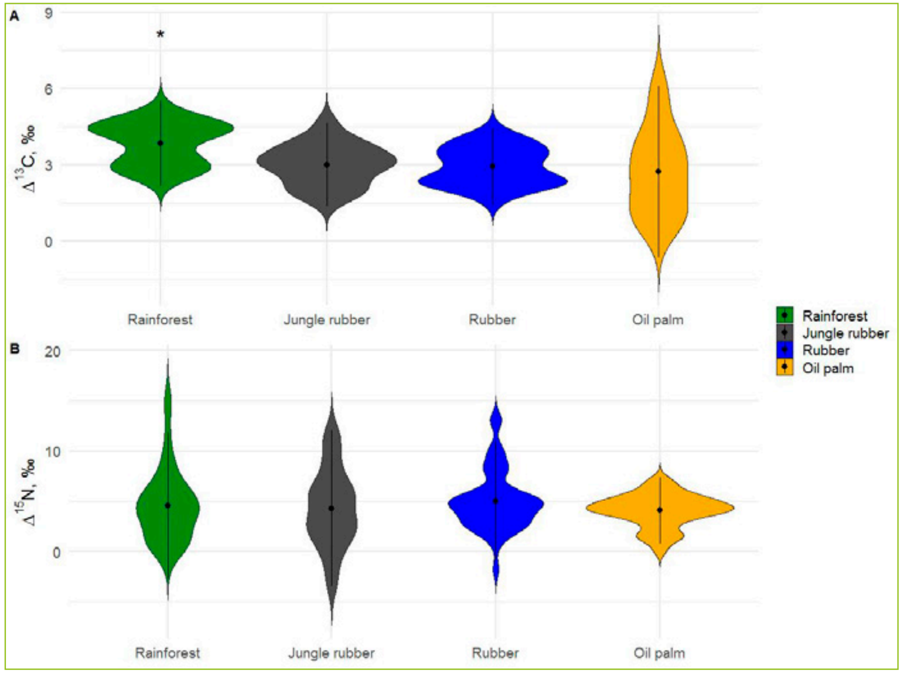


Figure 96. Variations in $\Delta^{13}C$ and $\Delta^{15}N$ values of Collembola among the studied land-use systems (rainforest, jungle rubber, rubber and oil palm plantations). Violin plots show frequency distribution of values (mirrored Kernel density estimation), all individual measurements are displayed together, independently of the taxonomic identity. *Average $\Delta^{13}C$ values in rainforest were significantly higher than in the other three land-use systems ($P < 0.05$).

were used and Collembola data were combined with data on environmental factors (litter C/N ratio, pH, water content, composition of microbial community and predator abundance). Overall, land-use change negatively affected Collembola communities in the litter layer, but less in the soil layer. Pantropical genera of Collembola (i. e., *Isotomiella*, *Pseudosinella*, and *Folsomides*) dominated across land-use systems, reflecting their high environmental adaptability and/or efficient dispersal, calling for studies on their ecology and genetic diversity. The decline in species richness and density of litter-dwelling Collembola with the conversion of rainforest into plantation systems calls for management practices mitigating negative effects of the deterioration of the litter layer in rubber plantations, but even more in oil palm plantations (Fig. 97).

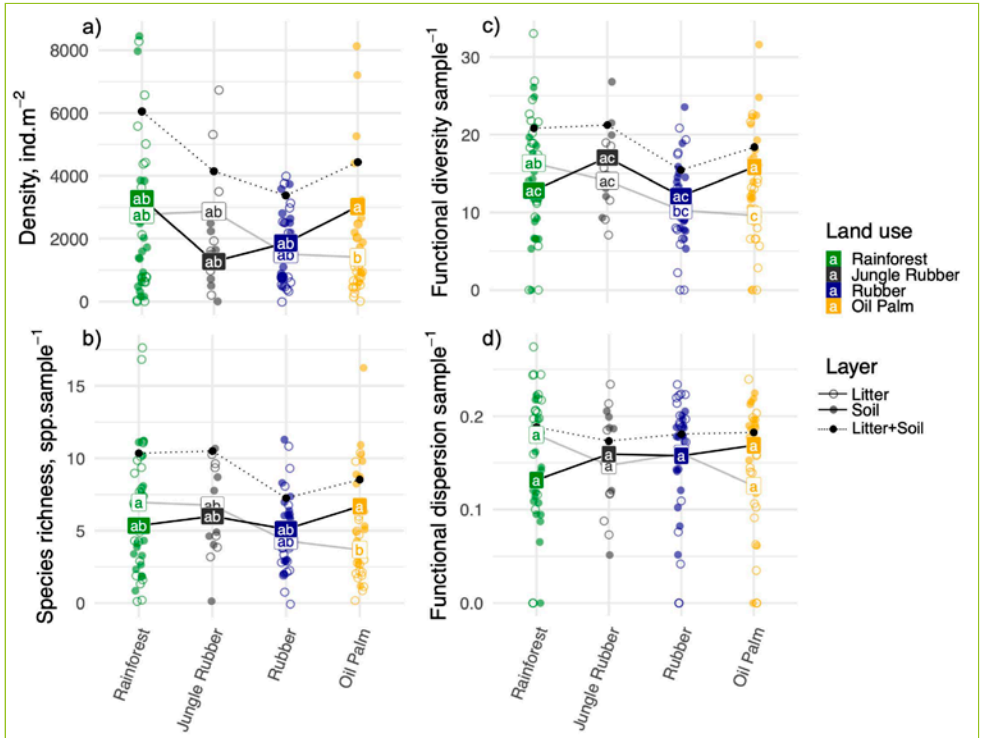


Figure 97. Density and species richness of Collembola in different land-use systems across sampling years. (a) Density of Collembola per square meter, (b) number of Collembola species per sample (256 cm²), (c) functional diversity (FD) of Collembola communities per sample, and (d) functional dispersion (FDis) of Collembola communities per sample. Each soil core was divided into litter and soil layers (0-5 cm), and these layers were treated as replicates and presented as separate points in the figure (open points – litter, filled points – soil). Labels connected by solid lines show mean values for litter and soil separately (white labels – litter, black labels – soil). Mean values across layers and systems sharing the same letter are not significantly different for the given variable (Tukey contrasts). Black points connected with dotted lines show mean values for litter and soil combined (sum of density, newly calculated after combining layers for species richness, FD and FDis).

Publications:

Susanti, W. I., Widyastuti, R., Scheu, S., & Potapov, A. (2021). Trophic niche differentiation and utilisation of food resources in Collembola is altered by rainforest conversion to plantation systems. *PeerJ*, *9*, e10971.

Susanti, W. I., Bartels, T., Krashevska, V., Widyastuti, R., Deharveng, L., Scheu, S., & Potapov, A. (2021). Conversion of rainforest into oil palm and rubber plantations affects the functional composition of litter and soil Collembola. *Ecology and evolution*, *11*(15), 10686-10708.

Seminar and training:

1. Indonesian Collembola identification with collembologist Louis Deharveng and Anne Bedos in Muséum National d'Histoire Naturelle, France (January–February 2019)
2. Oral presentation at 10th International Seminar on Apterygota, Paris-France, 17th–21st June 2019
3. Seminar on Stable Isotope Analysis (KOSI-Goettingen University), February 2020

Pictures 71a–c. Winda at the Gänseliesel. In Göttingen, it is an old custom for graduates to go to the "Gänseliesel" in the city's market square after the graduation ceremony.

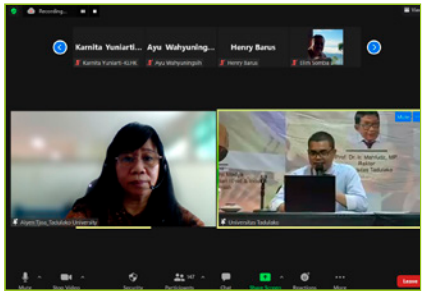
3. CAPACITY BUILDING WORKSHOPS

1. ABS Workshop, held on November 4, 2021: Updates on the implementation of the Nagoya Protocol in Indonesia, Japan and India.
   - The hybrid workshop, conducted by IPB University was attended by 135 participants from Indonesia, Japan and India.
   - Aims: Introduction to current/respective country policies & regulations, to decision-making processes and tools in Access & Benefit Sharing in order to facilitate the effective implementation of Nagoya Protocol (NP).
   - The different countries shared their experiences. For the Indonesian site, Aiyen Tjoa presented the hindrances that an international research partnership may face to implement the NP, taking *EFForTS* as an example.
   - In conclusion: Each country has its unique system on which its builds on. Both Japan and India – although having similar procedure compared to in Indonesia – involve fewer institutions with regard to the management of NP. At the same time, the legislation is more complete and effective than in Indonesia.

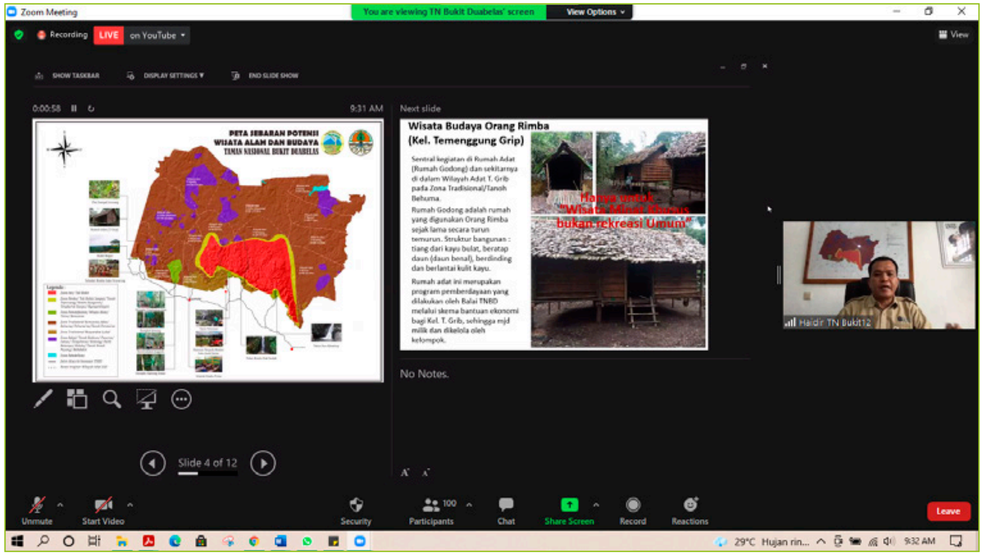
Picture 72 a and b. Outline of the ABS workshop on the implementation of the Nagoya Protocol on November 4, 2021

2. ABS Workshop on November 11, 2021: International research collaboration, research permit, and implementation of the Nagoya protocol
   - The hybrid workshop, conducted by UNTAD, was attended by 187 participants from BRIN and universities.
   - Aim: Sharing experiences from *EFForTS* which is regarded as best practice example in international research collaboration. At the same time, network activities should be strengthened and extended.

Picture 73 a and b. Outline of the ABS workshop on international research collaboration, research permits and the implementation of the Nagoya Protocol on November 11, 2021.

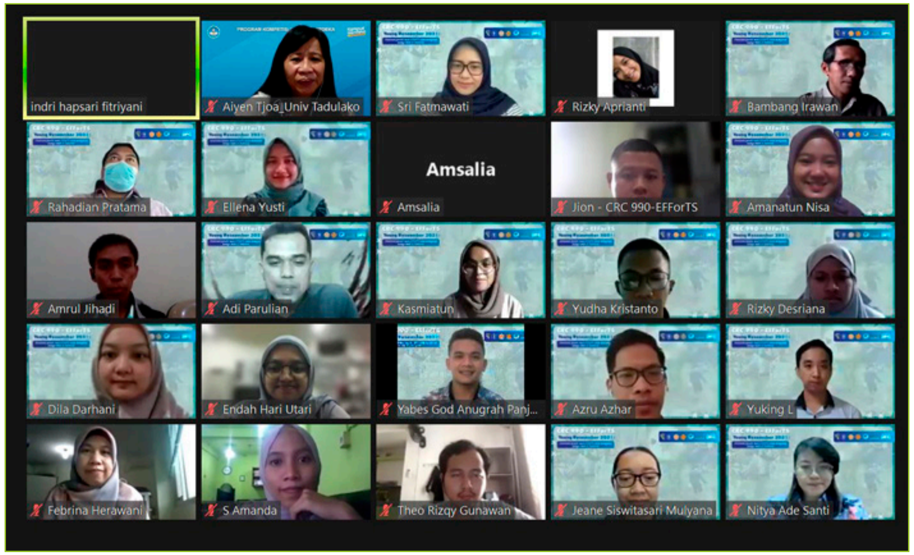


3. ABS Workshop on November 18, 2021: Agro-tourism at conservation forest areas
   - The online workshop was conducted by the National Park Bukit Duabelas (TNBD) & IPB University and was attended by 100 participants.
   - Aim: To improve the capacity of TNBD in the management of their conservation area – by a) to build capacity to generate income by agro-tourism in conservation areas, and b) to establish networks with experts from IPB University in the field of 'Agro-tourism in Conservation areas'.



