RUBIS INTERNATIONAL WORKSHOP ON THE RESILIENCE OF RUBBER-BASED AGROFORESTRY SYSTEMS IN THE CONTEXT OF GLOBAL CHANGE

PROGRAM BOOK

BRIEF CONTENTS

PROGRAM AGENDA

Virtual RUBIS International Workshop

“The Resilience of Rubber-based Agroforestry Systems in the Context of Global Change”
Universitas Gadjah Mada (virtual host), April 5th - 9th, 2021

Program time is in Jakarta Time (GMT+7)

Day 1: Monday, April 5th, 2021

13:30 – 14:00	Invited speakers and participants enter Zoom meeting	Live in Zoom: ugm.id/Rubisworkshop
14:00 – 14:20	Opening:	
	1. Welcome remarks	
	2. Indonesia national anthem	
	3. Hymn Gadjah Mada	
	4. Remarks from UGM by Rector of UGM – Prof. Panut Mulyono	
	5. Remarks from RUBIS by RUBIS Coordinator – Dr. Pascal Montoro	
	6. Group photo	
14:20 – 14:50	Introductory Speech: Dr. Gede Wibawa (IRRI) - Historical Review of Rubber-based Agroforestry Systems in Indonesia	
14:50 – 15.00	Closing day 1	

Day 2: Tuesday, April 6th, 2021

14:00 – 14:10	Opening	Live in Zoom: ugm.id/Rubisworkshop
14:10 – 14.40	Plenary keynote speeches: Dr. Suyanto (ICRAF) - Socio-Economic of Rubber Plantation	
14:40 – 15:00	Plenary session by invited speaker: Dr. Miles Kenney-Lazar - Variegated Transitions of Agrarian Capitalism: The Rubber Boom and Bust in Northern Laos	
15:00 – 15:15	Q & A plenary session	
15:15 – 17:45	Presentation by participants of Sub-theme 1. Socio-economy of rubber-based agroforestry systems	
17:45 – 17:55	Closing for day 2	

Day 3: Wednesday, April 7th, 2021

14:00 – 14:10	Opening	Live in Zoom: ugm.id/Rubisworkshop
14:10 – 14.40	Plenary keynote speeches: Prof. Meine Van Nordwijk (ICRAF) - Tree-Soil-Crop Interactions in Rubber Agroforestry	
14:40 – 15:00	Plenary session by invited speaker: Dr. Aris Hairmansis - Development of Shading Tolerant Rice Varieties Suitable for Intercropping Cultivation in Agroforestry Systems	
15:00 – 15:15	Q & A plenary session	
15:15 – 17:45	Presentation by participants of Sub-theme 2. Agronomy of rubber-based agroforestry systems	
17:45 – 17:55	Closing for day 3	

Day 4: Thursday, April 8th, 2021

14:00 – 14:10	Opening	Live in Zoom: ugm.id/Rubisworkshop
14:10 – 14:40	Plenary keynote speeches: Dr. Vincent Gitz (CIFOR) - Forests, Trees and Agroforestry Programme	
14:40 – 15:00	Plenary session by invited speaker: Dr. Budiadi - An Overview and Future Outlook of Indonesian Agroforestry	
15:00 – 15:20	Plenary session by invited speaker: Dr. Raphael Perez - Evaluating Rice Tolerance to Light Conditions under Agroforestry Systems: An Experimental Approach	
15:20 – 15:35	Q & A plenary session	
15:35 – 16:40	Presentation by participants of Sub-theme 3. Agroforestry, Food Crops, and Food Security	
16:40 – 16:50	Closing for day 4	

Day 5: Friday, April 9th, 2021

14:00 – 14:10	Opening	Live in Zoom: ugm.id/Rubisworkshop
14:10 – 14.40	Plenary keynote speeches: Dr. Eric Justes (CIRAD) - Is agroforestry-based rubber systems a relevant solution for contributing to mitigation and adaptation to Climate Change?	
14:40 – 15:00	Plenary session by invited speaker: Dr. Eleanor Warren-Thomas - Biodiversity in Rubber Plantations and Agroforestry Systems	
15:00 – 15:15	Q & A plenary session	
15:15 – 16:30	Presentation by participants of Sub-theme 4. Ecosystem Services and Environmental Issues	
16:30 – 17:10	Presentation by poster participants	
17:10 – 17:25	Workshop conclusion by RUBIS Scientific Committee: Dr. Eric Penot	
17:25 – 17:35	Closing for day 5	

SPEAKERS AND PRESENTERS

Virtual RUBIS International Workshop

"**The Resilience of Rubber-based Agroforestry Systems in the Context of Global Change**"
Universitas Gadjah Mada (virtual host), April 5th - 9th, 2021

1. SUMMARY OF KEYNOTE SPEAKERS

No	Name	Title	Institution
1	Dr. Vincent Gitz	Forests, Trees and Agroforestry Programme	CIFOR
2	Prof. Meine van Noordwijk	Tree-Soil-Crop Interactions in Rubber Agroforestry	ICRAF
3	Dr. Suyanto	Can Rubber Agroforestry Resolve Global Issues with Social-Economic Dimensions?	ICRAF
4	Dr. Eric Justes	Is Agroforestry-based Rubber Systems a Relevant Solution for Contributing to Mitigation and Adaptation to Climate Change?	CIRAD

2. SUMMARY OF INVITED SPEAKERS

No	Name	Title	Institution
1	Dr. Gede Wibawa	Historical Review of Rubber-based Agroforestry Systems in Indonesia	Indonesian Rubber Research Institute
2	Dr. Budiadi	An Overview and Future Outlook of Indonesian Agroforestry	Universitas Gadjah Mada
3	Dr. Raphael Perez	Evaluating Rice Tolerance to Light Conditions under Agroforestry Systems: An Experimental Approach	CIRAD
4	Dr. Eleanor Warren-Thomas	Biodiversity in Rubber Plantations and Agroforestry Systems	Bangor University, United Kingdom
5	Dr. Aris Hairmansis	Development of Shading Tolerant Rice Varieties Suitable for Intercropping Cultivation in Agroforestry Systems	Indonesian Agency for Agricultural Research and Development
6	Dr. Miles Kenney-Lazar	Variegated Transitions of Agrarian Capitalism: The Rubber Boom and Bust in Northern Laos	National University of Singapore

3. SUMMARY OF PRESENTERS
Day-2 (6th April, 2021)

No	Author	Title	Institution
1	Lutfi Izhar	Dissemination Technologies for Smallholders Rubber Production Systems in Jambi, Indonesia	BPTP Jambi

No	Author	Title	Institution
2	Eric Penot	Rubber Agroforestry systems (RAS) evolution in West-Kalimantan, Indonesia	CIRAD
3	Andhika Silva Yunianto	The early benefits of agroforestry as the solution of social conflict and peat land degradation in Kampar-Riau, Indonesia	Ministry of Environment and Forestry
4	Aura Dhamira	Indonesian Natural Rubber Export Potential in European Market	Universitas Gadjah Mada
5	Esekhade, T.U.,	Sustainability of Rubber Agroforestry Strategies in Boosting Smallholder's Resilience to Cope with The Realities of New Global Challenges	Rubber Research Institute of Nigeria
6	Dwi Shinta Agustina	Rubber Agroforestry System in Indonesia: Past, Present, and Future Practices	Indonesian Rubber Research Institute
7	Imade Yoga Prasada	The competitiveness of the natural rubber exporting country in the world market	Universitas Gadjah Mada
8	Miftahul Azis	Economic Perspective of Indonesian Rubber on Agroforestry Development	Indonesian Center for Agriculture Socio Economic and Policy Studies (ICASEP)
9	Subekti Rahayu	Women involvement in smallholder rubber management in Ogan Komering Ilir and Banyuasin District, South Sumatra	World Agroforestry (ICRAF)
10	Fajri Shoutun Nida	The Profitability Analysis of Rubber Plantation in Batang Hari Regency and Sanggau Regency (Study Case: Penerokan Village and Semoncol Village)	Department of Agricultural Socio-Economics Universitas Gadjah Mada
11	Esekhade, T.U.,	Economic Prospects of a Large Scale Rubber Agroforestry in Nigeria	Rubber Research Institute of Nigeria
12	Chioma Okwu-Abolo	Socio-Economic Benefit of Rubber Agroforestry System for Improved Livelihood in Edo State, Nigeria	Rubber Research Institute of Nigeria

Day-3 (7th April, 2021)

No	Author	Title	Institution
1	Eni Maftuah	Agroforestry for Restoration of Degraded Peatlands	ISARI
2	Sri Rahayu Utami	Soil Macroporosity and Its Related Physical Properties After Forest Conversion to Rubber and Oilpalm Plantation in Jambi, Indonesia	University of Brawijaya

No	Author	Title	Institution
3	Sahuri	Development of Double Row Spacing to Improve the Land Productivity and Income of Rubber Smallholders	Indonesian Rubber Research Institute
4	Christine Wulandari	Land Elevation and Slope Exposition Impacts on Rubber Wood Volume under Agroforestry System	Lampung University
5	Yuli Lestari	Peatland Water Conservation by Agroforestry System	Indonesian Swampland Agricultural Research Institute (ISARI), Banjarbaru South Kalimantan
6	Ratna Akiefnawati	Rubber Agroforestry Experiments in Jambi at The End of a 25-Year Cycle	Independent researcher
7	Desi Aryani	Economic Impact 0f The Use of Stimulants on Rubber Farming in Tanjung Makmur Village Pedamaran Timur Sub-District Ogan Komering Ilir District	Universitas Sriwijaya
8	Shima Nazri	Nutritional Requirements of Rubber Trees Planted Under Rubber Forest Plantation Systems	Malaysian Rubber Board
9	Frédéric Gay	Which model to simulate the ecosystem services provided by agroforestry systems based on rubber trees?	CIRAD
10	Stephane Boulakia	Preliminary results of prospective trials on Rubber-Forest tree associations in Cambodia	CIRAD
11	Fetrina Oktavia	Proggres of Rubber Breeding Program to Support Agroforestry System	Indonesian Rubber Research Institute
12	Philippe Thaler	On-farm effect of bamboo intercropping on soil water content and root distribution in rubber tree plantation	CIRAD

Day-4 (8th April, 2021)

No	Author	Title	Institution
1	Sukisno	A Review of Land Use Land Cover Change in the Catchment Area of Musi Hydropower Plant in Bengkulu Province	University of Bengkulu
2	Esekhade, T.U.,	Effect of Intercropping on the Development of Rubber Saplings in an Acid Sand in Southern Nigeria	Rubber Research Institute of Nigeria
3	Gerson N. Njurumana	Ecosystem services of indigenous Kaliwu agroforest system in Sumba, Indonesia	Environmental and Forestry Research Institute of Kupang, Kupang

No	Author	Title	Institution
4	Eko Pujiono	Sustainability status of agroforesttry systems in Timor Island, Indonesia	Forestry and Environment Research and Development Institute of Kupang, Kupang, Indonesia
5	Budiadi Suparno	Dynamics of Soil Properties on Post Shifting Cultivation in Natural Forest	Universitas Gadjah Mada

Day-5 (9th April, 2021)