Picture 74 a and b. Outline of the ABS workshop on agro-tourism in conservation forest areas on November 18, 2021.

4. ABS Workshop on December 14, 2021: Capacity building and networking of young researchers
   - The online workshop was conducted by young researchers and field assistants of *EFForTS* and was attended by 53 participants from various institutions.
     - Aim: To establish & strengthen networks, and to share knowledge and experiences.
   - The President of ALMI (Indonesia young academy of sciences) gave the opening key note to acknowledge the work of *EFForTS'* field and laboratory assistants.
   - Particpants from *EFForTS*: Ellena, Adi Parulian, Yabes, Nisa, Dilla, Nitya, Yudha, Ummu, Riko, Azru, Atun, Naufal and Rizky.



Picture 75 a and b. Outline of the ABS workshop on capacity building for young researchers and research assistants on December 14, 2021.

5. ABS Workshop on Dec 22, 2021: Data management and country regulation
    - The hybrid workshop was conducted by IPB University, it was attended by 62 participants.
    - Aim: Build up an (inter)national wide forum to share knowledge on data management from different countries; for Indonesia: share knowledge & experience with regard to law 11/2019.

Picture 76. Outline of the ABS workshop on capacity building for young researchers and research assistants on December 14, 2021.

6. ABS Workshop in 2021: Data mining from DNA barcoding research

Name	Counterpart	Title
Iskandar Z. Siregar, Muhammad Majiidu	**B14**	Data mining on DNA barcode research

Background and Objectives

DNA barcoding is a method used for rapid identification of species using a sequence of bases from an organism's tissue (Kress *et al*., 2002; Lahaye *et al*., 2008). Hajibabaei *et al*. (2007), Meier *et al.* (2006) and Virgilio *et al.* (2012) stated that the process of identifying a molecular scale by DNA barcoding is rapid, accurate, and unambiguous compared to the morphological identification. DNA barcoding requires only a small sample of the specimen taken from all body tissues of the organism. Unfortunately, this method is not yet sufficiently developed in plants compared to animals. The markers commonly used in plants are maturase-K (matK) and *ribulase-1,3-biphosphate carboxylase oxygenase (rbcL)* (Kress *et al.* 2005; Wicke & Quandt 2009). Current technology development based on the 3rd NGS technologies that employ long-read and short read sequences has potentials to improve the traditional DNA barcode analysis. Considering both technologies, we conduct specific activities aimed at: i) building capacity for the use of genomics data for SNPs and microsatellites markers and ii) supporting the finalisation of pending manuscripts on plant DNA barcodes on Fabaceae and Anacardiaceae.

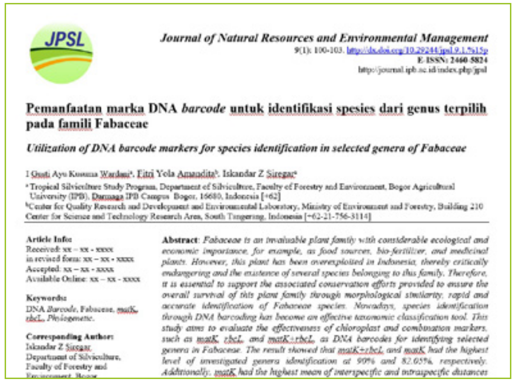
ABS Workshop

- A mini workshop was conducted at IPB University; it was attended by undergraduate and postgraduate students from IPB University, Bengkulu University and Jambi University (Picture 77).
- The workshop aimed at discussing about genomic research and its applications such as DNA barcode primers design. Dr. Deden Derajat Matra, a lecturer from Agronomy and Horticulture, Faculty of Agriculture, IPB University, was a speaker in this mini workshop. Fourteen students participated in the workshop and were trained to use bioinformatics tools (e.g. Geneous, MASER platfrom from NIG Japan).

Picture 77. Mini workshop on genomic research, held at IPB University for 14 undergraduate and postgraduate students from IPB University, Bengkulu University and Jambi University.

Outcome

- Two manuscripts result from this work: one article (Fig. 98) has been accepted by the *Jurnal Pengelolaan Sumber Daya Alam dan Lingkungan*. Another manuscript is in the final stage of preparation.



JPSL

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E-ISSN: 2460-5824
http://journal.ipb.ac.id/index.php/jpsl

Pemanfaatan marka DNA *barcode* untuk identifikasi spesies dari genus terpilih pada famili Fabaceae

Utilization of DNA barcode markers for species identification in selected genera of Fabaceae

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Keywords:
DNA Barcode, Fabaceae, matK, rbcL, Phylogenetic.

Corresponding Author:
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Abstract: *Fabaceae is an invaluable plant family with considerable ecological and economic importance, for example, as food sources, bio-fertilizer, and medicinal plants. However, this plant has been overexploited in Indonesia, thereby critically endangering and the existence of several species belonging to this family. Therefore, it is essential to support the associated conservation efforts provided to ensure the overall survival of this plant family through morphological similarity, rapid and accurate identification of Fabaceae species. Nowadays, species identification through DNA barcoding has become an effective taxonomic classification tool. This study aims to evaluate the effectiveness of chloroplast and combination markers, such as matK, rbcL, and matK+rbcL, as DNA barcodes for identifying selected genera in Fabaceae. The result showed that matK+rbcL and matK had the highest level of investigated genera identification at 90% and 82.05%, respectively. Additionally, matK had the highest mean of interspecific and intraspecific distances*

Figure 98

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Meier R, Shiyang K, Vaidya G, Peter KL. 2006. DNA barcoding and taxonomy in Diptera: a tale of high intraspecific variability and low identification success. Systematic Biology. 55(5):715-728.

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Wicke S, Quandt D. 2009. Universal primers for the amplification or the plastid trnK/matK region in land plants. Anales Jard Bot Madrid. 66(2):285-288.

7. ABS – Training course: Quality management in the laboratory according to ISO/IEC 17025 – March 28 to April 2, 2022

- *EFForTS* supported a six-day education/training course from March 28 to April 2, 2022 at IPB University on "Laboratory management according to the ISO 17025:2017 standard" with the aim of establishing a quality management system and accreditation of the respective laboratory at our partner universities.
- The course was held at the Department of Soil Science and Land Resources, Faculty of Agriculture, IPB University. In total, 13 participants (head and technicians

Picture 78 a. Participants and organizers of the training course ISO/IEC 17025:2017, held from March 28 to April 2, 2022 at IPB University.

of laboratories), from IPB University, UNJA and UNTAD have taken part in the course.

- The course specifically pursues the goal of improving the quality as well as the reliability of the testing and calibration methods of laboratories. In addition to the general requirements for laboratory management, ISO IEC 17025 also defines the technical requirements for a laboratory. After the successful implementation of a quality management system, this can then be accredited.

Picture 78 b. Opening of the training course ISO/ IEC 17025:2017 by Arief Hartono, Department of Soil Science and Land Resources, organizer of the course.

Picture 78 c. Participants and trainer Ida Farida, trainer of the course ISO/IEC 17025:2017

8. English training in 2022

- *EFForTS* supported three months English classes, starting from mid-February 2022, for field assistants, office staff, young staff of UNJA and staff from the National Park Bukit Duabelas as well as for kids at Pematang Kabau and Bungku where two of our core sites are located.

Pictures 79 a and b. English class for field assistants of *EFForTS*.

4. PUBLICATIONS ORIGINATING FROM ABS PROJECTS

A02	**Agusta H**, **Handoyo HC, Sudaryanto MT, Hendrayanto** (2020) Cover crops and frond piles for improving soil water infiltration in oil palm plantations; IOP Conf. Ser.: Earth Environ. Sci. 460: 012045 *https://iopscience.iop.org/article/10.1088/1755-1315/460/1/012045/meta*
Z02	**Azhar A**, **Hartke TR, Böttges L, Lang T, Larasati A, Novianti N, Tawakkal I, Hidayat P, Buchori D, Scheu S, Drescher J** (2022) Rainforest conversion to cash crops reduces abundance, biomass and diversity of parasitoid wasps in Sumatra, Indonesia Agricultural and Forest Entomology: 1–10 *https://resjournals.onlinelibrary.wiley.com/doi/10.1111/afe.12512*
Z02	**Buchori D, Hidayat P, Nazarreta R, Ardiyanti RM, Siddikah F, Amrulloh R, Azhar A, Kasmiatun, Scheu S, Drescher J** (2022) Keanekaragaman Serangga Hutan Hujan Tropis Dataran Rendah di Provinsi Jambi, Sumatra: Dampak Perubahan Tata Guna Lahan; e-Publishing, Penerbit BRIN, ISBN-13 (15) 978-602-496-282-1 *https://penerbit.brin.go.id/press/catalog/book/280*
C02	**Budi B**, **Kartodihardjo H, Nugroho B, Mardiana R** (2021) Implementation of social forestry policy: Analysis of community access; Forest and Society 5: 60-74 *https://journal.unhas.ac.id/index.php/fs/article/view/9859*
A03	**Kii MI**, **June T, Santikayasa** (2020) Dynamics Modeling of CO2 in Oil Palm; Agromet 34: 42-54 *https://journal.ipb.ac.id/index.php/agromet/article/view/31110*
B10	**Kristanto Y**, Tarigan S, June T, Wahjunie ED (2021) Evaluation of different runoff curve number (CN) approaches on water regulation services assessment in intermittent micro catchment dominated by oil palm plantation; Agromet 35: 73-88 *https://journal.ipb.ac.id/index.php/agromet/article/view/35338*
Z02	**Nazzareta R**, Hartke TR, Hidayat P, Scheu S, Buchori, D, Drescher J (2020) Rainforest conversion to smallholder plantations of rubber or oil palm leads to species loss and community shifts in canopy ants (Hymenoptera: Formicidae); Myrmecological News 30: 175-186 *https://myrmecologicalnews.org/cms/index.php?option=com_content&view=category&id=1567&Itemid=435*
Z02	**Panjaitan R**, **Hidayat P, Peggie D, Buchori D, Scheu S, Drescher J** (2021) The butterflies of Jambi (Sumatra, Indonesia): An *EFForTS* field guide; e-Publishing, Penerbit BRIN, ISBN-13 (15) 978-602-496-270-8 *https://penerbit.brin.go.id/press/catalog/book/370*
Z02	**Panjaitan R**, **Drescher J, Buchori D, Peggie D, Harahap IS, Scheu S, Hidayat P** (2020) Diversity of butterflies (Lepidoptera) across rainforest transformation systems in Jambi, Sumatra, Indonesia; Biodiversitas 21: 5119-5127 *https://www.smujo.id/biodiv/article/view/6152*
B08, Z02	**Rizqulloh MN**, **Drescher J, Hartke TR, Potapov A, Scheu S, Hidayat P, Widyastuti R** (2021) Effects of rainforest transformation to monoculture cash crops on soil living ants (Formicidae) in Jambi Province, Sumatra, Indonesia; IOP Conf. Ser.: Earth Environ. Sci. 771: 012031 *https://iopscience.iop.org/article/10.1088/1755-1315/771/1/012031*
B10	**Romadona K**, **Tarigan S, Widiatmaka, Setiawan Y** (2021) Modeling of nutrient retention ecosystem services in oil palm plantations in Sei Jentikar sub-watershed using ISPO policy approach; IOP Conference Series: Earth and Environmental Science 771: 012025 *https://iopscience.iop.org/article/10.1088/1755-1315/771/1/012025*
B08	**Susanti WI**, **Bartels T, Krashevska V, Widyastuti R, Deharveng L, Scheu S, Potapov A** (2021) Conversion of rainforest to oil palm and rubber plantations affects the functional composition of litter and soil Collembola; Ecology & Evolution 11: 10686-10708 *https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.7881*
B08	**Susanti WI**, **Widyastuti R, Scheu S, Potapov A** (2021) Trophic niche differentiation and utilisation of food resources in Collembola is altered by rainforest conversion to plantation systems; PeerJ 9:e10971 *https://peerj.com/articles/10971/*
B10	**Tarigan S**, **Stiegler C, Wiegand K, Knohl A, Murtilaksono K** (2020) Relative contribution of evapotranspiration and soil compaction to the fluctuation of catchment discharge: case study from a plantation landscape; Hydrological Sciences Journal 65: 1239-1248 *https://www.tandfonline.com/doi/full/10.1080/02626667.2020.1739287*
B14	**Wardani IGAK**, **Armandita FY, Moura CCM, Gailing O, Siregar IZ** (2022) Molecular taxonomy via DNA barcodes for species identification in selected genera of Fabaceae; Journal of Natural Ressources and Environmental Management 12 *https://journal.ipb.ac.id/index.php/jpsl/article/view/36609*
B14, B06	**Wati R**, **Amandita FY, Brambach F, Siregar IZ, Gailing O, Carneiro de Melo Moura C** (2022) Filling gaps of reference DNA barcodes in Syzygium from rainforest fragments in Sumatra; Tree Genetics & Genomics 18:6 *https://link.springer.com/article/10.1007/s11295-022-01536-z*

5. THE CONTRIBUTION OF ABS TO THE SUSTAINABLE DEVELOPMENT GOALS: LESSONS LEARNED AND BEST PRACTICES

- *EFForTS* was selected as one of 20 Best-Practice Cases / Partnerships to highlight how access to genetic resources and benefit-sharing (ABS) contributes to conservation and sustainable use, as well as to the United Nations Sustainable Development Goals (SDGs).