No	Author	Title	Institution
1	Yahya Shafiyuddin Hilmi	Relationship Between Economic and Environment of the Natural Rubber Industry in Major Producers	Universitas Gadjah Mada
2	Avry Pribadi	Understory and Soil Macrofauna Diversity under the Three Young Native Species in a Drained Peatland of Pelalawan-Riau, Indonesia	Balai Litbang Teknologi Serat Tanaman Hutan Kementerian Lingkungan Hidup dan Kehutanan
3	Christine Wulandari	Roles of Rubber Agroforestry to Support the Sustainability of Protection Forest through Community Forestry Program	Lampung University
4	Angga Eko Emzar	Promoting Carbon Trading Scheme for Natural Rubber Plantation as a Potential Way for Having a Better Environmental conservation and Sustainability	Gabungan Perusahaan Karet Indonesia (GAPKINDO)
5	Radhiah Abdul Kadir	Impact of Forest Fragment on Bird Community at the Bukit Kuantan Rubber Forest Plantation	Malaysian Rubber Board
6	Wahida Annisa	Potential of Agroforestry System on Peat Land to Enhance Food Security and Environmental Sustainability	Indonesian Swampland Agricultural Research Institute
7	Muhammad Akbar Abdul Ghaffar	Effects of Haze Period on Rubber Forest Clone’s Tree Productivity	Malaysian Rubber Board
8	Mohd Syolahuddin Bin Mokhter	Growth Performance of Untapped Rubber Clones Planted in Rubber Forest Clone Trial Using Platform System	Malaysian Rubber Board
9	Wahyu Adhi Saputro	Contribution of Agroforestry Plants to Farmers' Income in Nglanggeran Agricultural Technology Park	Universitas Duta Bangsa Surakarta

No	Author	Title	Institution
10	Sankalpa J. K. S.	Smallholder Rubber Agroforestry Farming in The Non-Traditional Areas of Sri Lanka: An Application of Assets-Based Livelihood Capital Indicator Approach	Rubber Research Institute of Sri Lanka
11	P.K. Viswanathan	Building Institutional and Innovation Capacities for Enhancing the Socio-economic Impacts of Rubber-based Agroforestry Systems: A study of Rubber Smallholders in India	Amrita Vishwa Vidyapeetham, Kochi, India

ABSTRACT OF KEYNOTE SPEAKERS

Can Rubber Agroforestry Resolve Global Issues with Social-Economic Dimensions?

S. Suyanto[1], and Sonya Dewi[1]
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Introduction

Around 2.5 million smallholder rubber farmers in Indonesia suffer from the declining of rubber price, low productivity, and disturbance from pest, weather and climate. Rubber is an important resource for smallholder livelihoods. Smallholder rubber accounted for 84% of 2.82 million ha in 2002, and it increased to 86% of 3.24 million ha in 2019. The average yield of rubber still ranges from 550-600 kg of dry rubber content (DRC) per hectare, which is low compared to Thailand and Malaysia (Ari¬fin,2005). The objective of this paper is to identify current problems of the social-economic position of smallholder rubber farmers and propose strategies to resolve them.

Current social-economic problems of smallholder rubber farmers in Indonesia

It is widely believed in Indonesia that the so-called ‘jungle rubber’ system is a primitive and unprofitable method of growing rubber, even though careful quantitative studies of this system seldom have been attempted. Suyanto et al. (2001) conducted a survey of the 162 households in two villages in Jambi on smallholder rubber management. This study found that labour, particularly family labour, is the main cost of rubber production, where labour by men dominates in most rubber production activities. The investment in smallholder rubber trees is not very lucrative but still profitable. The profitability of smallholder rubber, however, tends to decline. The latest ICRAF analysis shows a declining Net Present Value of smallholder rubber systems, both for monoculture and agroforestry systems.

Table 1. The declining of rubber profitability in Jambi

	Net Presen Value (USD)			Return to Labor (USD)		
	2010	2014	2020	2010	2014	2020
Rubber monolultur	3,213	1,327	825	7,39	5,67	4,80
Rubber Agroforestry	2,508	819	401	7,09	5,45	4,60

Comparing to other tree crops like oil palm, coffee and cacao, the smallholder rubber profitability is the lowest, about half of the oil palm value. This matches the massive conversion from rubber gardens to oil palm (Sofiyuddin, 2012). The conversion from rubber to oil palm and the expansion of private land through purchasing are options for wealthy rather than poor farmers. This resulted in an increase of income inequity. Khususiyah et al (2013) reported that the income from rubber plantations reduced the overall inequity of income distribution. On the other hand, income from oil palm plantations from private land leads to unequal income distribution.

The declining world rubber prices resulted in low and declining farm gate prices. Lack of post-harvesting handling skill, lack of quality and price information and long supply chains are further issues, as rubber farmers are not strongly organized institutionally.

How to Resolve?

1. Promote Rubber Agroforestry

With high uncertainty and risk in rubber management, especially the fluctuation of rubber prices, the strategy is to promote rubber agroforestry with reducing the number of rubber trees per hectare and planting more commercially interesting trees, such as fruit or timber species. With the past fluctuation of rubber prices, the mean annual profit in monoculture rubber has been higher than that rubber agroforestry, but the lowest annual profit monoculture rubber is much lower that of rubber agroforest, showing a high risk exposure (Figure 1). In other words, rubber agroforestry is a resilient livelihood strategy in anticipation of risk and uncertainty, allowing farmers to reallocate labour to other sources of income when rubber process are low.

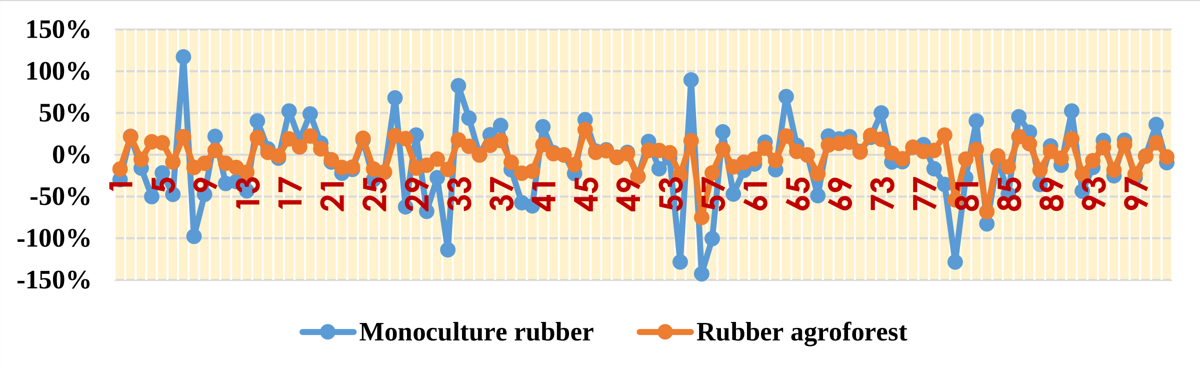

Figure 1. Differences between annual profit with fluctuating price and yield and with constant price and yield

2. Smallholder rubber revitalization as a n intervention in green growth plan

ICRAF supported the Provincial Government of Sumatera Selatan (2017) in developing its green growth plan. One of the proposed interventions is smallholder rubber revitalization and rejuvenation using high-quality planting material, improved good agriculture practice and balancing fertilizing, in combination with improvement of the raw rubber marketing chain through the improvement of farmers' bargaining power for increasing rubber prices at the farm gate.

Conclusion

In the context of sustainable commodity production and green growth, smallholder rubber revitalization with rubber agroforestry could be considered to achieve improved social-economic as well as environment indicators.

References

[1] Arifin, B. Supply Chain of Natural Rubber in Indonesia. Jurnal of Management & Agribisnis.,2005, 2 (1), pp.1-16

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Tree-Soil-Crop Interactions in Rubber Agroforestry

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EXTENDED ABSTRACT

Managing complex rubber agroforestry systems may be surprisingly simple. Five basic rules are: 1) Use and build on what you have; 2) Harvest what you need, but leave something for tomorrow; 3) Reduce growth of species that hinder other, more valuable components; 4) Protect the plot from external disturbance, and 5) If you want, actively introduce valuable components from outside. Use of space probably is the primary concern, but it stands for light, water and nutrients as primary abobe- and belowground gropwth resources. Management requires an expectation of how trees and other components will grow and interact over time, but much of the de facto rules of thumb have not been made explicit, and transfer of local ecological knowledge requires learning by doing, visiting other plots and discussing differences and similarities observed. In interaction with policy rules and incentives, farmers are faced with distinctions between forest and agriculture that may be hard to understand (Figure 1), as their land use straddles the boundary (Figure 1).

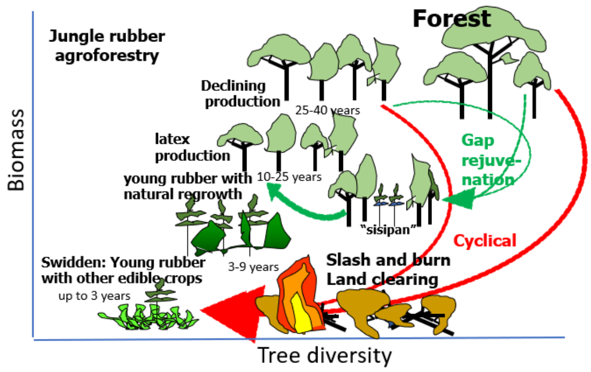

Figure 1. Transitions and choices across the life cycle of rubber agroforestry systems[1]

When researchers start interacting with agroforesters (or agroforestry farmers), they can do so at two levels: A. Documenting the existing variation in conditions that is observable, and B. Exploring the explanatory models, theories and hypotheses about how the agroforest world works, as social-ecological system. One of the building blocks for the latter are Tree-Soil-Crop interaction models, as a step towards Bio-economic models that translate choices on input use to expected outputs in units relevant for farmer decisions. Tree-soil-crop interaction models are themselves constructed on the basis of components such as descriptions of dynamic tree architecture and functioning (how trees respond to availability of growth resources, influenced by their neighbours), soils and their influence on availability of water and nutrients in response to climate (rainfall, potential evapotranspiration) and the balance of nutrient imports and losses, and short-lived crops that tend to be important especially in the early phases of agroforestry systems. Agronomic models may focus on yield gaps (Fig. 2) when comparing actual to potential yield.

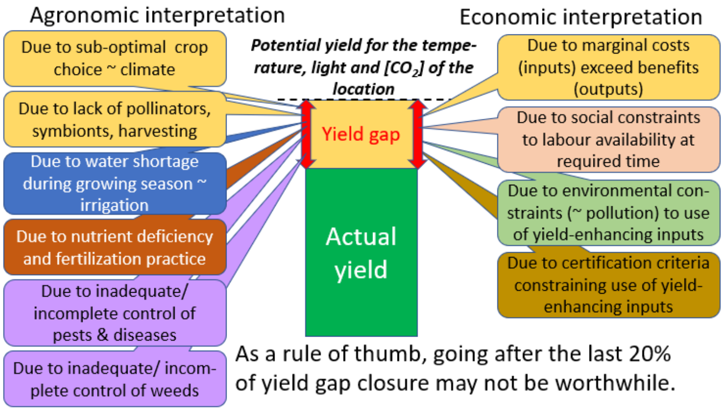

Figure 2. Two complementary interpretations of yield gaps: agronomic factors on the left, social and economic ones on the right

The existence of yield gaps has been interpreted as indication that „land sparing“ might be possible by intensification (closing of yield gaps) of the main commodity, making it easier to designate part of the landscapes as conservation areas, while providing income to the existing human population density. The flip-side of the argument, „land sharing“, emphasizes the multifunctionality of land use and expands the yield gap formula (ratio of actiual to potential yield) to a sum of such ratios for all harvested components, plus all regulating services achieved, plus all social-cultural services that can be maintained (Figure 3).