- The report was presented at the *10 years celebration of the Nagoya Protocol (Video)*. The handouts are published on the *CBD website* .

The contribution of Access and Benefit-Sharing (ABS) to the Sustainable Development Goals.

Lessons learned and best practices

Handout

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

BfN Federal Agency for Nature Conservation

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All contact persons mentioned in the different cases are kindly acknowledged for their contribution with information and pictures.

Design: MediaCompany GmbH

Date: November 2020

These handouts are prepared in order to inform participants of the online conference “Building the ABS we all need for the Post-2020 Biodiversity Framework” on 25 November 2020 held by the UNDP-GEF ABS Project and the Secretariat of the Convention on Biological Diversity. They are part of the project “ABS in practice – Benefits for increasing global funds for the conservation of biodiversity” which has been funded by the German Federal Agency for Nature Conservation with funds from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.”

A long-term research partnership for the tropical rainforest of Sumatra, Indonesia
Asia

Social networing and agricultural extension services © Yuking Linatra

OVERVIEW	Basic research on ecological and socioeconomic aspects of changing rainforest landscapes in Indonesia, in an evolving ABS legal framework
SUBJECT MATTER (GR / BR)	Plants, animals, and microorganisms
SCIENTIFIC OR COMMERCIAL USE	Basic research on biodiversity, including studies on diversity of plants, animals and soil microorganisms, collection of genetic material for barcoding, and assessments of environmental processes and socioeconomic impacts
PROVIDER COUNTRY	Indonesia
ABS FRAMEWORK IN PROVIDER COUNTRY	Indonesia is Nagoya Protocol Party since 2014. Nevertheless, national strategies and actions for the implementation of the Nagoya Protocol have been in place since 2011. In 2011, a decree issued by the Ministry of Agriculture regulated the conservation and utilization of plant genetics resource. In 2018, a decree issued by the Minister of Environment and Forestry regulated access to genetic resources of wild species and benefit-sharing. A 2019 law on research and innovation slightly modified ABS processes.
USER COUNTRY	Indonesia and Germany

ACTORS

Resource providers:
- Bukit Dua Belas National Park, managed by National Park Authority
- Harapan Rainforest and other protected areas in the Jambi province, managed by BKSDA Jambi, the provincial conservation agency
- Smallholder farmers and public and privately-owned companies in Jambi

Competent authorities:
- Ministry of Environment and Forestry, Indonesia
- Ministry of Research and Technology/National Research and Innovation Agency, Indonesia
- Indonesian Institute of Science (LIPI), Indonesia

National collaborators:
- Institut Pertanian Bogor (IPB University), Indonesia
- Tadulako University (UNTAD), Indonesia
- Jambi University, UNJA, Indonesia
- Public and privately-owned companies (including PTPN VI, PT BSU, PT Humusindo Makmur Sejati), Indonesia

Users:
- University of Göttingen, Germany
- University of Hohenheim, Germany
- Leibniz-Institute GIGA Hamburg, Germany
- Thünen-Institute Braunschweig, Germany

• Handout

SHORT DESCRIPTION

Over the last decades, the lowlands of Jambi province have undergone a major transformation from forest towards a cash crop-dominated landscape of rubber and oil palm plantations. The project “Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems” (EFForTS) investigates the ecological and socioeconomic effects of such transformation. Its objective is to provide science-based knowledge on how to protect and enhance the ecological functions of tropical forests and agricultural transformation systems at a landscape scale, while improving human welfare. EFForTS is funded by the German Research Foundation (DFG) for two project phases since 2012 and funding has been renewed for a third project phase lasting until 2023.

ACCESS AND BENEFIT-SHARING ELEMENTS

Within EFForTS, a range of different agreements have been established since 2012, including:
- Memorandums of Understanding (MoUs) or similar documents signed between research institutions in Indonesia and Germany, establishing the research partnership
- MoUs signed between local universities and national authorities for establishing long-term plots in protected areas
- Plot contracts between national collaborators and both farmers and companies for compensation measures
- Counterpart agreements signed between participating universities

Additionally, research permits have been obtained from the Ministry of Research and Technology/National Research and Innovation Agency and sample collection permits from the Ministry of Environment and Forestry. Other permits were required for the national and international transport of biological material, and for national and international material transfers.

Since 2013, material transfer agreements (MTAs) between research partners have also regulated the export and use of specimens and samples - particularly ensuring these were only loans.

In 2018, prior informed consent (PIC) was issued by the National Park Authority (for the Bukit Dua Belas National Park) and by BKSDA Jambi (for non-national park areas). Mutually agreed terms have not been signed, as a template for the agreement is not yet available.

The project includes both monetary and non-monetary benefit-sharing.
Monetary benefits: A significant proportion of the 42.7 million euro project funding goes to Indonesian partners through about 160 research grants, 16 capacity building grants, and the setup of new infrastructure (research stations, a herbarium, a soil ecology lab, a hydrology lab and a palynology lab).
Non-monetary benefits:
- Long-term cooperation (over 20 years) between about 200 project members from Germany and Indonesia, including 230 publications, of which 72% jointly with counterparts and 34 with Indonesian first author
- Capacity-building (94 lectures, 24 workshops, 28 lab trainings, training of students: 10 PhD, 28 MSc, 45 BSc and exchange of researchers) and setup of demonstration plots
- Samples deposited in national collections in Indonesia

2 • Handout

Lessons learned and best practices

NATIONAL ABS FRAMEWORKS
- Internal approaches adopted by users facilitate ABS processes (e.g., establishing ABS service within consortium and as interface with local partners, a CBD Board to monitor the implementation of relevant guidelines at project level, and a Data Management Board to monitor the compliance of data transfer)
- Local coordinator with in-depth knowledge of the subject matter gives crucial support on ABS matters
- In spite of facilitation by local partners, ABS processes are sometimes bureaucratic. It is not always understood that studies on genetic material can be done for mere scientific purposes, without any commercial use

BENEFIT-SHARING
- Sharing of benefits contributes to building trust with national and local stakeholders involved in the administrative and legislative implementation of the project
- Benefit-sharing is a way to disseminate project activities and outcomes among scientists, decision makers, and the general public. However, related administrative procedures are complex, difficult to comprehend for the outsider, and may trigger conflict of interests

SUPPORT THROUGH CAPACITY-BUILDING PROJECTS
- Capacity-building is essential for ABS processes. It improved collaboration between researchers in Germany and Indonesia
- Increasing involvement of Indonesian students in projects facilitated sample processing, sample export and joint publications

RELATIONSHIP BETWEEN USERS AND PROVIDERS
- Long-term partnerships - in this project, over 20 years - and a successful cooperation with local scientists, competent authorities, smallholder farmers and other stakeholders enables ABS processes

OTHER SUPPORTIVE MECHANISMS
- Voluntary tools, such as guidelines, can advance ABS principles in cases where no precise ABS requirements exist in the provider country. In this case, the DFG guidelines to promote ABS principles and procedures among its applicants, adopted in 2008, usefully inform and support ABS processes. Moreover, the project developed its own guidelines for scientists on how to use ABS-related funds available from DFG

Contributions to the SDGs

SDG 1, target 1.4, 1.5: Contribution to human welfare and poverty alleviation of smallholder farmers through mobilization of financial resources. For example, project involves plot contracts with farmers and companies that provide compensation measures for research activity and use of data and material.

SDG 4, target 4.7, 4.B: Comprehensive capacity-building and training of students, as part of monetary benefits and non-monetary benefits, including numerous grants and trainings for counterparts, stakeholders, office staff and local assistants in Indonesia. In addition, counterparts and coordinators in Indonesia conduct regular agricultural extension programmes to improve capacity of farmers and to disseminate the research results (for example, on optimal fertilization, organic farming, composting, and farm management).

SDG 8, target 8.5: Mobilization of financial resources for creation of new jobs for researchers as monetary benefit (see under SDG 15 and 17).

SDG 9, target 9.1, 9.5, 9.A: Substantial financial start-up support to counterparts in 2012 (47 projects) and by research grants for partners and stakeholders (ca. 120 grants). Contribution to the development of research infrastructure through the establishment of research stations and different labs (herbarium, soil ecology, hydrology and palynology).

SDG 12, target 12.2, 12.8, 12.A: Support of responsible consumption and production was provided as non-monetary benefit (see under SDG 4 and 15).

SDG 13, target 13.3: Increasing knowledge on influence of land use transformation and climate change on biogeochemical cycles supports decision-making of local authorities and smallholder farmers work.

SDG 15, target 15.1, 15.5, 15.6, 15.9, 15.A: EFForTS contributes to the protection and enhancement of the ecological functions of tropical forests with science-based knowledge with 20 scientific projects by monetary and non-monetary benefits, which are shared with local researchers, authorities and smallholder farmers.

SDG 17, target 17.3, 17.6, 17.8, 17.9: Involvement of stakeholders and indigenous communities: Cooperation with universities, national parks, state and private companies and governmental organizations in Indonesia. Researchers from Germany and Indonesia work in close cooperation on a wide range of disciplines (e.g., ecology, forestry, agriculture, remote sensing, economics, cultural anthropology) and have produced a large amount of joint publications.

4 • Handout

Relevant contacts/sources of information:
- Prof. Dr Stefan Scheu & Dr Barbara Wick (University of Göttingen, Germany)
- Dr Aiyen Tjoa (UNTAD - Tadulako University, Indonesia)
- Interview with Prof. Dr Stefan Scheu and Dr Barbara Wick
- Website: https://www.uni-goettingen.de/de/310995.html
- ABS-Clearing House: https://absch.cbd.int/search/nationalRecords

IV. Publications

1. **Journal articles (237)**
2. **Reviews (20)**
3. **Other Publications (27)**
4. ***EFForTS* Discussion Paper Series (35)**

Since the beginning of the project in 2012, *EFForTS* has published 319 journal articles, of which 53 are first-authored by counterparts or junior researchers from Indonesia. Overall, 236 articles are disciplinary papers, published by one subproject, and 83 articles are interdisciplinary ones, published by two (53) or more than two (30) subprojects.

Tables below show the scientific publications of *EFForTS* since the last issue of newsletter no. 7, April 2020.