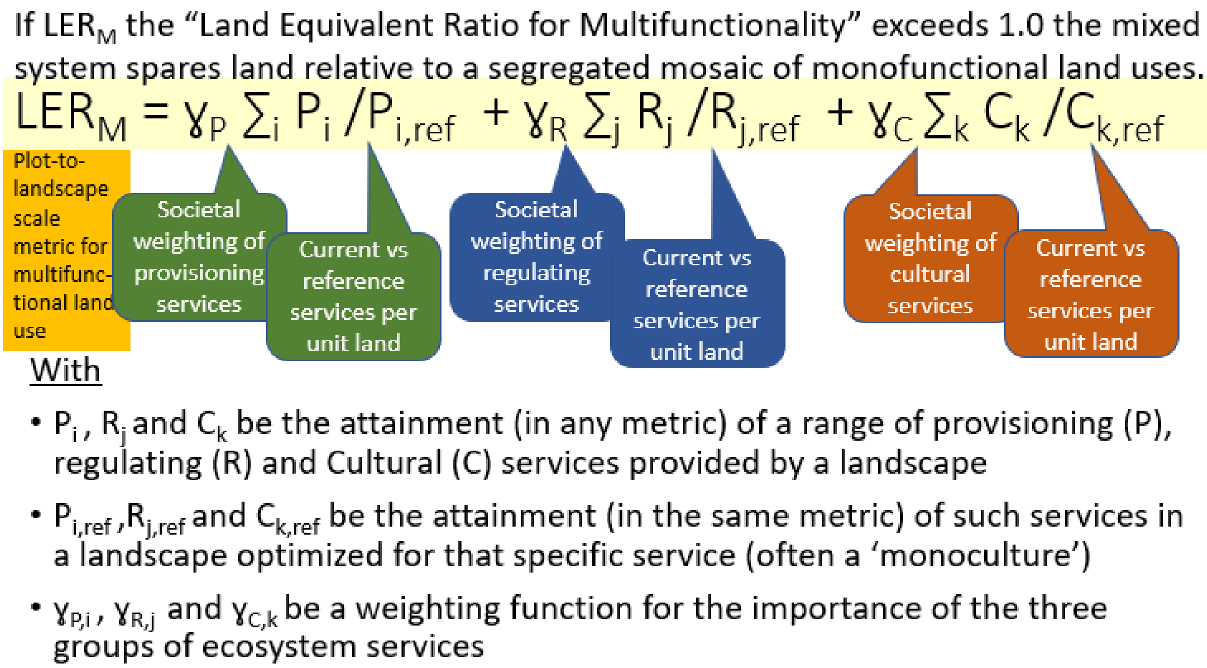

Figure 3. Land Equivalent Ratio (LER) for multifunctional land use asbasis for evaluating agroforestry systems[2]

To assist in the process-based evaluation of existing or foreseeable agroforestry systems, existing tree-soil-crop models (such as WaNuLCAS)3 will need to go beyond yield predictions and include changes in soil conditions that interact with greenhouse gas emissions, carbon stocks, buffering of water flows, surface runoff and groundwater recharge.

Conclusions are that the external (policy) perspectives on what various types of rubber agroforestry systems achieve are changing, increasing the demands on process-based and internally consistent model descriptions that are sufficiently flexible to represent the diversity of practices and species compositions found in the field. Further development of the existing models to meet these increasing demands is needed, with the Land Equivalent Ratio as primary alternative to the yield gap focus of discussions of monocultural plantations.

References

[1] van Noordwijk M (Ed.) 2019. Sustainable Development Through Trees on Farms: Agroforestry in its Fifth Decade. World Agroforestry (ICRAF), Bogor, Indonesia

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Are rubber-based agroforestry systems a relevant solution for contributing to mitigation and adaptation to Climate Change?

Speaker: Eric Justes[1]
Contributors: Frédéric Gay[2], Eric Gohet[2], Didier Lesueur[3], Yann Nouvellon[4], Eric Penot[5], Philippe Thaler[6], Rémi Cardinaël[7], Alexis Thoumazeau[2], Emmanuel Torquebiau[7]
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Summary:

Since the Paris Agreement in 2015, the Agriculture, Forest and Land Use (AFOLU) sector has been recognized for its key role in climate change mitigation. This sector provides a range of food, feed, fiber, bio-energy, bio-products and renewable material such as the natural rubber (NR), which is a "green" substitute to petroleum made elastomers, representing in 2020 about 47% of the global elastomer market. Moreover, like other tree plantations, rubber plantations can provide carbon sequestration on the medium-term. They can also mitigate green gaseous emission by CO_2 capture by photosynthesis and evaporative cooling due to their high actual evapotranspiration as other land-uses such as crops or grasslands. On the other hand, NR is an important land-user and a major driver of deforestation and biodiversity erosion in some countries and in case of some plantation and management practices.

There is a lot of uncertainty about the effects of climate change on NR production in the future. Rubber is mainly cultivated in so-called "traditional areas" with warm and humid climate conditions similar to the Amazonian basin where the rubber specie, *Hevea brasiliensis,* stems from. In the last decades, rubber plantations have spread to areas with three types of marginal climate: warm/dry, cold/dry and cold/humid. There is no doubt that climate conditions will change in the different areas where rubber is cultivated nowadays. The first and most direct climatic factor that will affect rubber cultivation is the rise in mean air temperature. This rise will likely induce changes in rainfall regimes and will also trigger more frequent extreme events (heat wave, storms…). Those irregular and unpredictable climate conditions will increase risks as a whole for conventional rubber cultivation.

As a consequence, the NR sector must develop adaptation strategies to face the climate change threat. Rubber-based agroforestry systems (RAS) are often put forward as one of the best options. Economically speaking, RAS are reported to contribute to the resilience of rubber smallholders by diversifying their source of incomes. Ecologically speaking, there are less evidence that RAS are better adapted to climate change than traditional monospecific plantations. Nor has it been clearly demonstrated that RAS have a higher mitigation potential in comparison to other land uses, except for the jungle rubber, even if there is still a lack of results. The crucial point is the basis of reference for comparing the RAS to other systems for climate change mitigation potential. This methodological aspect will then be discuss.

In this keynote, we propose an objective and open analysis of the role of RAS in the adaptation of the NR sector to climate change and its potential impact for mitigation. We will analyse the pros and the cons of the so-called technological "climate-smart agriculture" versus "nature-based" solution that recover an agroecological transition of NR based on a better soil health and practices respecting environment, biodiversity and human health. To this end, we will highlight the main processes that underpin the provision of ecosystem services in agroforestry

systems and how they occur in rubber plantations, and the conditions for transforming a potential into a real effect. We will illustrate the need to distinguish the different types of agroecological practices and RAS for making a relevant analysis. This, we will present the different cases of (i) intercropping between the tree lines during the immature phase, (ii) association between rubber trees and (iii) other perennial species at the mature stage with a range of diversity up to the jungle rubber model. We will highlight the relevance of the sustainable management of the soil at the different steps of the life cycle of a rubber plantation, from the planting to the felling of the plantation. Our purpose is to demonstrate that, beyond agroforestry, there is a need to design agroecological practices for the sustainable management of rubber plantations that will be adapted to climate change and contribute to mitigation.

ABSTRACT OF INVITED SPEAKERS

An Overview and Future Outlook of Indonesian Agroforestry

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ABSTRACT
Indonesian agroforestry has being developed along the history, since been reported that homegarden was practiced from 3,000 BC as an evolutional stage of hunting and collecting to cultivating traditions. A literature study was done to analyse history and future projection of Indonesian agroforestry, especially in forestry views. In the first stages, agroforestry was practiced by exploiting natural forests in shifting cultivation systems, and hence have known as illegal practices since the colonial era. Some of indigenous groups manage the forest ecosystems in a more ecological ways, e.g. tembawang and simpukNg in Kalimantan, dusung in the Mollucas, and mamar in East Nusa Tenggara. In production forests, the forest dwellers engage in contracts with the forest owner in a kind of taungya system, especially in Java. In the country, agroforestry is also classified based on the type of commodities. It is including under explored and less identified NTFPs, including latex from jungle rubber. Many local practices convince that mix plantation systems are well adopted than simple patterns. However, agroforestry practices were still known to have less contribution to people welfare. Site level agroforestry improvement by combining intensive silviculture and agronomy approaches can be promoted, for better outputs of the adopted agroforestry practices.

Keywords: tropical forest, indigenous knowledge, adoptability, intensive silviculture

Evaluating Rice Tolerance to Light Conditions under Agroforestry Systems: An Experimental Approach

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EXTENDED ABSTRACT

Climatic hazards affecting the main rice producing regions of Indonesia increase the risk of annual production loss (1) and encourage the development of innovative strategies to maintain stable production. Conversion of perennial monocultures to rice-based intercropping systems is a strategy to be considered, but relies on the existence of rice varieties that are productive under these shady conditions.

Despite the growing interest in rice-based agroforestry systems (2), the diversity of rice response to fluctuations in radiation as well as to low light remains unexploited. Up to now, varietal improvement programs in rice have focused on the selection of productive materials in full sun conditions and which show good production in low radiation (3). The tolerances to daily quantitative fluctuations (shade / light changeover) have not yet been tested, which does not guarantee the productive capacities of these varieties in agroforestry systems. The existence of genetic variability in the induction of photosynthesis in response to light fluctuations (4), and independently to shade tolerance (5,6), suggest that it is however possible to select material suitable for agroforestry.

The hypothesis of this project is that the rice genotypes selected to be the most efficient under optimal radiation are not necessarily the most efficient when the quantity and the dynamics of the radiation are altered, as in agroforestry systems. This hypothesis is based on the evidence that there are genotype x light condition interactions in rice in terms of photosynthetic capacity and production and that the latter can be exploited to improve varieties for rice cultivation in an agroforestry system.

A project was launched at CIRAD in May 2020 to assess the diversity of responses of height rice accessions to light fluctuations under controlled conditions (phytotrons). Considering the light regime selected through in silico experiments aiming at optimizing light availability for the intercrop in a rice-palm agroforestry system, we carried out an experiment to assess the phenological, morphological and ecophysiological responses of rice accessions to light treatments differing in either the quantity or the dynamics of radiation (Figure 1). The results obtained confirmed the importance of the amount of radiation on productivity, with losses compared to the control treatment varying from 15% to 35% depending on the varieties and light treatments.