1. JOURNAL ARTICLES

A07, A02, A03, A05, B04, B06	**Ali, AA, Fan Y, Corre MD, Kotowska MM, Preuss-Hassler E, Cahyo AN, Moyano F, Stiegler C, Röll A, Meijide A, Olchev A, Ringeler A, Leuschner C, Ariani R, June T, Tarigan S, Kreft H, Hölscher D, Xu C, Koven CD, Dagon K, Fisher RA, Veldkamp E, Knohl A** (2022) Implementing a new rubber plant functional type in the community land model (CLM5) improves accuracy of carbon and water flux estimation; Land 11: 183 *https://www.mdpi.com/2073-445X/11/2/183*
A07, A05, B06	**Ali, AA, Nugroho B, Moyano FE, Brambach F, Jenkins ME, Pangle R, Stiegler C, Blei E, Cahyo AN, Olchev A, Irawan B, Ariani R, June T, Tarigan S, Corre MD, Veldkamp E, Knohl A** (2021) Using a bottom-up approach to scale leaf photosynthetic traits of oil palm, rubber, and two coexisting tropical woody species; Forests 12: 359 *https://www.mdpi.com/1999-4907/12/3/359*
Z02	**Azhar A, Hartke TR, Böttges L, Lang T, Larasati A, Novianti N, Tawakkal I, Hidayat P, Buchori D, Scheu S, Drescher J** (2022) Rainforest conversion to cash crops reduces abundance, biomass and diversity of parasitoid wasps in Sumatra, Indonesia; Agricultural and Forest Entomology: 1–10 *https://resjournals.onlinelibrary.wiley.com/doi/10.1111/afe.12512*
B07, B02	**Ballauff J, Schneider D, Edy N, Irawan B, Daniel R, Polle A** (2021) Shifts in root and soil chemistry drive the assembly of belowground fungal communities in tropical land-use systems; Soil Biology and Biochemistry 154: 108140 *https://www.sciencedirect.com/science/article/abs/pii/S0038071721000122*
B07, B11, B02	**Ballauff J, Zemp DC, Schneider D, Irawan B, Daniel R, Polle A** (2020) Legacy effects overshadow tree diversity effects on soil fungal communities in oil palm-enrichment plantations; Microorganisms 8: 1577 *https://www.mdpi.com/2076-2607/8/10/1577*
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C02	**Budi B, Kartodihardjo H, Nugroho B, Mardiana R** (2021) Implementation of social forestry policy: Analysis of community access; Forest and Society 5: 60-74 *https://journal.unhas.ac.id/index.php/fs/article/view/9859*
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Z02	**Nazzarretta R, Buchori D, Hashimoto Y, Hidayat P, Scheu S, Drescher J** (2021) A guide to the ants of Jambi (Sumatra, Indonesia): Identification key to ant genera and images of the *EFForTS* collection; e-Publishing, Penerbit BRIN, ISBN-13 (15) 978-602-496-257-9 *https://penerbit.brin.go.id/press/catalog/book/273*
Z02	**Panjaitan R; Hidayat P, Peggie D, Buchori D, Scheu S, Drescher J** (2021) The butterflies of Jambi (Sumatra, Indonesia): An *EFForTS* field guide; e-Publishing, Penerbit BRIN, ISBN-13 (15) 978-602-496-270-8 *https://penerbit.brin.go.id/press/catalog/book/370*
B08, B01, B06	**Potapov AM; Dupérré N, Jochum J, Dreczko K, Klarner B, Barnes AD, Krashevska V, Rembold K, Kreft H, Brose U, Widyastuti R, Harms D, Scheu S** (2020) Ground spider communities under tropical land-use change; Bulletin Ecological Society of America 101: e01668 *https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/bes2.1668*
C07	**Quaim M** (2020) Would Banning Palm Oil Really Improve Sustainability?; Sustainable Palm Oil Choice, 4 November 2020 *https://www.sustainablepalmoilchoice.eu/would-banning-palm-oil-really-improve-sustainability/*
B08	**Salomon JA, Wissuwa J, Frank T, Scheu S, Potapov AM** (2020) Trophic level and basal resource use of soil animals are hardly affected by local plant associations in abandoned arable land; Ecology and Evolution 10: 8279-8288 *https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.6535*
C07	**Sibhatu KT** (2020) Response: Commentary: Oil palm bom and farm household diets in the tropics; Frontiers in Sustainable Food Systems 4: 107 *https://www.frontiersin.org/articles/10.3389/fsufs.2020.00107/full*

4. EFForTS DISCUSSION PAPER SERIES

C08	**Brenneis K, Irawan B, Wollni M** (2022) How to promote agricultural technologies that generate positive environmental effects? Evidence on tree planting in Indonesia; *EFForTS* discussion paper series 34 *https://publications.goettingen-research-online.de/bitstream/2/108253/1/EFForTS%20Discussion%20Paper%20No%2034.pdf*
C08	**Brenneis K, Edison E, Asnawi R, Wollni M** (2022) Environmental concern and pro-environmental behavior among residents in an oil palm cultivating hotspot; *EFForTS* discussion paper series 35 *https://publications.goettingen-research-online.de/bitstream/2/108254/1/EFForTS%20Discussion%20Paper%20No%2035.pdf*

V. Early Career Support: Education and Promotion of Junior Researchers

1. Postdoctoral researchers

Around **38 Postdoctoral researchers** have been employed in *EFForTS* since the start of the project in 2012. In Phase 3 (2020–2023), each of the Postdocs in the project is integrated in synthesis activities that receive particular attention from *EFForTS* PIs as well as Group Speakers and Foci speakers to the benefit of the career of postdoctoral researchers functioning as first authors of these papers.

2. Doctoral researchers

About **100 doctoral researchers** participate(d) in *EFForTS*, thereof 40 researchers with external scholarships or university (UGoe) funding.

To date, 71 doctoral researchers have completed their dissertations at the University of Göttingen, including 21 PhD students from Indonesia.

At IPB University in Bogor, nine doctoral researchers concluded their work.

Table 26. Newly completed dissertations in Phase 3 –
University of Göttingen. Update since newsletter no. 7, April 2020.

Table 27. Newly started dissertations in Phase 3 –
University of Göttingen. Update since newsletter no. 7, April 2020.

3. Master theses

EFForTS also supports the higher education of master students. Since 2012, **93 master students** completed their studies at Göttingen and **39 master students** at our partner universities in Indonesia.

Table 28. Master theses at the University of Göttingen –
newly started or completed since newsletter no. 7, April 2022.

Table 29. Master theses at IPB University, Bogor –
newly started or completed since newsletter no. 7, April 2020.

DISSERTATIONS

Table 26. New completed dissertations of Phase 2 and 3 – University of Göttingen. Update since newsletter no. 7, April 2020.

Scientific Project	Name	Type of funding	Title of thesis
A02	**Florian Ellsäßer**	DFG	Predicting evapotranspiration from drone-recorded land surface temperatures – Method testing and development (*August 2020*)
A02	**Joyson Ahong-shangbam**	Institute Hölscher	Tree and oil palm water use: scaling, spatial heterogeneity and temporal dynamics (Sumatra, Indonesia) (*October 2020*)
A04	**Nina Hennings**	DFG	Impact of tropical rainforest transformation in Indonesia on soil carbon sources, turnover and losses (*August 2021*)
A05	**Greta Formaglio**	DFG	The effect of reduced management intensity on soil nutrient dynamics in a large-scale oil palm plantation: soil nitrogen cycle, asymbiotic nitrogen fixation and nutrient leaching losses (*June 2020*)
B02	**Dirk Berkelmann**	DFG	Impact of rainforest conversion: How prokaryotic communities respond to anthropogenic land use changes (*June 2020*)
B04	**Pierre-André Waite**	DFG	Variability of wood and leaf functional traits in response to structural and environmental changes in natural and transformed systems in Indonesia (*August 2020*)
B07	**Johannes Ballauff**	DFG	Compositional and functional shifts in belowground fungal communities in tropical land-use systems (*June 2020*)
B07	**Rachmawaty Aisjah Ryadin**	LPDP, Republik of Indonesia	Influence of oil palm plantation management on root biomass, functions and associated microorganisms (January 2022)
B08	**Winda Ika Susanti**	DFG & Institute Scheu	Soil fauna in the lowland rainforest and agricultural systems of Sumatra: Changes in community composition and trophic structure with focus on Collembola (*October 2021*)
B08	**Garvin Schulz**	DFG & Institute Scheu	Soil protists in tropical systems: From morphological variation to trophic groups (*March 2022*)
B09	**Kevin Li**	DFG	Pollinator communities, function, and service in the oil palm landscape of Jambi Province, Indonesia (August 2020)
B13	**Alena Krause**	DFG	Changes in trophic niches of oribatid mites with transformation of tropical rainforest systems – from rainforest into rubber and oil palm plantations in Sumatra, Indonesia (*May 2020*)
C01	**Rakhma Melati Sujarwo**	DFG	Palm oil and rubber price and trader's behavior at international towards local level (*May 2020*)
C01	**Bernhard Dalheimer**	DFG	Economic policy in global commodity markets – Methods, efficiency and trade-offs (*July 2020*)
C02	**Jennifer Merten**	DFG	Agrarian change and hydro-social transformations. The socio-natural production of water, risk and inequality in Jambi province, Indonesia (*January 2021*)
C06	**Arieska Wening Sarwosri**	DFG	Analysing smallholder farmers' adoption of new technology under the consideration of risk attitudes and time preferences (*December 2020*)
C07	**Daniel Naek Chrisendo**	LPDP, Republik of Indonesia	A blessing in disguise? Effects of oil palm adoption on smallholder farmers' wellbeing and agricultural transformation in Indonesia (*May 2021*)
C07	**Nadjia Mehraban**	DFG	Land-use change, socioeconomic welfare, and gender roles in rural Indonesia (*May 2021*)

C08	**Karina Brenneis**	DFG	Policy interventions, perceptions, and pro-environmental behavior for sustainable oil palm cultivation in Indonesia (*November 2021*)
C08	**Katrin Rudolf**	Institute Wollni	Policies and management practices for sustainable oil palm – Evidence from Indonesia (*May 2020*)
Z02	**Rawati Panjaitan**	IPB University & Institute Scheu	Diversity and abundance of butterflies (Lepidoptera: Papilionoidea) in four land use systems in the Bukit Duabelas and Hutan Harapan landscape, Jambi, Sumatera (September 2020)
INF	**Miryam Sarah Merk**	DFG	Spatial and spatiotemporal stochastic processes – Estimation and modeling of spatial dependencies with applications in environmetrics (February 2021)

Table 27. Newly started dissertations of Phase 3 – University of Göttingen. Update since newsletter no. 7, April 2020

Scientific Project	Name	Type of funding	Title of thesis
A01	**Svea Lina Jahnk**	DFG	The effect of climate and human impact in Sumatra, Indonesia – Long-term and modern palaeoecological studies in different rainforest and transformation systems (since January 2021)
A01	**Chunk Nguyen**	DAAD	The long-term effects of fire, climate and human impact in the highland and lowland ecosystems of Sumatra, Indonesia (since October 2020)
A02	**Pallavi**	Indian Council of Agricultural Research, Ministry of Agriculture and Farmers Welfare (ICAR)	Thermal heterogeneity and heat stress across different land use systems in the lowlands of Sumatra (since April 2021)
B08	**Simin Wang**	China Scholarship Council (CSC)	Changes in structure and functioning of soil nematodes communities due to land use changes in tropical lowland rainforests (since June 2020)
B08	**Zheng Zhou**	China Scholarship Council (CSC)	Energy channeling and trophic structure in soil food webs under tropical land-use change (since November 2020)
B10	**Eyal Goldstein**	Minerva Grant (BMBF, Germany & MOST, Israel)	*EFForTS*-LGraf-EU: Generalization of *EFForTS*-LGraf to new horizons (since September 2021)
B11	**Vanessa Montoya-Sánchez**	Institute Zemp, University of Neuchâtel	Up-scaling biodiversity and structural complexity in lowland rainforest transformation systems (since February 2021)
B11	**Yevgeniya Korol**	Institute Hölscher	Tree-based ecosystem restoration in the lowlands of Sumatra in *EFForTS* (since April 2022)
C01	**Gabriela Carbajo Alvarez**	DFG	Marketing channels among rubber and palm oil smallholders in traders in Jambi Indonesia (since May 2021)
C06	**Dienda Hendrawan**	DFG	Understanding the certification and replanting behavior of Indonesian oil palm and rubber smallholder farmers (since August 2020)
C06	**Charlotte Reich**	DFG & Institute Mußhoff	Understanding the certification behavior of Indonesian smallholder farmers in the Palm Oil Industry (since January 2021)
C07	**Jakob Vincent Latzko**	DFG	Land-use change and socioeconomic development in rural Indonesia (since April 2021)
C08	**Tobias Benedikt Bähr**	DFG & Institute Wollni	Assessing mid- and long-term financing options of ecosystem service payments for oil palm smallholders in Sumatra, Indonesia (since December 2020)
C10	**Tobias Hellmundt**	DFG	Drivers and consequences of land use change: Evidence from spatial data (since March 2021)

MASTER THESES

Table 28. Master theses at the University of Göttingen – newly started or completed since April 2020.

Completed		
A01	**Svea-Lina Jahnk**	The effect of climate variability on pollen rain-vegetation relationship in different rainforest and transformation system in Sumatra, Indonesia (November 2020)
A01	**Natascha Willkomm**	Late Holocene vegetation and climate dynamics inter-related to human and volcanic impact in the mountainous region in Sumatra, Indonesia (March 2021)
A02	**Tongming Kang**	3D Canopy light transmission and its influence on tree water use in a tropical rainforest (August 2020)
A02	**Tama Ray**	Canopy metrics and transpiration of a tropical secondary forest patch (September 2020)
A02	**Puja Sharma**	Variability of tree transpiration in a tropical rainforest explained by environmental fluctuations, stand structure and site conditions (August 2021)
A02	**Delima Nur Ramadhani**	Drone-based assessment of vegetation indices over an oil palm management experiment in Jambi, Indonesia (November 2021)
A03	**Mahan Subedi**	Investigating the influence of extreme climatic events on net ecosystem carbon-dioxide exchange (NEE) and evapotranspiration (ET) in a commercial oil palm plantation, Indonesia (November 2021)
A07	**Anuj Thapa Magar**	Investigating the litterfall dynamics of semideciduous tropical woody ecosystems: An analysis with space and time December 2021)
A07	**Sunom Shrestha**	Using field measurements and a soil water balance model to investigate changes in soil moisture in oil palm plantations (December 2021)
B06	**Duc Anh Le**	The effects of tropical land-use change on multi-taxon phylogenetic diversity and structure in lowland Sumatra, Indonesia (November 2021)
B11	**Aninha Lassen**	Interdisciplinary consideration of social and ecological benefits of single trees in an oil palm plantation in the province of Jambi Sumatra, Indonesia (May 2020)
B11/ A02	**Laura Donfack Somenguem**	Heterogeneity in microclimate and canopy leaf temperatures in experimental oil palm agroforests in lowland Sumatra, Indonesia (October 2020)
B11/ B06	**Fernanda Cantillo Rodriguez**	Large, diverse and dense tree islands with low vertical structure promotes diversity of tree regeneration in an oil palm agroforestry system in Sumatra, Indonesia (August 2021)
B11/ B06	**Vanessa Montoya-Sanchez**	Beta-diversity patterns and multi-trophic interactions in an enriched oil palm plantation (Sumatra, Indonesia) (November 2020)
B11/ B06	**Denver Cayetano**	Landscape effects on multi-taxa diversity and ecosystem functioning in experimental tree islands: A multi-scale analysis (September 2021)
B11	**Bed Prakash Dhakal**	Drivers of invasion by Clidemia hirta in an oil palm agroforestry in a biodiversity enrichment experiment in Sumatra, Indonesia (December 2021)
B11/ B06	**Marc Aurel Tagne Mambou**	Influence of land-use changes on multi-taxa diversity along spatial scales in Sumatra, Indonesia (March 2022)
C01	**Jakob Vincent Latzko**	Dynamic efficiency and resource productivity of oil palm smallholders in Jambi, Indonesia – a non-parametric analysis (March 2021)
C02	**Aileen Thomas**	Crop diversification of smallholder farmers in Jambi Province, Sumatra, Indonesia: Understanding inhibiting and promoting factors with the help of a causal realist approach (July 2021)
C08	**Aiden John Holley**	Are agricultural advisory services fit to support sustainable land management among oil palm smallholders? A study for Jambi, Indonesia (June 2020)
C08	**Thomas Horn**	Awareness of sustainability standards among independent oil palm smallholders in Jambi Province, Indonesia (December 2021)
C10	**Joshua Jäger**	Palm oil expansion and social conflict in Indonesian villages: An empirical analysis (August 2020)

C10	**Svenja Horn**	Floods and sexual violence against women in Indonesia: A panel data analysis (April 2021)
C10	**Katharina Neumann**	Do earthquakes and tsunamis trigger local conflicts? Empirical evidence from Indonesian village data (August 2021)
C10	**Isabel Eggers del Campo**	The footprint of economic development: Comparing remotely sensed settlement and nightlight data (January 2022)
C10	**Jacqueline Seufert**	Modelling ex ante spatial risks of Covid-19 in Indonesia using network analysis and Bayesian geostatistics (November 2020)
C10	**Dorothee Verena Seybold**	Environmental shocks and land use transformation: The effects of earthquakes on deforestation in Indonesian villages (March 2022)
PR / A03	**Ivo Daumann**	Biodiesel from palm oil – The impact of land use transformation on biogeochemical cycles addressed as socioscientific issue unit for Indonesian teacher education (October 2020)
PR	**Jacqueline Dischereit**	More sustainable oil palm management – A socioscientific issue teaching and learning unit for Indonesian teacher education about the *EFForTS* Oil Palm Management Experiment (OPMX) (February 2021)
PR	**Dominik Finke**	Inquiry-based teaching and learning on the *EFForTS* Biodiversity Enrichment Experiment for ecological restoration of oil palm plantations – An educational unit for social and agroforestry courses in Indonesian higher education (April 2021)
PR	**Mai Pham**	Evaluation of an *EFForTS* self-learning module on sustainable oil palm management for biology teacher students in Indonesia – Results of test-ings at the University of Jambi (Sumatra) and at Ganesha University of Education (Bali) (October 2021)
PR	**Gina Göhmann**	Utility value of a self-learning unit on oil palm management in Indonesian teacher education (March 2022)
Z02	**Camille Revest**	Changes in diversity and community assembly of canopy theridiid spiders (Araneae: Theridiidae) after rainforest conversion to rubber and oil palm plantations (October 2021)
Z02	**Matthieu Bussy**	Changes in diversity and community assembly of canopy rove beetles (Coleoptera: Staphylinidae) after rainforest conversion to rubber and oil palm plantations (October 2021)
Z02	**Tuan Anh Nguyen**	Application of ALS data to assess edge effects on forest structural characteristics in tropics (October 2021)
Sauer – associated	**Karin Bezler**	Impacts of land use transformation from tropical lowland rainforest to oil palm plantations on the silicon release of phytoliths (February 2021)
Sauer – associated	**Felix Schwarz**	Plant silicon status in oil palm crops in Jambi Province, Indonesia (July 2021)
Newly started		
A02	**Katja Weyhermüller**	Surface temperatures and evapotranspiration of a forest patch in an oil palm landscape (December 2021)
A03	**Bayu Budi Hanggara**	Analysis of the dynamics of land-use gradient intensity on the greenhouse gas emissions, surface energy balance, and water efficiency in South-east Asian forest and plantation systems (April 2022)
B09	**Angelina Stockinger**	Predation services by bats, birds and ants in tree-enriched oil palm plantations (January 2022)
B09	**Laura Stoerzer**	Trade-offs and synergies between predator diversity and crop yield in treeenriched oil palm plantations (January 2022)
Z02	**Valentine Lautent**	Shift in diversity and trophic positions of beetle (Coleoptera) families after rainforest conversion to monoculture cash crops in Jambi, Sumatra (April 2022)
Z02	**Radit Sawaskorn**	Changes in diversity and community assembly of canopy leaf beetles (Coleoptera: Chrysomelidae) after rainforest conversion to rubber and oil palm plantations (April 2022)
Z02	**Kristin Cavanaugh**	The effects of tropical rainforest transformation on the trophic structure of canopy Diptera, Formicidae, and parasitoid wasps (April 2022)

Table 29. Master theses at the IPB University – newly started or completed since April 2020.

Completed		
Tania June, Akhmad Faqih, A03	**Ummu Ma'rufah**	Land use change in Jambi: Implication to biogeophysical and biogeochemical processes analyzed using CLM5 (2020)
Taniy June, A03	**Meriana Ina Kii**	Dynamic modelling of CO2 fluxes from oil palm canopy (2020)
Tania June, Suria Tarigan, A03	**Yudha Kristanto**	Water regulating ecosystem services of multifuction landscape dominated by monoculture oil palm (2022)
Anja Meryandini, Yulin Lestari, B02	**Mazidah Noer Inayah**	Community of soil Actinobacteria in PTPN VI oil palm plantation Jambi based on amplicon sequencing of 16S rRNA gene (2020)
Triadiati, B04	**Amanatun Nissa**	Potential conductivity of oil palm root xylem vessel in riparian and well-drained zones at Harapan Jambi forest (2021)
Triadiati, B04	**Jamaluddinsyah**	Linkage between tree height, diameter and hydraulic conductivity of twigs xylem vessels in Jambi forests (2021)
I Nengah Surati Jaya, B05	**Nitya Ade Santi**	Measuring the land cover change in burned area using change vector analysis approach (2020)
Rahayu Widyastutu, B08	**Di Ajeng Prameswari**	Diversity of soil Mesostigmata in different types of land-use on rainy season and dry season in Jambi Province (2021)
Rahayu Widyastutu, B08	**Muhammad Naufal Rizqulloh**	Effects of tropical rainforest transformation into monoculture plantations on ants abundance and diversity in Jambi Province, Sumatra (2021)
Iskandar Z. Siregar, Fitri Yola Amandita, B14	**Ridha Wati**	Utilization of DNA barcode markers for species identification of selected genera in Myrtaceae (2020)
Newly started		
Tania June, A03	**Siti Nadia Nurul Azizah**	Biogeophysical impacts of land use change in Jambi Province on lifting condentation level and rainfall
Triadiati, B04	**Davit Alex Sander**	Xylem hydraulic conductivity of tree banches on riparian and non riparian in Harapan forest, Jambi Province
Triadiati, B04	**Melda Syam Tonra**	Competition and resource sharing on roots in enriched oil palm plantations
Triadiati, B04	**Susi Susilawati**	Effect of land-use change Intensification on root strategy in utilizing resources
Triadiati, B04	**Evan Vria Andesmora**	Physiological tolerance of oil palm trees to waterlogged
Purnama Hidayat, Z02	**Endah Hari Utami**	Diversity of beetles (Coleoptera) at Harapan rainforest, Jambi
Damayanti Buchori, Z02	**Nadila Dwi Lestari**	Diversity of Hymenoptera parasitica on canopy at Bukit Duabelas National Park and Harapan rainforest, Jambi
Damayanti Buchori, Z02	**Rizky Desriana**	Richness and composition of arboreal ants in different landuse type at Harapan rainforest and Bukit Duabelas National Park, Jambi
Damayanti Buchori, Z02	**Ulfa Ulinuha**	Diversity of Diptera canopy across landuse systems in Bukit Duabelas National Park and Harapan rainforest, Jambi

VI. Central Meetings of *EFForTS*: Meetings, Workshops, Retreats, Colloquia, Trainings, Seminar Series and Social Gatherings

Central meetings of the CRC play an essential role to promote scientific exchange between the researchers, to foster the international collaboration and networking with the partners in Indonesia, and to provide a fruitful research environment for our young academics (for example through the organization of doctoral / postdoctoral colloquia). In 2020 & 2021 most meetings could only be held online due to the pandemic.

Table 30. Central / group meetings of *EFForTS* in 2020, 2021 and 2022: Overall Project Team, Research Groups, Boards, Counterparts and Stakeholders

Event / Venue Date	Topic	
Kick-Off Phase 3 Jul 2 & 9, 2020	- The kick-off was conducted as an on-line event. The keynote was given by Prof. Bambang Brodjonegoro, Minister of Research and Technology, Republik of Indonesia. The scientific focus of the retreat was to plan the *Landscape Assessment* and present the status quo of the project groups (Figs. 1 a and b).	
Annual Retreat Oct 7, 2021	- The annual retreat took place online with focus on integrative activities and status-quo of the *Landscape Assessment*.	

Figure 99 a and b. Outline of Kick-Off meeting Phase 3 on July 2 & 9, 2020.

	Integrative activities
Focus 3 Sep 9, 2020	- Identification of synthesis projects (see chapter 2)
EFForTS-BEE & OPMX Dec 7, 2021	- Planning of central sampling campaign of core experiments in 2022
Landscape Assessment Mar 16, 2022	- LA synthesis & publication workshop, data road map, 'elevator talks' about planned publications, publication projects of groups involved
Focus 2 Jan 11, 2022	- Ideas for / Identification of five synthesis papers
Boards Göttingen & Indonesia 17 Jul 2020 5 Oct 2021 28 Oct 2021 12 Mar 2022 30 Mar 2022	- The Joint Management Boards met online on Jul 17, 2020 & Oct 5, 2021. Topics were: Extension of MoA, data management & research infrastructure (storage and handover), counterpart agreements, sample export, ABS funding, office structures, continuation after Phase 3. - The Board in Göttingen held online meetings on Oct 28, 2021 and on Mar 30, 2022: New appointments of board and foci representatives, financial management, data privacy in Datverse, central sampling campaign in 2022, documenta 15 and annual retreat 2022. - Board meeting in Indonesia took place on Mar 12, 2022 in Jambi (Picture 80 a) with focus on: Handover of research data & infrastructure, continuation after Phase 3, ABS funding and sample export.