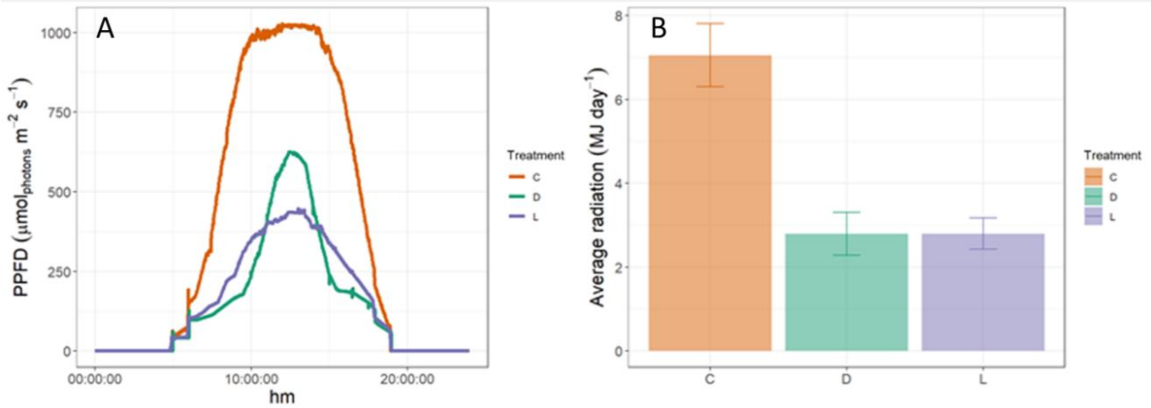

Figure 1. Light treatments applied in controlled conditions (C: Control; D: agroforestry, L: Constant low). Daily dynamics (A) and accumulations (B) of radiation measured during the experiment (mean value +/- standard deviations)

The screening of phenotypic traits revealed high plasticity of plant architecture with specific responses to light environment depending on varieties. Besides, ecophysiological measurements highlighted significant interactions between varieties and treatments. The important range in phenotypic variations prevented the clear identification of specific features adapted to agroforestry light conditions. Although no significant G x E interaction emerged on yield, one variety stood out in the agroforestry-like light regime, suggesting the capacity of some varieties to better adapt to agroforestry systems (Figure 2).

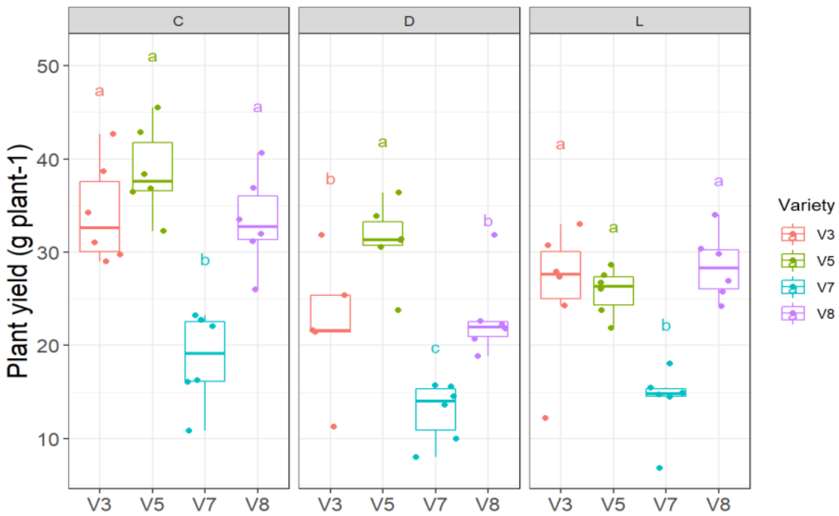

Figure 2. Yield depending on variety and light treatment. Points represent individual values, letters correspond to varietal significantly different within each treatment (Tuckey test)

Focusing on the behavior of the variety with the highest production under the agroforestry light regime, we put forward some traits of interest that could be further investigated in larger studies. The field trial under natural conditions proposed in the Rubis project would allow testing the relevance of these traits and making possible the screening of a larger panel of rice accessions.

Acknowledgment
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Biodiversity in Rubber Plantations and Agroforestry Systems

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ABSTRACT

Biodiversity – the variety of life across ecosystems, species and genes – sustains the functioning of ecosystems. Healthy, functioning ecosystems provide multiple benefits and services to people, including healthy and productive soils, clean water, nutrient cycling, carbon sequestration and storage, pollination, pest and disease control, food, fibre, oils and latex, medicines and much more. People also value multiple aspects of biodiversity culturally and spiritually. There is strong evidence that widespread changing of natural habitats to intensive agriculture and plantations is causing the loss of biodiversity at a global scale, which puts these benefits, services and values at risk. This means that management of plantations, which cover large areas of land, has an extremely important part to play in protecting biodiversity, and its benefits, alongside protecting remaining natural habitats. The tropics are the most biodiverse places on earth, and as rubber is one of the most important and widespread plantation crops in the tropics, it is important to understand how biodiversity is affected both by the establishment of rubber plantations, and by ongoing plantation management, including agroforestry practices. In this talk I will present a summary of evidence for the biodiversity value of rubber plantations and agroforests, particularly focussing on birds, butterflies and plants. I will show the loss of biodiversity that happens when natural forests are converted to rubber, but also the ways in which biodiversity is supported within plantations and agroforests, and where there are opportunities to make rubber growing more biodiversity-friendly to benefit people, nature and ecosystem functions. I will discuss evidence for trade-offs between biodiversity value, ecosystem function and rubber-based livelihoods, and conclude with ideas for how agroforestry practices can help support biodiversity long into the future.

Variegated transitions of agrarian capitalism: The rubber boom and bust in northern Laos

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ABSTRACT
Over the past two decades, the rubber tree as a cash crop in Southeast Asia has expanded from its longstanding bases in southern Thailand, Malaysia, and Indonesia to new sites of cultivation in southern China, Northeast Thailand, Laos, Cambodia, and Myanmar, driven by favorable government policies and high prices. A price crash since 2011, however, has prompted a reassessment of the potential for the crop to help the rural poor across these regions improve their livelihoods. This presentation highlights the social-environmental manifestations of the rubber boom and bust in Northern Laos through a longitudinal study of varying rubber growing arrangements and resulting agrarian transitions. The theoretical lens of variegated capitalism is applied to the question of agrarian change to show the diverse ways in which agrarian capitalism has been expressed across a single region. Comparing research that spans a decade, conducted in 2008 and again in 2018, I trace how the roller coaster of rubber prices have been absorbed in different ways by independent smallholder, contract farming, and large-scale estate forms of rubber production. These distinct social arrangements have led to a divided landscape of rubber winners and losers, between those who are driving the crop's expansion and upgrading their living standards to those who have been dispossessed of their land, lost access to the forest frontier, and resorted to piecemeal labor on other farmers' plantations.

Sub-Theme: Agronomy of Rubber-based Agroforestry Systems

Agroforestry for restoration of degraded peatlands

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EXTENDED ABSTRACT
Peatlands have the potential to be exploited, but must consider environmental functions (carbon storage, water reservoirs, habitat for flora and fauna), as well as their zoning. The area of peatland in Indonesia is 14.9 million ha, degraded around 4.4 million ha (3.7 million ha of scrub and 0.7 million ha in the form of open and ex-mining land) [1]. The rampant clearing of peatlands in the past has caused a lot of damage to the peatlands. According to [1] the area of degraded peatland is around 4.4 million ha (3.7 million ha of scrub and 0.7 million ha in the form of open and ex-mining land). Degraded peatlands are scattered in Sumatra, Kalimantan and Papua. Degraded peatlands are more susceptible to land fires, due to overdrain and land cover that is dominated by shrubs, making it easy to burn. Over-drained peat has caused the top layer of the peat to dry out and triggered land fires. Land management, in terms of water, plants and proper crop selection, is expected to restore degraded peatlands.

Degraded peatlands need to be saved so that further land damage does not occur. Agroforestry systems can be an option for restoring degraded peatlands. The agroforestry system is a cropping pattern that uses a combination of forestry plants (trees) with agricultural crops (seasonal), which aims to obtain maximum results without neglecting aspects of land conservation and practical cultivation of local communities [2]. The agroforestry system can be applied to community-owned peatlands and production forest areas. The purpose of this paper is to describe the restoration of degraded peatlands using agroforestry systems.

Degraded Peat Land
Degraded peatlands are peatlands that have been converted from natural forest to other areas that are not utilized and are experiencing a decline in both their function as a growth medium and an environmental function. Based on PP 71 of 2014 in conjunction with PP 57 of 2016 damage to the peat ecosystem in cultivation areas occurs when the water level is more than 0.4m below the peat surface and / or exposure to pyrite sediment and or quartz sand under the peat layer. The degraded peat layer is generally hydrophobic, making peat soils dry, making them very susceptible to land fires.

Degradation of natural forests or peatlands in Indonesia are generally caused by several factors, among others; illegal logging, encroachment, forest and peatland fires, construction of drains or drainage in peatlands that are not well calculated, weak and lack of public awareness and understanding of the beneficial functions of peat swamp forests [3]. The conversion of peatland in Indonesia mostly emits CO_2 or peat decomposition which is greater than the initial condition of the land, namely primary forest. Land conversion to acacia plantations contributed the most to peat decomposition compared to other land changes, followed by oil palm plantations [4, 5].

Agroforestry In Degraded Peatlands

Agroforestry is an alternative to restoring degraded peatlands. The background of the concept of agroforestry is land use that is not optimal, especially in production forest areas. On the other hand, the economic condition (income) of the community around the forest area is still mostly low. This often triggers activities that lead to environmental destruction. This trend of environmental destruction needs to be prevented by means of land management that can effectively preserve the physical environment and at the same time meet the needs of food, shelter and clothing for the people living around the forest. Empowerment of peatland communities around forest areas has two considerations: (1) because of the poverty and helplessness experienced by most communities on peatlands (often the cause of their ignorance of environmental quality), and (2) awareness and motivation to participate in land conservation (difficult to do if the basic needs of the community are still not fulfilled [6].

An agroforestry system is defined as an optimal land use method that combines short and long rotation biological production systems (a combination of forestry production and other biological production) in a manner based on the principle of sustainability, concurrently or sequentially, within the forest area or outside. with the aim of achieving people's welfare [7]. The agroforestry system can be applied to forest development through a mixed pattern of tree and seasonal crops which is carried out on community-owned peatlands and production forest areas.

The Role Of Agroforestry To Mitigate Carbon Emissions In Degraded Peatlands

Agroforestry can be developed in various land conditions, both wet and dry areas. Planting trees with shrubs under tree stands will increase the absorption of CO2 from the decomposition of peat matter, thereby reducing carbon emissions in the atmosphere. Furthermore, it will increase the carbon stock above the soil surface by using CO2 for photosynthesis and producing plant biomass. In general, the short life plant biomass average is very low, which is below 10 kg per individual plant. This means that throughout the life of the plant, the need for CO2 consumption is estimated at only 104-105 CO2 molecules [8]. On the other hand, agroforestry practices usually use 50 - 70% perennials (plantation crops, fruit trees and forest plants). Perennials generally have plant biomass above 50 kg per individual plant, which means that the need for CO2 consumption is far above 5 x105 molecules. These results show that the agroforestry agricultural model has the greatest contribution to the absorption of CO2 from the earth's atmosphere, if this pattern is applied appropriately and with quality management [9].