Picture 80 a. Board meeting of the Indonesian University Consortium on March 12, 2022 in Jambi. Back, from left to right: Bambang Irawan, Zulkifli Alamsyah, Damayanti Buchori, Aiyen Tjoa, Zulkarnain, Marsetyo, Iskandar Z. Siregar. Front, from left to right: Rayandra Asyhar, Lukman Nadjamuddin, Sutrisno, Dodik R Nurrochmat, Amar Akhbar Ali

Boards Göttingen & Indonesia	Subsequently, the board visited the SEMAH BUMI festival, the Nature-Science and Art Festival, a collaboration between Sikukeluang (Riau) and *EFForTS* within the frame of *documenta 15* on March 13, 2022 in Pematang Kabau (see chapter 7). The program was attended by Pak Dodik, Pak Rayandra, Pak Amar, Pak Lukman, Ibu Damayanti, Pak Iskandar, Pak Zulkarnain, and Ibu Aiyen. The board and the guests of *EFForTS* were welcomed with the Sekapur Sirih Dance, a tradition in Jambi province – one of the dancers is offering bitter nut (pinang) and betel nut (sirih) to the guests (Pictures 80 b and c). Further impressions of the visit are shown in pictures 80 d to f.
May 25, 2021	- Stefan Scheu met with Mr. Ardian Wicaksono (new Consul General in Hamburg) and Mr. Acep Soemantri (Consul General in Frankfurt) in Göttingen: Introduction of project activities of *EFForTS* in Jambi.

Picture 80 b and c. Welcoming the guests of *EFForTS* with the Sekapur Sirih Dance (2b); Amar (Vice rector from UNTAD) is taking the offer (2c).

Picture 80 d. The JMB Aiyen, Rayandra and Zulkarnain socializing with villagers.

Picture 80 e. Pak Dodik, Pak Amar, Pak Marsetyo, Pak Iskandar, Bu Aiyen and Bu Damayanti enjoying the Semah Bumi festival.

Picture 80 f. Exchanging with Tumenggu Maladang, a respected figure of the Suku Anak Dalam (from left to right: Marsetyo, Lukman, Dodik, Tumenggu & son, Iskandar, Amar, Ummi and Immanuel).

Table 31. Workshops and trainings of *EFForTS* in 2020 and 2021.

Venue / Date	Event
Universitas Lampung Oct 2020 **B14** – Carina Moura **IPB University** Nov 2020 **B14** – Carina Moura	- Phylogeography and DNA barcoding: Molecular methods for tropical biodiversity. - DNA barcoding and metabarcoding. Summer school: "The role of youth in the forest and environmental management to achieve sustainable development goals" was held by the Faculty of Forestry and Environment of IPB University in October 2020 and November 2020 (Fig. 100).  **Figure 100.** Outline of summer course at IPB University.
UGoe Oct & Nov 2020 **Z01** (- Thomas Fester -)	- A two-day online training workshop – Science Graphics – was conducted on 13 & 20 Oct 2020 and on 26 Oct & 2 Nov 2020 for 11 doctoral and post-doctoral researchers: Conception of scientific graphics, creating vector graphics and handling bitmaps, …  **Figure 101.** Outline science graphics – *Scivit.de*.

UGoe INF Nov 2020 – Apr 2022	Statistical Courses (Miryam Sarah Merk) & Introduction to Dataverse (Faraz Fatemi Moghaddam, Aytaj Badirova) Introduction to Spatial Data and Applications in R - Import and Visualization(30 Nov 2020) - Spatial Autocorrelation (3 Dec 2020) - Spatial Regression Models (3 Dec 2020) - Geostatistical Methods (4 Dec 2020) Introducing Dataverse - Introducing Dataverse (15 Sep 2021) - Introducing Dataverse 2 (22 Sep 2021) Data Visualization with ggplot2 in R - Getting started with ggplot2 (1 Apr 2022) - Extensions of ggplot2 (1 Apr 2022)
IPB University 17-19 May 2022	- Three-day training of Facilitator (TOF) Participatory Rural Appraisal for field assistants and local junior researchers will be held from May 17–19, 2022 in Bogor/IPB University. The course is conducted by PT Adil Organik Indonesia. - Course content: Learning and practicing methods of participatory qualitative data collection and practice methods of participatory qualitative data collection – important for conducting workshops, as well as focus group interviews.

Table 32. Scientific and social networking of doctoral and postdoctoral researchers at UGoe

15 June 2020	- Online meeting: Welcoming new and old team members to *EFForTS* – Phase 3; presentations of new/planned research activities and continuation of ongoing work.
9 June 2021	- A virtual social meeting of junior researchers of *EFForTS* took place on June 9, 2021 to get to know each other better, to small-talk and exchange and connect without reference to scientific project work. (Picture 81) - Finn Matthiesen (PR) set up a wonder.me room where we chit-chatted. The group also met via Zoom for an "*EFForTS* Get-to-know-you-BINGO" (thanks to Finn, Fig. 102). The winners of the Bingo – Martyna (B04), Johannes (former B07) and Tobias (C10) – got an *EFForTS* T-Shirt. Finally, a real meeting could take place in August 2021 in the Old Botanical Garden of UGoe.  **Picture 81.** Participants of virtual social meeting on June 9, 2022.

EFForTS Get-to-know-you-BINGO

Mingle with each other in the wonder room. During this time, introduce yourselves to one ANOTHER and find people who match the traits on the bingo card.

Once you have found the person with the correct trait, you must put the person's name in the corresponding box. When you have filled in five boxes horizontally or vertically (or diagonally) yell "Bingo" (well, write it alternatively in the chat). You might be the winner, if everything is correct.

Wants to become a new member of the Social Media Team: ________	*Follows the EFForTS account on Instagram:* ________	*Has won trophy or medal in a sport competition:* ______	*Is taller than You:* ________	*Has no TV:* ________
Owns more than 20 pairs of shoes: ________	*Knows the lyrics to a Justin Bieber song:* ________	*Belongs already to the Social Media Team:* ________	*Can't whistle:* ________	*Drinks coffee every morning:* ________
Was born in the same year as you: ________	*Hates chocolate:* ________	*Is currently in Göttingen:* ________	*Is younger than 30 years old:* ________	*Knows how to rap:* ________
Has a pet: ________	*Has consumed something with palm oil today* ________	*Is from or has already been to Jambi:* ________	*Has never played BINGO before:* ______	*Has the same eye color as you:* ________
Speaks more than 3 languages fluently: ________	*Was "onboard" during all three phases of EFForTS:* ________	*plays a music instrument:* ________	*Always wanted to become a scientist:* ________	*Knows the EFForTS SharePoint:* ________

Figure 102. Bingo outline of virtual social meeting on June 9, 2022.

Table 33. Joint colloquium of Göttingen and Indonesian researchers

Z02 & IPB University 10 Nov 2020	- Jochen Drescher / Z02: *Canopy Ecology in EFForTS Z02 – past and current projects* - Rawati Panjaitan / IPB University: Diversity of butterflies in Jambi
1 Dec 2020 C01, B08	- Karina Brenneis / C08: *How to promote an agricultural technology that generates positive environmental effects? Evidence from Jambi, Indonesia* - Clara Zemp / B11: *Biodiversity Enrichment Experiment BEE*
12 Jan 2021 C07, B04, B10, C08	- Nadjia Mehraban / C07: *What about her? Oil palm cultivation and intra-household gender roles* - Sasya Samhita / B04: *Presentation of ongoing research activities* - Julia Henzler / B10: *Modelling terrestrial biodiversity* - Dienda Hendrawan & Charlotte Reich / C06: *Presentation of project work*
2 Feb 2021 A05, C12, C07	- Najeeb Iddris / A05: *Upscaling greenhouse gas fluxes from plot to a rainforest-transformation landscape* - Volker von Groß / C12: *Collaborative farm-modelling for reconciling socio-economic and ecological functions* - Kibrom Sibhatu / C07: *The geography of oil palm cultivation in independent smallholder farm households: A systematic approach to spatial heterogeneity*
13 Apr 2021 A05, C02, C11	- Britta Greenshields/ A-group: Impact of rainforest transformation into oil-palm plantations on silicon pools in soils - Heinrich Petri/ C02: *Replanting processes and their effects on smallholder livelihoods* - Anette Ruml / C11: *Smallholders in agro-industrial production: Lessons for rural development at new frontiers from a comparative analysis of Ghana's and Indonesia's oil palm sectors*
4 May 2021 UNJA, A02, Z02	- Bambang Irawan / UNJA: *Responses of a light-demanding and shade-tolerant species to the humidity and light intensity* - Medha Bulusu / A02: *Thermography-based evapotranspiration mapping of rainforest canopies in Jambi* - Nicolo Camarretta / Z02: *Using Airborne Laser Scanning to characterize different land uses in a tropical landscape based on their structural complexity*
8 Jun 2021 IPB University, B14, B08	- Rika Raffiudin / IPB University: *How the forest honey bee Apis dorsata is adapting to the land use changes in Sumatra* - Carina Carneiro de Melo Moura / B14: *Dual-loci DNA metabarcoding of mixed pollen to investigate forest heterogeneity* - Simin Wang / B08: *Determining the optimal steps for analyzing HTS data, from gene database selection to compositional data analysis: A case study of tropical soil nematodes*
6 Jul 2021 Universitas Brawijaya, A01, B11	- Syahrul Kurniawan/ Universitas Brawijaya: *Soil physical pattern and nutrient leaching losses from forest conversion to rubber and oil palm* - Svea Jahnk / A01: *The effect of climate variability on modern pollen and spore rain in different rainforest and transformation systems in Sumatra* - Gustavo Paterno / B11: *Phylogenetic structure of tree natural regeneration in an oil-palm agroforest*
7 Dec 2021 A05, A03	- Guantao Chen / A05: *Soil GHG fluxes in conventional and reduced management system of a large-scale oil palm plantation in Jambi, Indonesia* - Christian Stiegler / A03: *The CRC 990 Rapid Assessment Field Campaign: Results of microclimatic measurements within the most common land-use types in Jambi Province, Sumatra, Indonesia*

11 Jan 2022 IPB University, C10, B09	- Ummu Ma'rufah / IPB University: *Land Use Change Modelling* - Tobias Hellmundt / C10: *Land use change and local violence: The effects of oil palm expansion in Indonesia* - Arne Wenzel / B09: *Updates on B09 research activities*
8 Feb 2022 IPB University, A07, PR	- Tania June / IPB University: Evaluating the impact of deforestation to atmosphere condition and rainfall in Jambi Province: The coupling strength between surface biophysical characteristics with atmospheric processes - Ashehad Ali / A07: Land surface modelling - Finn Matthiesen / PR Project: *EFForTS* education: Conceptual approach, instructional design and first evaluations results of testings in Indonesian teacher and higher education

Table 34. *EFForTS* Professional Learning Community talk and conferences – Project Ö / PR

29 Mar 2021	- Finn Matthiesen: *Teaching and Learning Biology during the COVID-19 Pandemic – Current State of Digital (Teacher and School) Biology Education in Germany. Keynote BioExpo from 27-28 March 2021, University of Jambi, Jambi.*  **Picture 82.** Keynote Finn Matthiesen at BioExpo, UNJA
19 Apr 2021	- Safwatun Nida: *Challenges and Potentials of SSI-based Instructions – Lessons learnt from an Empirical Study on Indonesian Teacher Views. EFForTS* Professional Learning Community Talk, University of Göttingen, Göttingen. Safwatun Nida is an expert in SSI education and has just completed her doctorate at the Department of Chemistry Education at the University of Bremen. She is also a lecturer and researcher at the Universitas Negeri Malang.
2 Nov 2021	- Finn Matthiesen: *Land-Use Change in Indonesia as Socio-Scientific Issue for Higher Education – Conceptual Approach and Preliminary Evaluation Results of the EFForTS Public Relation (PR) Project.* Keynote UNJA Workshop and Webinar for Lecturers, Nov 2 – 5, 2021, University of Jambi, Jambi – about 160 participants.  **Picture 83.** Keynote Finn Matthiesen at Webinar for Lecturers, UNJA

Summer semester 2021	- Sabina Eggert (Central Institute for Teacher Education and Research, ZEWI), associated scientist of Project Ö / PR: Two semesters with joint virtual classroom courses on Education for Sustainable Development with students from UGoe and students from Undiksha: *http://schloezerlb.newsletter.uni-goettingen.de/2021/08/04/eggert/*

Joint Virtual Classroom on Education for Sustainable Development

UNIVERSITAS PENDIDIKAN GANESHA

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

This summer term, students from Ganesha University of Education in Singaraja, Indonesia, met with teacher education students from the University of Göttingen, Germany, for a joint virtual classroom on Education for Sustainable Development (ESD). The seminar was integrated into the "Education for Sustainable Development Strand" of the certificate programme "Interdisciplinary Teaching" at the University of Göttingen (**Lehramt PluS** in cooperation with the **Schlözer Programm Lehrerbildung**).