Conclusion

Degraded peatlands need to be restored to avoid further damage that could impact the environmental and socio-economic quality of the surrounding community. One of the ways to restore degraded peatlands can be done through revegetation. Agroforestry systems can be developed to restore degraded peatlands through planting forest and seasonal crops. The role of agroforestry in mitigating GHG emissions in degraded peatlands through its function as a carbon sink and reducing the danger of land fires due to the exploitation of degraded peatlands. Agroforestry is expected to be one of the solutions for climate change mitigation, because besides being able to meet the short-term needs of the community so that the pressure on exploitation of forest land is reduced, it is also a potential source of carbon storage.

Soil macroporosity and its related physical properties after forest conversion to rubber and oilpalm plantation in Jambi, Indonesia

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EXTENDED ABSTRACT

Tropical forests which typically play important role in maintaining environmental quality, continues to decline in three decades, as forest conversion into other land uses increased significantly. Outside Java, Jambi is one of the main areas for the development of oil palm and rubber in Sumatra. From 2000 to 2010, the area of rubber plantations in Jambi increased by about 19 %, while oil palm plantations increased by 85 % [1], which was mainly converted from forest. Previous study showed that forest conversion caused higher bulk density and lower soil porosity in tea plantation [2]; coffee based agroforestry systems [3] and cultivated lands [4]. Therefore, it is interesting to study the effect of forest conversion to rubber and oil palm plantation on soil porosity, as one of the indicators used to evaluate soil quality.

The research was conducted in Bukit Duabelas landscape of Sarolangun District, Jambi Province. We selected four land use systems (SF = secondary forest, JR = jungle rubber, RP = rubber monoculture, and OP = oil palm plantations), and each repeated three times. The number of macro-pore in vertical or horizontal planes was measured using Methylene Blue, which in principle is calculating the area of the methylene blue dye infiltrate in the soil profile [3]. Root mass were sampled using a metal block (20 cm x 20 cm x 10 cm) at 10-cm depth interval in 0-100cm depth. Root samples were categorized into fine roots (≤ 2-mm diameter) and coarse roots (> 2-mm diameter), oven-dried at 700C for 5 days and weighed. Soil samples were taken from 5 depth (0-20, 20-40, 40-60, 60-80, and 80-100 cm) for soil physical analysis (bulk density, particle density, water content at pF0 and pF2.54, aggregate stability) and % organic C. Observations and soil samples were taken in the middle of the adjacent trees (in forest, jungle rubber and rubber plantation), and 3 different zones in oil palm (fertilized zone, inter row, and frond piles).

The results showed that macro pores both on vertical or horizontal planes in the secondary forest were higher than jungle rubber, rubber plantation and oil palm plantation. For vertical macro pores, there was no significant difference between jungle rubber, rubber and oil palm plantation. Horizontal macro pores, in jungle rubber however was similar to secondary forest, and higher than rubber and oil palm plantation.

These results indicated that forest conversion to other land uses decreased macro porosity especially upper soil layer (0 – 50 cm). The number of macro pores was closely associated to litter thickness. Macro porosity is normally determined by rooting depth and soil fauna activities, which largely depend on the quality and quantity of the litter as a source for organic matter. The coarse root mass in the top soil (0-20 cm) were larger in the rainforests than in the rubber and oil palm plantation. This could be due to the higher tree densities [5] in forests

(471 ± 31trees ha-1) than in oil palm plantations (134 ± 6 trees ha-1). In the deeper layer (60-80 cm depth of soil) however, the coarse root mass in the rubber and oil palm plantation were larger as compared to the forest. Aggregate stability could also determine macro pores stability. The smaller diameter of water stable aggregates (WSA) was increased from forest to rubber plantation, indicating that larger stable aggregates were more dominant in the forest. Soil secondary particles will be disaggregated [6], and these particles will be easily transported to the deeper layer and filled the pores inside. This study also showed that macro pores in the soil profile was significantly correlated to macro pores in the soil matrix (determined by water content at pF 0 minus pF 2.54). Soil macro pores may consist of rooting channels, wormhole and other soil fauna, as well as macro-pores in the soil matrix. However, the number of macro pores was not significantly correlated to soil bulk density and % C-org.

It can be concluded that forest conversion to jungle rubber, rubber and oilpalm plantation in Jambi lead to a decrease of macroporosity in the soil profile as well as in the soil matrix, especially in the upper 50 cm. Macropores both at vertical and horizontal plane in the secondary forest was significantly higher than other landuses. Macropores at horizontal plane in jungle rubber was higher than rubber and oilpalm plantation, but not the vertical macroporosity. This pattern was in accordance to soil organic C content, aggregate stability, total and macropores in soil matrix, and litter thickness. Among the soil properties measured, litter thickness, coarse root dry mass (Ø > 2 mm), and aggregate stability were closely associated to soil macroporosity. However, macroporosity in soil profile was apparently unsignificantly correlated to soil bulk density and % organic C.

Development of double row spacing to improve the land productivity and income of rubber smallholders

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EXTENDED ABSTRACT

Rubber is an important commodity in Indonesia, especially in Sumatera and Kalimantan. Farmers choose rubber as main crop because it is easy to grow, yield can be stored for long period, rubber can be grown in low fertility soil, and provide daily income. Low prices of rubber has been a serious problem to rubber growers in Indonesia. Rubber-based intercropping systems offers a practical solution to this issue and increasing overall productivity (Rodrigo et al., 2004). This study was aimed to determine the suitable spatial arrangements in rubber planting to facilitate long-term rubber-based intercropping systems.

A technology that might be developed is the cultivation of rubber with double row spacing 18 m x 2 m x 2.5 m. Plant population of using this planting distance is 400 trees/ha. Light intensity is still high and enable to grow intercrop for longer period of time. To determine land productivity, we used Land Equivalent Ratio (LER), which is the ratio of area needed under monoculture to a unit area of intercropping at the same management level to give and equal amount of yield (Jalloh et al., 2003; Rosyid, 2007). Table 6 show the yield from different cropping scenarios. The total area required for rubber, upland rice and maize grown in monoculture to produce an equivalent of a one hectare of rubber-upland rice-maize intercrop is 1.87 (calculation below). This means the intercropping has an advantage compared to monoculture.

The DR system was technically suitable for long term intercropping, because when the rubber tree reached 8 to 9-year-old, the light penetration was > 80% at distance of about 4 m from the rubber tree rows. Economically, DR system can increase the added values for rubber farmers because it allows long term intercropping. The effort to increase productivity of land and farmer income can be done through development intercrop. In selecting a suitable farming system, market channels, labour availability and security are the most important socioeconomic factors in consideration. To extend the period of intercrops cultivation, there is need to modify rubber spacing with double rows of 18 m x 2 m x 2.5 m.

Land elevation and slope exposition impacts on rubber wood volume under agroforestry system

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EXTENDED ABSTRACT
Besides on species or cultivar and silviculture practice, the impacts of environmental variables on rubber wood production under agroforestry system have been much revealing by some researchers, including the microclimate, soil fertility, and associate plants as well as pest disease attacking. But extremely rare for both variables of land elevation and exposition. This research aimed at revealing the impact on rubber wood production under these variables. Postulate model of Ordinary Least Square was employed at significant level of 90%. The respond variable is rubber production [WOOD] whereas the predictor were land elevation in an-100 m above sea level [ELV], land slope expositions that were decomposed into 4 categories with the reference of the geographical direction between 337.50 to 225.50 follow needle clock's direction while the tree others were the westward [WEST], southwest ward [SWST], and northwest ward [NWST]. The reference applied in the model is under assumption that exposition is the best for rubber crop's photosynthesis in relation to solar radiation. In order to control the model error we also employed the variables of the air temperature [TEMP] and air humidity. Data collected by surveying to 75 parcels of land belong to HKm member of Mangga Mulyo exist in Way Kanan Regency. Parameter optimization used Minitab 16. The results suggest that the rubber wood production: (1) will increase significantly around 0.01948 (Sd=0.01159) m3 for every 100 m higher of land elevation, and (2) will decrease significantly around 0.23744 (Sd=0.07952) m3 which land exposition face to westward than that of eastward. This funding may useful especially for management practice in relation to the efficiencies of resource allocation including the material distribution and extension service provider etc.

Key words: resource allocation, wood rubber, agroforestry system, and HKm

Peatland water conservation by agroforestry system

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EXTENDED ABSTRACT
Peat swamp forest have a high economic value and are potential for agricultural development. However, peatlad are fragile ecosystems because they are easily damaged and difficult to restore. The main problem of all peat soil types is their irreversible drying. In this condition the peat soil is easy burning, unable to store water, and if the groundwater is far from the surface, the plants will be stressed from lack of water. Therefore to support sustainable agricultural development on peatlands it requires careful planning, application of appropriate technology and suitable management. One of the land management systems that can be applied on peatlands is combining agricultural crop and forest plant (agroforestry). Forest plant and seasonal agriculture crops can increase CO2 absorption so that photosynthetic efficiency and oxygen production increase. These proses increase the production of biomass which can maintain soil organic matter and prevent erosion. Organic matter enhance the effectiveness of rewetting and water retention capacity. In addition, this system also affects the microclimate, such as the soil becoming more humid because it gets shade from the vegetation above it, so reduce temperature and elevated air moisture. Indirectly, agroforestry can reduce excessive evaporation and maintains the ground water level, especially during the dry season. This review aim to explain the role of intercropping system in peatland water conservation.

Key words: sustainable agriculture, intercropping, water retention capacity

Rubber agroforestry experiments in Jambi at the end of a 25-year cycle

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EXTENDED ABSTRACT
The rubber agroforestry experiments in Jambi started with the theory of change that productive clonal rubber could be economically used in low-labour intensity rubber agroforests, allowing selective retention of forest species or planted fruit trees in interrows. At the end of what was expected to be a 25-year production cycle we revisited the farmers (or their next generation), recorded what had happened to the plot and registered farmer plans for a way forward.

Qualitatively, the results showed a wide range of directions of actual change. The envisaged plots, with full-grown tapped rubber in a secondary forest setting did occur – but as exception rather than rule. Some plots had early on been converted to oil palm when white root rot disease killed many of the rubber trees. Others were in a gradual transition to oil palm, already interplanted, or depended on natural regeneration of rubber within the plot for the trees currently being tapped. Some plots had been completely destroyed as the land was sold to a local coal-mine developer. Overall tapping frequency was low, as farmgate rubber prices have in recent years been low and farmers had other options (including participating in small-scale gold mining).

In only a few of the RAS experimental plots (Wibawa et al. 2006) clonal rubber stems were currently tapped. In some plots a next generation of rubber trees, spontaneously established from seed, was currently being tapped. Some had large rubber trees available for tapping if prices and labour conditions would make that relevant. Other plots had been converted to oil palm, were in the process of conversion, or had been sold to a local coal mining entreprise. Some plots had a healthy growth of timber trees. We will discuss observation based on this post-doc classification.

Plots where rubber trees continue to grow and are still being tapped
Farmers are still tapping the rubber stems that are still alive (Figure 1) and are growing saplings of clonal rubber. These farmers depend on rubber latex for family income, medical expenses and for school fees for their children; some had used the proceeds from selling rubber latex to pay for a pilgrimage to Mecca (Saudi Arabia).

Rubber trees continue to grow and are not tapped
Rubber trees of the PB260 and IRR clones had died from attack by the white root fungus disease in several of the plots. According to farmers, the BPM1 clone had been the most resistant to fungal attack. Tapping results for PB260, RRIC100, RRIM600 and BPM1 clones had been better than expected for local rubber germplasm, while GT1 results were considered t be average. Although not currently being tapped, farmers still let the clonal rubber trees

grow, as there were valuable meranti (Shorea leprosula) (Figure 2A; Tata et al. 2014), tembesu (Fagraea fragrans) (Figure 2B) and various local fruit trees in the plot. As other sources of wood had become scarce, e.g. for house building or repair, they expected to use the wood locally.

Rubber trees have been felled and land use switched to oil palm and Coal Mining

Most of the rubber gardens where trees had died due to white root fungus disease have been converted to changed to oil palm (Figure 3A), or where in the process of conversion by interplanting methods (Figure 3B). One of the plots had been converted to a coal mine and still had no land cover (Figure 3C). Farmers expected the oil palm to be resistant to white root rot and other diseases. Farmers followed the practices of neighbours who planted oil palm before and had worked in commercial oil palm plantations. They expect oil palm to require less labour than rubber farming.

Farmer experience with intensified rubber agroforestry systems

Farmer experience with the various clones tested led to mixed opinions on which (if any) of the clones introduced were superior to what farmers used in the past (and what still regenerates in the landscape). GT1, a robust clone, was seen as hardly more productive than local germplasm, the PB260 and BPM1 clone were productive, but especially PB260 sensitive to white root rot disease. The quality of rubber wood from the IRR clones was a concern for some farmers. A more in-depth comparison is called for. The most successful intervention, from farmers' as well as environmental perspective, has probably been the interplanting of meranti (Shorea leprosula) or tembesu (Fagraea fragrans) trees in young rubber stands, with good prospects for generating substantial income.

Economic impact of the use of stimulants on rubber farming in Tanjung Makmur Village Pedamaran Timur Sub-District Ogan Komering Ilir District

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EXTENDED ABSTRACT
Rubber is one of Indonesia's leading plantation commodities. Rubber plants are widely spread throughout Indonesia, especially on the island of Sumatra, and also on other islands that are cultivated by state, private and community plantations. A number of areas in Indonesia have conditions suitable for rubber plantations, mostly in Sumatra, including North Sumatra, West Sumatra, Riau, Jambi and South Sumatra (Budiman, 2012). The main problem in natural rubber development is the low productivity level of rubber land (Riyadi et al., 2017). Based on the total area, Indonesia actually has a larger area than Thailand, but the productivity of rubber in Indonesia is only 836 / kg / ha / year, while in Thailand the productivity reaches 1,600 / kg / ha / year. The low quality of bokar (rubber processed material) causes the competitiveness of Indonesian rubber to be relatively low and is valued at a lower price compared to rubber produced by Thailand, Malaysia, Vietnam and India (Zahri, 2014). One of the ways to increase rubber farming production is through a stimulant exploitation system. Exploitation of rubber plants is the act of harvesting latex from rubber trees so that maximum results are obtained in accordance with the production capacity of rubber plants in the planned economic cycle (Wibowo, 2014). This study aims to analyze the comparison of income and analyze the revenue ratio of rubber farmers who use stimulants and non-stimulants in Tanjung Makmur Village, Pedamaran Timur District.

Sampling was done using the proportionate stratified random sampling method. There are 2 layers in the sample of farmers, namely farmers who use stimulants (layer 1) and farmers who are non-stimulants (layer 2). The total population of rubber farmers was 399 households consisting of 325 stimulant farmers and 74 non-stimulant farmers. A sample of 13 percent was taken for each layer so that layer 1 amounted to 40 farmers and layer 2 amounted to 10 farmers, the total sample for the analysis tool was 50 farmers. The data were processed using descriptive and mathematical statistical analysis.

A stimulant is a mixture consisting of vegetable oil (for example palm oil) with natural fat (called a carrierstimulant) and the active ingredient etephone. Stimulant technology has long been known by rubber agribusiness actors to increase crop productivity. The best known stimulant is a type of liquid with the active ingredient etephon. This type of stimulant is used in almost all natural rubber producing countries. Giving etephon can increase production mainly due to its effect on latex flow and regeneration, etephon can increase the stability of the lithoid so that the blockage index decreases. The positive effects of using stimulants are: making cell walls elastic; accelerate and increase the activity of enzymes in the biosynthetic latex; accelerates the flow of latex. Apart from positive effects, the use of stimulants also has negative effects, namely: inducing irregularities in metabolic processes, such as thickening of the bark, necrosis, the formation of cracks in the skin, and the appearance of unproductive parts; excessive use of etephon also results in cessation of latex flow; and shorten the economic life of plants (Njukeng et al., 2011; Sumarmadji and Atmaningsih, 2013).

The stimulant or growth regulator used by farmers in Tanjung Makmur Village is made from the active ingredient etefon with the trademark Guela. The technique used by farmers in Tanjung Makmur Village is using the groove application technique. This technique is used for the lower tapping field by applying a stimulant to the tapping field that has dried using a paint brush or toothbrush. After the stimulant was applied, tapping was not done for 1 day.

Based on the results of mathematical calculations, it is known that the production yield and income of rubber farmers who use stimulants are higher than those of non-stimulant rubber farmers. The difference in production is 15.08 kg/ha/month and the difference in income is Rp. 20,973.22 per hectare per month. The existence of a small difference in income is due to the higher production costs of stimulant rubber farmers, while the price received is lower than that of non-stimulant farmers. Based on the calculation of R/C ratio, it is known that the R/C ratio of non-stimulant farmers is actually higher than that of stimulant farmers. The use of etephone stimulants can increase the yield of latex, but the size of the rubber plant's response to stimulants, among others, depends on the type of clone, the age of the rubber plant, the concentration of stimulants, and the tapping system, especially the intensity of the tapping. Application of latex stimulants that do not follow the recommendations can cause side effects including: decreased dry rubber content, decreased stem convolution rate and increased occurrence of tapping groove dryness. Stimulants are generally given to rubber plants that have entered their productive period (producing rubber plants that have reached the age of 15 years), because stimulants to young plants can affect plant growth if applied without reducing tapping intensity. The application of stimulants is also not recommended for 25 year old rubber plants (Suherman et al., 2020).

Based on the results of the study, it is known that stimulant farmers' rubber production was 5.56 percent higher than non-stimulant farmers, while the difference in income was only 0.89 percent. It can be ruled out that giving stimulants to plants in Tanjung Makmur Village has little economic impact in terms of production and farmer income.

Nutritional requirements of rubber trees planted under rubber forest plantation systems

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EXTENDED ABSTRACT
In order to accommodate the demand of the wood industry in Malaysia, a concept of rubber forest plantation was introduced in early 2000. Planting density of the forest plantation was increased from 450 trees/ha to 625 trees/ha of land. The rubber forest plantation concept allows the planters two options, either to produce latex at 9th years after planting and harvesting the wood after seven years of tapping have elapsed or solely harvesting the rubberwood after 15 years of planting. Economically, Johari et.al (2005) has stated that the options involving both latex and-wood extraction will provide higher net returns compared to those involving only wood extraction which involves 15-year planting cycle. In order to maximize the profit return, fertilizer input for the rubber forest plantation was reduced to half of normal fertilizer given in conventional rubber plantation. However, the effects of reducing the fertilizer input towards the growth and yield of the rubber tree were never fully examined. Subsequently, a trial was carried out in 2008 to test the effects of different fertilizer rates on the growth of three different clones i.e. RRIM 2025, RRIM 3001 and PB 350. The fertilizer treatments were half of the normal fertilizer rates, normal fertilizer rates, 1.5 times the normal rates and twice of the normal fertilizer rates. Results showed that rubber trees receiving half the rate of normal fertilizer had the smallest bold circumference at fifth year of planting which may indicate that the trees were not receiving an adequate fertilizer to support the growth of the trees. This paper will further elucidate the effects of receiving different rates on the growth of rubber trees planted under the rubber forest plantation system.

Which model to simulate the ecosystem services provided by agroforestry systems based on rubber trees?

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EXTENDED ABSTRACT
In rubber-based agroforestry systems, trees (*Hevea brasiliensis*) can be combined with other intercrops to improve ecosystem services such as primary productivity (i.e., biomass and yield), carbon sequestration in soils, soil organic matter, availability of mineral elements (N, P, K) for plants, and water transfers in the system. Models are necessary to provide analysis integrating these different processes influenced by cultural practices in all compartments of the soil-plant-atmosphere system. In order to learn about which model is best suited to meet this need, this article reviews the main crop models used and their characteristics, and presents a bibliometric analysis of their ability to simulate trees and intercrops. This review revealed that the WaNuLCAS model has the desired characteristics to simulate scenarios of rubber and intercropping associations, the impacts on ecosystem services, and which are not reflected to such an extent by other models. However, the WaNuLCAS model is intended to be a prototype model which does not include all the possible relations of tree-soil-crop interactions that can be expected. Therefore, as perspective of this work, we suggest to conduct sensitive analyses and adaptation of some specific parameters to improve the overall quality of its prediction according to local pedoclimatic conditions.

Key words Soil. Climate change. Rubber intercropping. WaNuLCAS

Preliminary results of prospective trials on Rubber-Forest tree associations in Cambodia

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EXTENDED ABSTRACT
Rubber plantations in association to timber trees species can be an interesting option to address several environmental issues in Cambodia. It could be a tool for reforestation, carbon sequestration, soil health enhancement, and ex situ conservation of endangered species via the constitution of large genes banks on attractive economic basis.

CCRI in partnership with CIRAD had implemented three trials in 2005, 2006 and 2008 in CRRI station (Chup, Tbong Khmum, Cambodia, 11°57'N, 105°34' E). The aim is to prospect feasibility of Rubber-timber tree species associations with 14 species, selected for different characteristics and production purposes: valuable/ endangered species (over-logged in forest area), reference species of timber and pulp trees and species for non-timber products.

The three trials are implemented on red oxisol developed on basalt substratum; preceding crops consist in old (> 50 y.) rubber plantations. They all follow the same planting pattern, with rubber trees planted at 555 trees/ha in hedge rows at (13,0 + 3,0 m) x 2,25 m, and timber trees in simple (or double) rows in the middle of the double inter-row space, at 250 (or 500) trees ha-1. The legumes Stylosanthes guianensis is implemented during the planting year and used as cover crop during first 3 years, up to its disappearance by shading.

The 2005 trial compares rubber-teak association (250 teak trees.ha-1) with two control plots (without teak trees), for 2 clones, GT1 and IRCA 230; the two control plot are located on each side of the rubber-teak association. Elementary plots contains 108 measured rubber trees. The 2006 and 2008 trials are simple collection of associations with various species (Table 1); elementary plots contains 108 rubber trees (GT1).