Students from both universities met via ZOOM each day for 2.5 weeks to work together on pressing global as well as local issues of (non-)sustainable courses of action such as climate change, loss of biodiversity, water pollution, problems of mobility and the impact of the COVID-pandemic on these issues. Students engaged in fruitful discussions about local problems in Indonesia and in Germany, about global interrelations and were subsequently able to better understand these issues from different perspectives.

SUSTAINABLE DEVELOPMENT GOALS

Sustainable Developmental Goals (c) UN

Finally, students exchanged ideas on how to implement these issues of sustainable development in their own future classrooms, integrating central ideas of the sustainable development goals as well as the key competencies and pedagogical principles for ESD as described in UNESCO's Agenda 2030. The seminar finished with group presentations in the third week that had been prepared in interdisciplinary, transnational teams.

Participants during a meeting (c) Sabina Eggert

Picture 84. Sabina Eggert: Joint Virtual Classroom on Education for Sustainable Development

VII. Public Relation and Knowledge Transfer

1. **Research and Art Connect for Sustainability: A collaboration with *documenta fifteen***
   - **Panel discussion urun rembuk in Kassel**
   - **Semah Bumi festival in Pematang Kabau**
   - **Sustainable village project in Pematang Kabau**
   - ***EFForTS – documenta fifteen* exhibition in the new Forum Wissen**
   - **Project works and social learning at school in Göttingen**
   - **Communicating Science to Society at AsiaFlux conference in Malaysia**
2. **Summer camp at UNJA**
3. ***EFForTS* – Social Media Group**
4. **5th Night of Science in Göttingen**

1. RESEARCH AND ART CONNECT FOR SUSTAINABILITY: A COLLABORATION WITH *DOCUMENTA FIFTEEN*

EFForTS and the *Forum Wissen*, Göttingen's academic museum have launched a joint cooperation with *documenta fifteen* in Kassel (Germany), the most recognized exhibition of contemporary art worldwide, and *Rumah Budaya Sikukeluang*, a collective of artists from Riau province on Sumatra Island, Indonesia.

The documenta, which will be held this year for the fifteenth time, will take place from June 18 to September 25, 2022 in Kassel. It pays particular attention to sustainability. The objective arises not least from the practice of *lumbung* ('barn'), which *ruangrupa*, an artist collective from Jakarta and this year's curator, has based the upcoming edition of *documenta 15* on. Based on a holistic understanding of sustainability, social and ecological dimensions are brought together in the concept of the communal rice barn and understood as the basis for the entire organizational and artistic activities.

PANEL DISCUSSION URUN REMBUK IN KASSEL

The collaboration of *documenta fifteen* and *EFForTS* started on November 5, 2021 with the panel discussion "*urun rembuk* (YouTube playlist) – thinking and acting on sustainability" in the ruruHaus, Kassel – where "urun rembuk" can be translated as "achieving something together".

In this kick-starter event, the international and local partners and projects involved were introduced as part of urun rembuk. Also, the so called "sustainability euro", which is included in the admission ticket to documenta fifteen was presented. The euro will benefit three projects, one of which is the Sustainable Village project (see below).

Alexander & Christian (A03), Martyna (B04), Fabian & Holger (B06), Dienda (C06) and Meike (C08) presented our *EFForTS* research and together with artists and the general audience they discussed the topics of sustainability and human-environmental relationships through a multifaceted spectrum of research presentations, artistic installations and panel and open discussions (Picture 85).

Heri Budiman and Adhari Donora from the artists' collective Rumah Budaya Sikukeluang, in conversation with Fabian Brambach, introduced the "Semah Bumi Festival of Science, Nature, Society and the Arts" in the province of Riau in Sumatra. *Link to video*

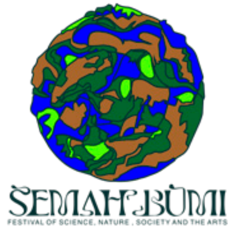
Picture 85. *EFForTS* presentation during the "urun rembuk – Thinking and acting on sustainability" event, Nov 5, 2021 in ruruHaus, Kassel. From left to right: Holger Kreft, Meike Wollni and Alexander Knohl (@ Christian Stiegler)

SEMAH BUMI FESTIVAL IN PEMATANG KABAU

One highlight of this joint collaboration was the *Semah Bumi* (balancing-serving-seeding) festival, which took place from March 11 to 13, 2022 in Pematang Kabau, one of our core site. The area is dominated by rapid and substantial land transformation from tropical forests to agricultural landscapes, such as oil palm and rubber plantations.

This festival featured concerts, art exhibitions and theatre performances. It was organized jointly by the artist collective *Rumah Budaya Sikukeluang* from Riau and *EFForTS*. Rani Jambak, an artist/musician from Medan, Helmi Hardian and Uncle Twist from WAFT-LAB, an interdisciplinary collective based in Surabaya, Ismet Raja Tengah Malam, an artist & musician from Jambi, as well as the Sikukeluang artists collective from Pekanbaru stayed in residence in Pematang Kabau a month before the start of the festival (Picture 87).

During this time, they worked collectively to observe, recognize, and experience the local environment and its community while having access to the research of the Sustainable Village Project (see below). The artworks they produced based on their explorations and collaborations with the local participants was presented during the festival.



Picture 86

Picture 87. Artists' collective Rumah Budaya Sikukeluang and artists in residence in their Backyard Studio

Workshop Teater Boneka

Boneka ini adalah hasil dari workshop teater boneka, bagian dari kegiatan Semah Bumi Festival 2022. Workshop ini diberikan oleh Waftlab dan Sikukeluang yang diikuti oleh guru PAUD Desa Pematang Kabau. Workshop ini, berangkat dari naskah cerita anak yang bertemakan "Menjaga lingkungan dan alam". Naskah cerita kemudian dianalisis dari segi penokohan, latar tempat, peristiwa dan waktu.
Boneka ini dibuat menggunakan bahan-bahan yang sederahana, dan bahan daur ulang.
Workshop ini dimaksudkan untuk mengembangkan keterampilan guru dalam melaksanakan proses pembelajaran yang lebih terampil dan kreatif.

Sikukeluang

Pupet Theater Workshop

This puppet is the result of a puppet theater workshop, part of the Semah Bumi Festival 2022 activity. This workshop was provided by Waftlab and Sikukeluang, which was attended by PAUD teachers in Pematang Kabau Village.
This workshop, departed from a children's story script with the theme "Protecting the environment and nature". The story script is then analyzed in terms of characterizations, setting of place, events and time.
This doll is made using simple materials, and recycled materials.
This workshop is intended to develop the skills of teachers in carrying out a more skilled and creative learning process.

Sikukeluang

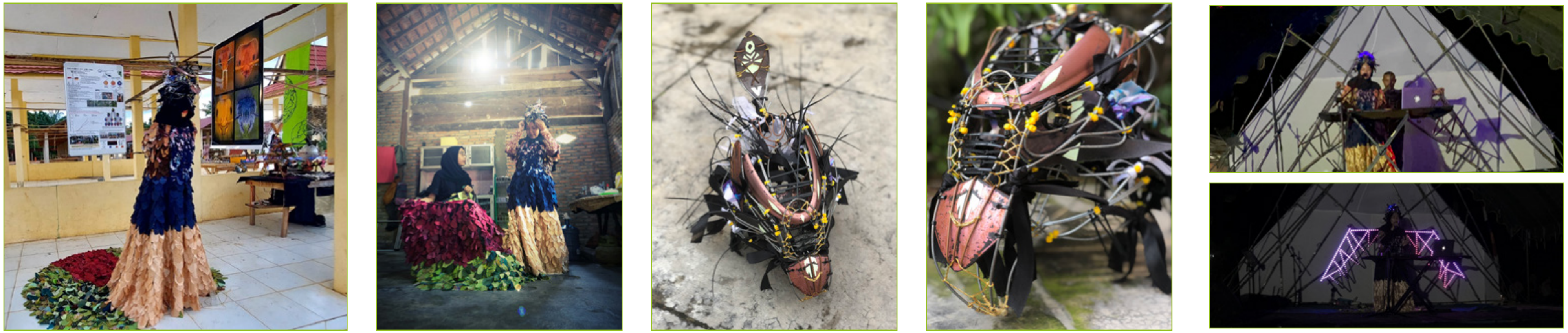

Pictures 88 a to c. Presentation of puppet art work by Waftlab and Sikukeluang at Semah Bumi Festival

Eagle Reflection -Rani Jambak-

Terinspirasi dari tari elang, Bededikiron (ratapan) khas dari Suku Anak Dalam, dan situasi hutan saat ini, Rani berupaya menggabungkan semua unsur tersebut dalam satu pertunjukan. Rani mencoba mengadaptasi melodi yang ada di Bededikiron menjadi sebuah lagu baru yang diiringi oleh musik elektronik. Dalam riset lapangan yang dilakukan selama residensi, saat ini tidak hanya Suku Anak Dalam yang merasakan dampak dari berkurangnya lahan hutan tempat mereka tinggal dan bertahan hidup, namun juga hewan-hewan yang sudah kehilangan beberapa sumber makanan. Ini adalah akibat dari menyempitnya lahan hutan yang kemudian mempengaruhi situasi keanekaragaman yang ada secara alami.
Bekerjasama dengan Indri dan Waftlab, Rani akan merepresentasikan ratapan elang yang berupaya bertahan hidup dalam keadaan hutan saat ini. Lebih jauh, pemaknaan eagle reflection juga sebagai simbol bahwa tidak hanya elang yang semakin sulit bertahan hidup, tetapi juga manusia.

Eagle Reflection -Rani Jambak-

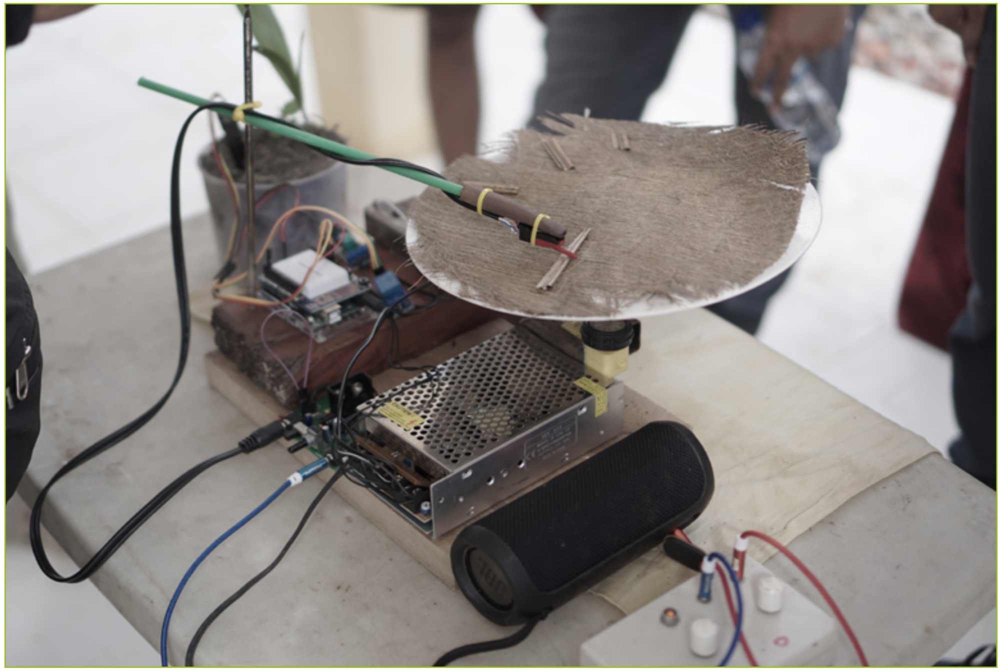
Inspired by the eagle dance, Bededikiron (wailing) typical of the Anak Dalam Tribe, and the current forest situation, Rani tries to combine all of these elements in one performance. Rani tried to adapt the melody in Bededikiron into a new song accompanied by electronic music. In field research carried out during the residency, currently not only the Anak Dalam Tribe are feeling the impact of the reduced forest land where they live and survive, but also the animals that have lost several sources of food. This is the result of the narrowing of forest land which then affects the situation of natural diversity.
In collaboration with Indri and Waftlab, Rani will represent the wailing eagle trying to survive in the current state of the forest. Furthermore, the meaning of eagle reflection is also a symbol that not only eagles are increasingly difficult to survive, but also humans.



Pictures 89 a to f show collaboration and art performance "Eagle reflection". Dress: Rani Jambak, Indri (neighbor of *EFForTS* guest house in Pematang Kabau), Waftlab, Sikukeluang. New song 'Eagle reflection': Rani Jambak. Lightening: Waftlab, Sikukeluang.

Sikukeluang artwork: The Unseen.

Pictures 90a to d. Material used, among other things, fogging traps used in Z02 field work.



EFForTS staff in Jambi organized two workshops for kids

Picture 91 a and b. *EFForTS* staff and Rumah Budaya Sikukeluang.
a: from left to right: Wildan (C08), Febrina (Z02), Shara (Z01), Rizky (Z02), Fitryah (C06), Chatarina (C08), Dila (C11), Ida (Z01), Ardian (Z01)

b: Back row from left to right: Rizky (Z02), Shara (Z01), Ida (Z01), Fitryah (C06), Chatarina (C08), Dila (C11), Uncle Twis (Waft Lab). Front row from left to right: Raditya (Sikukeluang), Wildan (C08), Helmi (Waft Lab), Hamdyllatul (Z01), Ade (Sikukeluang), Acong a.k.a Ryan (Sikukeluang), Erwin (Z01), Husein (Sikukeluang), Ardian (Z01).

A. Learning English through play and drawing favorite animals & fruits

On Saturday (March 12, 2022) Kindergarten and school kids learned English names of fruits and animals using flash cards. The children picked one card of their favorite fruits/animals and painted them. The B09 team hosted the painting workshop in which children also learnt about local biodiversity.

Picture 92 a and b. Kindergarten kids paint favorite animals and fruits.

Picture 93 a to d. School kids watching animals under the stereomicroscope and putting puzzles together.

Picture 94. Donation of painting material to the school. Left: Shara (Z01 *EFForTS*), right: Bapak Suwahna (Vice principle of school SD Negeri 177 Desa Pematang Kabau)

B. Animals under the stereomicroscope and puzzling

On Sunday (March 13, 2022) the team of Z02 showed animal life under the stereomicroscope. Kids learned names of animals and watched them under enlargement. Thereafter, teams of children put animal puzzles together.

The Painting materials were donated to the school (SD Negeri 177 Desa Pematang Kabau, Picture 94)

Souvenirs were given to the children who participate in 'fun English' and drawing.

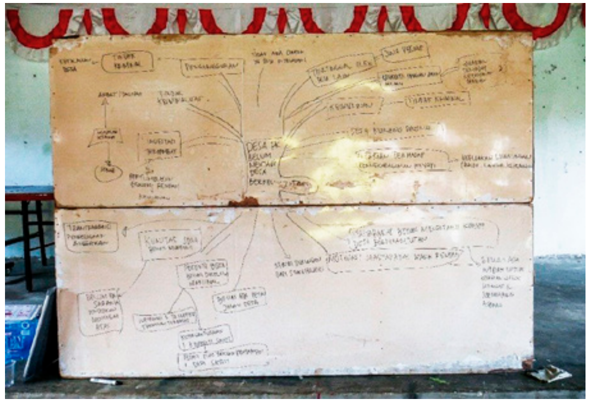
Picture 95 a to d. Handover of souvenirs to children.

Sustainable village project in Pematang Kabau – Desa Berkelanjutan

The Semah Bumi festival also served as a kick-off event to initiate the long-term Sustainable Village project, which explores and implements locally adjusted transformation pathways towards more sustainable land-use and value chain management using a Participatory Action Research approach. The project is led by C08 (Meike Wollni & Jana Juhrbandt) with collaboration from Immanuel Alfonsus and Chatarina Novianti. Together with local smallholder farmers in Pematang Kabau, the Sustainable Village Project aims to identify options to enhance local biodiversity and ecosystem functions, e. g. via planting trees while at the same time creating and safeguarding economically interesting and socially acceptable livelihood options.

Documenta fifteen is supporting this project as one of the three sustainability projects supported by the Sustainability Euro from every documenta fifteen ticket sold.

During the Semah Bumi festival a workshop was conducted by Immanuel and Chatarina – starting with the question "What do we want our village to look like in twenty years?", the participants formulated their wishes for the future and developed common goals from the perspective of sustainability in the region (Pictures 96 a and b) . The villagers also created a problem tree (Picture 97) and identified as main problem that Pematang Kabau Village has not become a sustainable village. Causes are: a) farmers satisfy with oil palm monoculture since this crop generate more profit than other commodities (rubber, paddy rice), b) the absence of a High school institution has delayed the development of human capital resources inside the village, and c) there is no social community that can host a knowledge sharing session especially for receiving villager's aspirations and exchanging information such as sustainability.



Picture 97. Villagers of Pematang Kabau created a 'problem tree' (@ Immanuel Alfonsus).

Pictures 96 a and b. Participatory mapping to visualize / identify vision for a sustainable village. Economics is the most important aspect for the villagers in order to create a sustainable village (@ Immanuel Alfonsus).

EFForTS – documenta fifteen exhibition "Saujana Membumi – Exploring sustainability" at the new Forum Wissen

First results of this joint collaboration and projects will be on display in a special exhibition about *EFForTS* in the *Forum Wissen* Göttingen from June 18 to September 25, 2022. The Forum Wissen is a new interface of science, public and culture at the University of Göttingen. The core idea of Forum Wissen is to enable people to understand, how scientists work and how knowledge is being created.

In parallel to *documenta fifteen*, visitors will be able to experience the social and ecological dimensions of research in Indonesia from different perspectives. Members of the artist collective *Rumah Budaya Sikukeluang* will be on site to show parts of the artistic process during the festival in Jambi. Complementing the artistic contribution, the exhibition will also give voice to the various actors – humans as well as animals and plants – and provide insights into the numerous specialized, interdisciplinary research practices used to collect and analyze data on site. The focus is on palm oil, a raw material used in numerous foods and cosmetics and an important source of income for local smallholder farmers.

From *EFForTS*, for example, Fabian (B06) will contribute a large number of physical and digital plant and will lead focused guided tours and participate in other public events during the exhibition. Jochen (Z02) prepared an exhibit showing various insects and other arthropods occurring in Sumatra, to represent animals that can be collected in the field, as well as a soil core and a small soil auger. Displayed arthropods include samples collected within the *EFForTS* framework (ants, Lepidoptera larvae), but also reared stick insects, centipedes and a scorpion by M. Niehkampf (Dept. Animal Evolution and Biodiversity, UGoe).

Project works and social learning at school in Göttingen

In collaboration with Forum Wissen and Theodor-Heuss-Gymnasium Göttingen, Christian & Alexander (A03) and Fabian & Holger (B06) developed joint project works and social learning activities to disseminate our *EFForTS* research and discuss sustainability, human-environmental interactions and arts with thirteen- to fourteen-year old students (Pictures 98 a and b). Based on presentations, discussions and learning activities, the students will develop their own artistic contributions and collections that later will be on display at an exhibition at the Forum Wissen from June 2022.

Communicating Science to Society at AsiaFlux in Malaysia

This year's AsiaFlux conference (*https://www.asiaflux2022.com/*) – September 20 to 22, 2022 in Malaysia – for the first time has a session on "Communicating Science to Society". Christian and Alexander (A03) will present, in collaboration with Fabian (B06), Jana & Immanuel (C08), Aiyen (UNTAD), Nina Knohl & Marie Luisa Allemeyer (UGoe), Ajeng (ruangrupa, Jakarta) and Ade (Rumah Budaya Sikukeluang, Riau) project works of the Sustainable Village project, the Semah Bumi festival and the exhibition at Forum Wissen.

Pictures 98 a and b. Project works and social learning activities at Theodor-Heuss-Gymnasium Göttingen – A: Fabian Brambach (B06; workshop on the role of research and art in the context of palm oil and sustainability), B: Christian Stiegler (A03). (@ Nina Knohl)

2. SUMMER CAMP AT UNJA

In 2020, Jambi University has implemented Merdeka Belajar dan Kampus Merdeka which can be translated as "Freedom to Learn and Independent Campus" with the aim of conducting lectures in the form of summer camps in the field. The Center of Excellence of Biodiversity and Landuse Transformation Systems (CoE BLasTS, headed by Bambang Irawan) at UNJA held a summer camp in 2021 on the topic "Biodiversity and Land Use Change". The students should increase the understanding and knowledge on how to protect and enhance the ecological functions of land-use systems while improving economic and social welfare. At the same time they should increase empathy and social sensitivity by interacting among fellow participants and with the community (learning the social structures and economic activities of the community).

Fourteen students from seven study programs worked together from November 14 to December 4, 2021. The camp sites included two *EFForTS* core sites, *EFForTS*-OPMX at PTPN 6 (oil palm plantation managed by state owned company, see chapter II)) and *EFForTS-BEE* at PT Humusindo (oil palm plantation managed by a private company, see chapter II)) as well as Sultan Thaha Grand Forest Park (forest) and Ladang Peris village, Batanghari District (rubber and oil palm plantations managed by the community; Pictures 99 a to f).

Pictures 99 a and b. Summer camp activities at the climate tower of *EFForTS* at PTPN 6 (top) and in an OPMX site (bottom).

Pictures 99 c and d. UNJA Summer camp at *EFForTS-BEE* Plots, PT. Humusindo Makmur

Pictures 99 e and f. Activities with the community (in the field) at Ladang Peris Village

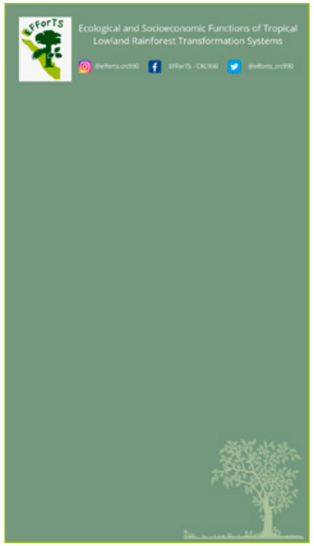
3. EFFORTS – SOCIAL MEDIA GROUP

The Social Media project group of *EFForTS* – Shara, Rizky, Mega, Yuking, Randi, Indri, Jion, Aiyen, Garvin, Christian, Fabian, Finn, Jörg, Barbara – have been meeting regularly online in 2021 to advance the social media activities of *EFForTS* and to increase the visibility of the project:

- Exchange, networking, knowledge transfer by using existing social media channels of *EFForTS*,
- Support early career researcher in Göttingen and Indonesia,
- Disseminate activities of members, announcement of awards, office activities, ABS measures …

Improvements made, for example, were:

- Announcement of new publications via twitter – inclusion in Publication Policy and Publication Logbook
- Development of standardized template for Instagram pictures



Picture 100. *EFForTS* template for Instagram pictures, developed by Shara.

4. 5TH NIGHT OF SCIENCE IN GÖTTINGEN

EFForTS participates in the forthcoming 5th Night of Science at the University of Göttingen on July 9, 2022. The exhibition will take place in the Forum Wissen.

Ideas and people:

- A01 – Svea & Jörg: Microscope and pollen slides from honey samples
- B04 – Sasya & Martyna: Demonstration of equipment used in field work (e. g. dendriometer) + "root game" (which root system belongs to which landuse)
- B08 – Doro: Stereomicroscope with living animals and pictures
- B09 – Arne: Soundscapes from oil palm and rubber plantations + "dummy caterpillar game" (caterpillars with bite marks – find out who caused them)
- B10 – Sebastian: *EFForTS*-ABM model
- B14 – Carina: Tree visualizing *EFForTS* + memory game "Trees & Flowers"
- C07 - Jakob: Interactive PC Game (Quiz) - General multiple choice questions
- Z02 – Jochen: Super market (products containing palm oil) + ant puzzles
- Z01 + Z02 + PR – Jochen, Finn, Barbara, Garvin: Efforts movie + infographics + video "Introduction to Jambi".

IMPRINT

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1. Pollen trap installed by Reza Mardhony in an oil palm plantation.
2. Water infiltration measurement in soil.
3. Vais measuring temperature differences across multiple locations with a thermal imaging system.
4. Dummy caterpillar used to determine predator diversity via identification of unique bite-marks left in the plasticine caterpillar after a predation event.
5. Collection of understory biomass in a rubber plot.
6. Separation of fine and big roots from soil.
7. Faunal extraction from soil samples.