Observations during immature period consists in girth measurements (at 1 m high) twice a year and mortality record for both rubber and associated species. Statistical treatment consists in mean comparisons; in the 2005 trial, two neighboring control plots allow catching potential gradient of bio-physical conditions. In 2006 and 2008 trials, means comparison are made under the disputable hypotheses of absence of any (i) soil effect and (ii) incidence of the neighboring species association.

In the 2005 trial, teak trees combined with Stylosanthes guianensis cover affects slightly rubber growth for less (GT1) and more (IRCA 230) vigorous clone. In 2006 trial, doubling the density of associated teak trees does not pair with a noticeable impact on rubber trees growth; in the trial 2008, the improved teak variety presents better growth performance compared to variety used in 2006, without noticeable increased incidence on rubber tree development. In 2006 and 2008 trials, among all associated species, sole Acacia auriculoformis induces a marked depressive effect on rubber development at 5 years old. The

trials permit to sort the timber species per behavior class and to identify notably which species have a good growth rate with a limited incidence on rubber growth, during the immature period:
-slow growing trees with no or low effects on rubber growth. Ex: Afzelia xylocarpa, Dalbergia bariensis,
-slow growing trees with no or low effects on initial rubber growth, but with an increasing speed of growth when rubber trees start to shade. Ex: Hopea odorata,
-Medium trees with probable medium effects on rubber growth. Ex: Pavonina adenantera, Albizia lebbeck, Moringa oleifera, Dipterocarpus alatus, Sindora siamensis, Pterocarpus macrocarpus,
-Fast growing trees with marked effect on rubber growth. Ex: Acacia auriculoformis.

Data collection and treatment for rubber production during first 10 tapping years will soon allow to complete the here presented observations made during the immature phase. With behavioral observations of the timber species, it could feed the conception of innovative rubber based agroforestry systems relying on more complex associations. For instance, these prototypes could mixed species with different purposes like
-production of high value log or non-timber products,
-harnessing cropping systems with agro-ecological functions (N fixation, litter production)
-ecosystem services (carbon sequestration, biodiversity conservation and enhancement, socio-cultural amenities.

They could be conceived for different production contexts (smallholders, private investors or estate) on different time horizons, for instance on one (30 years) or two (60 years) rubber cycles.

Proggres of rubber breeding program to support agroforestry system

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EXTENDED ABSTRACT
The use of superior rubber planting materials is one of the most important components of technology to support the cultivation program and sustainability of the natural rubber industry. The effect of the genetic components of planting materials to the rubber productivity can reach 60%, and the rest is the influence of agro-climatic conditions or environment. The aim of the rubber plant breeding program is to obtain the new superior rubber clones that have a high latex yielding potential and a good agronomic characters. The fluctuations of natural rubber price and climate changes also influence the direction and objectives of the rubber plant breeding program. To deal with the conditions, it is important to provide the rubber agroforestry technology by through intercropping of rubber with various other crops. The article provides information the progress of rubber breeding program and it is role in supporting agroforestry. Various of new superior rubber clones have been produced by the Indonesian Rubber Research Institute, namely IRR 112, IRR 118, IRR 220 and IRR 230 with a potential latex yielding about 2.5 - 3 ton / ha / year. Some of these clones had been planting with coffee, rice, soybean, corn, and other crops by through intercropping system. The system was estimated be be able to maintain latex yielding potential of clones as well as farmers' income can be improved.

Key words: Hevea brasiliensis, intercropping, latex productivity, clone

On-farm effect of bamboo intercropping on soil water content and root distribution in rubber tree plantation

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EXTENDED ABSTRACT

Introducing permanently an associated crop in rubber plantations may improve biodiversity and soil cover, optimize resource use and diversify farmer's income. One of the main issues in choosing the intercropped species and the plantation design is the potential competition between rubber trees and the associated crops for resources such as light, water and nutriments (1). In particular, there is a risk of competition for water if the root system of the associated crop and the tree share the same resource. However, agroforestry systems (AFS) may be more efficient in water use, as the competition with a crop may 'force' the tree roots to grow deeper and reach the water table, therefore enhancing the sustainability of the system (2).

Bamboo plants are multipurpose species that have a high potential for AFS, as they can be used for both self-consumption and as a cash crop (3). The case of bamboo-rubber agroforestry system is peculiar, as bamboos present features common to both grasses and trees, they grow fast and are considered strong competitors for water (4). There are no recent studies informing whether bamboo can be intercropped with rubber trees and what the competition for resources would be. However, some farmers in southern Thailand started to intercrop bamboos into existing rubber plantations. We took the opportunity of such existing plots to investigate the impact of rubber-bamboo intercropping system on root competition and soil water content in one such farm. The hypothesis was that intercropping bamboos in rubber plantations could improve the soil and enhance water conservation, therefore decreasing root competition and improving the sustainability of the system.

Soil organic matter and water content, bulk density, root distribution, canopy cover and rain interception were studied on farm to understand the effects of bamboo intercropped in rubber tree plantation, compared with rubber monoculture. The investigation was located in a smallholder rubber plantation in Songkhla Province, the traditional rubber cultivation area in southern Thailand. Two adjacent plots of the same farm were compared, both planted with RRIM600 budded-stump, the most common clone in Thailand. Soil texture was the same in the two plots. Both plots were first planted in 1996 as rubber monoculture (MO) with usual spacing of 3x7 meters (476 trees/ha). In one plot (RB, Figure 1), bamboo seedlings (Gigantochloa nigrociliata) were planted in the middle of the inter-row in 2006 when the rubber trees were 10 y-old. Bamboo spacing was the same as rubber (3x7 m). Sampling design is decribed in Figure 2. Soil physical properties were measured by core sampling at depth 0-10, 10-20 and 20-30 cm in June 2017. For chemical analyses, soil samples were collected at six random locations in each plot at depth 0-10, 10-20, 20-30, 30-40, and 50-60 cm by hand auger. Volumetric soil water content was measured weekly by a soil profile probe model PR2 (Delta-T, England) at the same depth plus 90-100 cm. There were 3 replicates in each treatment (MO and RB plot), along a diagonal transect. Fifteen profile tubes were installed per replicate. Fine root (≤ 2 mm diameter) distribution was measured in March 2017 when rainfall resumed. The samples were taken by hand auger next to one soil moisture monitoring location and diagonally between two representative rubber trees; at 50, 150 and 250 cm from each rubber trunk, by 10 cm long cores, down to 100 cm. The samples were washed to separate the soil from roots, then rubber and bamboo roots were separated. Root length density (RLD) is the ratio of total root length per volume of soil sampling (cm cm-3). The canopy cover was measured by hemispherical photography taken every week at 15 points in each plot. Throughfall, rainfall that is not intercepted by the canopy and reaches the floor, was collected by 15 rain gauges installed beneath the canopy at the same locations as canopy measurement. Rainfall was collected by three rain gauges installed in an open area, about 30 meters from the experimental plots. Data was collected weekly.

Soil properties were not much different in the monocrop or the association. However, there was a slight improvement with bamboo (RB) in shallow horizons (0-30 cm): bulk density tended to be lower whereas, soil organic matter, CEC and hydraulic conductivity were higher. The most significant result of this study was that the soil water content (SWC, Fig 3) was higher in MO at shallow depth (0-30 cm), particularly during dry periods, whereas it was the contrary in deep soil (30-100 cm). A first explanation could be that the water input to the soil was reduced in RB by higher rain interception. Actually, canopy cover was higher and throughfall lower in RB. SWC is a balance that can be either positively or negatively affected by factors linked to the density of the above and below ground biomass. In our case, the higher total biomass in RB had a negative effect on SWC in the upper soil layers, but a positive effect in the deeper soil layers.

Some bamboo species are considered invasive or too competitive for nutrients with associated species (5). But one of the major finding of this study was that in presence of bamboo roots, density of rubber fine roots was only reduced in the first 30 cm and that the total (rubber + bamboo) fine root density was higher in RB than in MO (Figure 4). The RLD of bamboo plants was in the same range as that of rubber trees, with a trend to be higher in deep soil (40 to 100 cm). The higher root density in RB may act as a buffer that could conserve water in deeper area. Previous results with other bamboo based systems showed that bamboo roots could increase water infiltration towards deeper soil layers (6). This showed that there was limited competition in space between the two root systems. This is an important result because root competition is considered one of the main issues in AFS, a particular concern in rubber-bamboo intercropping. Canopy cover was denser in RB than in MO, showing a complementarity between the two species. As bamboos were planted when rubber trees were already 10 year old, rubber trees occupied the top layer (20 m) and bamboos the lower layer (13 m) that was almost free of rubber branches due to self-pruning of shaded rubber branches. Thereby, the bamboo canopy did not impede the rubber canopy and did not limit its access to light. The limited throughfall was directly related to the denser canopy in RB. Bamboos can reduce the amount of throughfall because of their thick and evergreen canopy (7). This interception of raindrops by the bamboo canopy below the rubber trees may have a positive impact on erosion, an important issue when rubber plantations are set up on slopes (8).

Working on-farm induced specific limits to the study. We did not have real replications of the treatments, i.e. different plots for each treatment. Uncontrolled differences in the management of the monocrop (NPK fertilizer, no thinning) and the rubber-bamboo association (no fertilizer, thinning of the plot by removing "dry" trees) could have induced too some bias in our comparison. However, the expected effects of these differences would be contrary to the observed effects. Therefore, an RB plot with the same management as the MO (fertilized and no thinning of rubber trees) would likely show the same pattern we observed, but with enhanced differences with MO.

There was little competition for space above and belowground in an agroforestry system where bamboos were planted in between rows of 10 year old rubber trees. Because of a denser canopy and a denser root network, the soil water content was lower in the rubber-bamboo association than in the rubber monocrop. However, this was true only in the shallow soil layers. In deeper layers, the SWC was higher in the association, showing that this agroforestry system may have a positive impact on water resource and be more sustainable than the monocrop. The better soil cover in the Bamboo-Rubber association may limit erosion and the necessity to use herbicides, therefore reducing the main source of chemical pollution by rubber plantations (1). As bamboo offers an additional source of income, this makes rubber-bamboo agroforestry systems promising for farmers. The next step will be to survey latex yield and to better characterize the effects of bamboos on soil properties linked to water, herbicide and nutrient cycle.

Sub-Theme: Socio-economy of Rubber-based Agroforestry Systems

Dissemination technologies for smallholders rubber production systems in Jambi, Indonesia

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EXTENDED ABSTRACT
Rubber is one of the important agricultural commodities in Jambi, Sumatra, Indonesia. However, in developing rubber, especially smallholder plantations, there are still many obstacles existence. One of the efforts to overcome these problems is through the adoption of location-specific technological innovations. This paper describes the efforts to introduce and disseminate local-specific rubber technology innovations in Jambi. Activities were carried out in several farmers' plantations for several years (from 2010 to 2018). Numerous activities were applied in farmer fields such as assisting JAP control fertilization technology, SL-JAP replanting, Increasing KKK> 55%, Directing farmers to produce wind sheets and clean rubber products, Increasing the role of farmer groups to partner with the private sector. The results showed that through mentoring and the introduction of site-specific technology: the average rubber productivity at the farmer level ranged from 1-1.2 tonnes/ha/year, in terms of the potential production can be reached up to 1.5-2 tonnes/ha/year, replanting, seeding and improvement of seed quality, balanced fertilization recommendation, tapping shoot pattern and maintenance, and handling of harvest and post-harvest rubber products. The dissemination technologies that have been carried out by the Jambi AIAT as above will be described further in this paper.

Keywords: Rubber, Site-Specific Assessment, Jambi

Rubber Agroforestry Systems (RAS) evolution in West-Kalimantan, Indonesia

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EXTENDED ABSTRACT

In 1994 in the Sanggau/Sintang area in West Kalimantan province, most farmers relied mainly on jungle rubber, an old agroforestry system based on rubber seedling with low productivity lad low establishment and maintenance costs but high biomass and biodiversity due to the secondary forest regrowth. Most farmers at that period wanted to have access to clonal rubber planting material in order to improve their land and labor productivity. Basically, rubber clones do produce 3 times more than seedlings according to SRDP/TCSDP project farmers performance. The CIRAD/ICRAF/IRRI project called SRAP (Smallholder Rubber Agroforestry project) has set-up on farm trials with 60 farmers in order to optimize clonal based new RAS according to local conditions and constraints. When SRAP started (1994/2007), the original objectives were multiple: i) to provide clone and high rubber productivity, ii) to maintain agroforestry practices to profit from advantages and positive externalities, and iii) to diversify income through timber, fruits, resins (Gaharu, Damar…) and other forest products (rattan, medicinal plants, forest vegetables etc) as well as increase self-consumption of key products (rice intercropping, timber for housing, fruits for improved diets, medicinal plants etc…). In 1997, came in the landscape oil palm estates though the very high and rapid development of private concessions according to governmental policy on order to develop a so called "modern agricultural sector" compared to "old fashion jungle rubber" agriculture. Oil palm became in the 2000's the main priority for most smallholders due to high productivity and income and better return to labor. Today, all forest and most local jungle rubber have disappeared to the profit of roughly 2/3 of the area planted with oil palm (estates and smallholder) and 1/3 with clonal rubber for smallholder, either in monoculture or agroforestry. Official BPS statistics do not permit to establish the type of rubber plantation: jungle rubber, RAS or monoculture.

In 2019, CIFOR/FTA program funded a mission to CIRAD to obtain information about the evolution of rubber agroforestry trials plots that were established in the 1990's with ICRAF in the province of West Kalimantan. All villages located in Sanggau area were trials plots were established in 1994/1997 have been visited (Kopar, Engkayu, Embaong, Pana and Trimulia) as well as the former SRDP Sanjan village were project farmers were the very first to re-introduce fruit and timber trees within their project clonal rubber initial monoculture, providing preliminary results about local RAS. Surveys in this village enable to establish 2 main facts: i) combination of up to 250 associated fruit and timber trees with rubber in normal planting density do not have any negative impact on rubber production (at the condition that canopies are not above that of rubber) and 2) there is a necessity to optimize tree combination. This provided the basis for establishing 3 types of RAS trials in participatory approach with local farmers identify well adapted RAS according to local conditions on 2 main criterias: i) presence or not of Imperata cylindrica, a very constraining weed and 2) level of intensification for associated trees.

The survey provide the main results of RAS evolution and an idea of the historical and current trend in terms of local farming strategies. It raised also the question of clonal planting material availability for replanting and the poor tapping quality that lead to a reduction of the clonal rubber lifespan. In the region under study, the major change in land use and farmers' strategies has been clearly the rapid and significant development of oil palm which quickly became the priority number one for local smallholders. In the meantime, local estates took over most of the available land for their own oil palm plantations. Meanwhile, low rubber price hampered any interest in rubber cultivation. Despite this situation, smallholders did not want to abandon rubber definitively. Rubber is still planted, as it provides a better use of available family labor, in complement of that used for oil palm production and income diversification (monoculture and RAS 2 mainly). Evolution of trials status over the period1994/2019 display the following results: i) Conversion to oil palm (20 %) or to clonal rubber monoculture (20 % mainly in Trimulia in Transdmigration area), ii) with agroforestry systems maintained in RAS 1 or 2 (50 %) and iii) evolution to tembawang at the end of rubber lifespan (10 %).

We are back to the same problems and same situation that we faced in 1994: poor access to clonal planting material, no training on tapping frequency and practices but with some knowledge on clones and AF practices. It seems that there is no transmission of rubber cultivation techniques to young farmers and sons. All trials are at the end of their lifespan, which was reduced down to 20-25 years due to diseases and poor tapping practices. Agroforestry practices have been considered as very interesting for most farmers: i) during the immature period of rubber trees, for a better valorization of land with intercrops or reduced costs of establishment depending on the type of RAS and 2) income diversification (either for self-consumption or marketing, for some fruits and timber) and improved farm resilience and less dependency to commodity price volatility.

The lessons learned are the following: i) Rubber agroforestry trials came right in time in 1994, with a strong demand from farmers for systems providing low establishment cost and income diversification: the right time at the place, BUT, ii) Oil palm came in 1997 with a very strong pressure from companies (through the policy of concessions) providing a lucrative alternative to rubber cultivation with full credit (but loss of land) and better return to labor, iii) Interest in agroforestry practices remains high for old men but no interest is witnessed from younger generation, iv) It is now time for rubber replanting as trees are old, and the same old story remains (access to planting material), v) Good tapping practices (tapping school and training, technical information on panel management, upward tapping ….) are essential to be able to maximize tree lifespan up to 35 years long, vi) Important impact of white root and other root diseases in areas with forest or old jungle rubber before plantation and vii) Low rubber prices since 2013 especially compared to palm oil do not help in maintaining farmers' interest in rubber cultivation.

The early benefits of agroforestry as the solution of social conflict and peat land degradation in Kampar-Riau, Indonesia

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EXTENDED ABSTRACT
Riau is one of the provinces in Indonesia which has vast area of tropical peat swamp forest (TPSF). However, most of this forest have been degraded and deforested due several impolite management, especially which were related with uncontrolled water management through drainage/canal establishment. Another factor which cannot be neglected is about social conflict. Moreover, in TPSF degradation, the factor of social conflict has two sides, as the causal and impacted factor. Therefore, in order to overcome the TPSF degradation, concern also must be given to overcome the social conflict problem. Agroforestry has been mentioned has good potency to be selected as one of the tools to overcome the problem of degraded peat swamp forest (PSF) which was associated with social conflict. Here, we evaluated the early benefits of agroforestry for some aspects which has relationship with the attempt to overcome social conflict and peatland degradation.

We established the experimental plot of agroforestry (about 2.7 ha) in the conflict area at forest area with special purpose/kawasan hutan dengan tujuan khusus (KHDTK) in Kepau Jaya Village, Kampar District, Riau Province. In this plot, we planted three native tree species of TPSF namely were Balangeran (Shorea balangeran), Geronggang (Cratoxylum arborescens) and Gelam (Melaleuca cajuputi subsp. cumingiana) in similar planted spacing (6 m x 3 m). Around the edge of the plot, we also planted the Liberica Coffee (Coffea excelsa) and Aren (Arenga pinnata). In this plot, between rows of tree plantation the local farmer cultivated their crop. For this crop cultivation, the kinds of crops and its cultivation technique were selected based on farmer interest. Several cultivated crop were Melon, Chili pepper, Corn, Cucumber, Luffa (gambas) and Cassava. For early evaluation, we observed: survival rate, height and diameter of the three native tree species; the temporary income of local farmer from crop yield and the interest of local farmer to the agroforestry system. The instruments which were used for collected those data were measurement stick, caliper and questioner. Beside of those, the deep interview was also undertaken.

After one year of agroforestry plot establishment; the range of survival rate (SV), total height (H) increment and collar diameter (D) increment of all tree native species were 56.2% - 72.44%, 97.4 m/year – 163.0 m/year and 2.04 cm/year – 3.2 cm/year, respectively. Among the three native tree species, the best SV was shown by Geronggang, while for the best of H and D increment was showed by Gelam. Overall, in this early evaluation the growth of the native tree species was relatively promising. However, the improvement must be given to the survival rate, which the cultivated practice of farmer was suggested as one of main factor that contribute to the native tree species mortality. Among cultivated crops, the best income was obtained from the yield of Melon (Cucumis melo) and Chili pepper (Capsicum sp). From the yield of these crops, farmer could obtain income about 6 million IDR per month. However, the loss income was observed from the Luffa (gambas) cultivated, due to the inappropriate to predicted market demand. From this 2.7 ha agroforestry plot, thirty local farmers have been involved and joined in to one community forestry farmer group (kelompok tani hutan/KTH), although in fact the consistent active farmer in this agroforestry plot were relatively few of thirty local farmers. Beside of those results, we also observed that during this agroforestry activity, the intensity of forest disturbance by the local community around KHDTK was relatively reduced. It is important to manage and increase those diverse benefits in further years, so the existing of agroforestry in order to improve degraded peat forest and resolve the social conflict will be real. To realize this target, the good and intensive communication among stakeholders is one of important parts that must be continuously implemented in the field.

Keywords: Agroforestry, farmer, native tree species and social conflict

Indonesian natural rubber export potential in European market

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EXTENDED ABSTRACT
Indonesia is one of the largest natural rubber exporters in the world. On the other hand, the potential for natural rubber in the world market is enormous, given the large number of potential markets, especially for industrial purposes. Currently, the Asian continent is the largest market for Indonesian natural rubber, followed by American and European market. Currently there have been many studies on the competitiveness of Indonesian natural rubber exports to the international market, but there is not much research on the competitiveness and potential of rubber exports specifically to European countries. This study aims to determine the competitiveness and the potential of Indonesian natural rubber in European countries, namely Germany, French and Spain. The method used in this study is descriptive analytic, to be able to provide a systematic description of the facts and characteristics of the object or subject accurately. Meanwhile Revealed Comparative Advantage (RCA) was used to determine Indonesia's competitiveness in each of the partner countries while Export Product Dynamic (EPD) was used to determine the performance of Indonesian natural rubber in partner countries. The RCA index results show that Indonesia has competitive advantages in the partner countries, and the EPD matrix shows that Indonesia is in a rising star position in the German, French and Spanish markets. To strengthen this position, Indonesia needs to increase their export value, through the increase in production.

Sustainability of rubber agroforestry strategies in boosting smallholder's resilience to cope with the realities of new global challenges

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EXTENDED ABSTRACT
In the face of a global pandemic, the ever-present threat of climate change and the highly unstable economic and social global systems, the resource poor smallholder farmer is increasingly finding it harder to meet with the daily challenges of sustaining his family's livelihood. This paper is a review of the challenges of smallholder's rubber farmers, strategies adopted to build the resilience of the farmers and technological adaptations to sustain the resilience of the smallholder's farmers in Nigeria. The work looked at the manipulation of space or spacing techniques in rubber-based agroforestry systems, mixed farming in rubber production, cropping patterns, soil nutrient and weed management methods and socio-economic benefits to the rubber smallholders. The results indicated that Rubber Agroforestry systems help RESOURCE poor rural farmers increase family food supply, improve income and reduce the gestation period of rubber, leading improve family livelihood and national rubber production output.

Keywords: Rubber Agroforestry, smallholders, sustainability, resilience, climate change

Rubber agroforestry system in Indonesia: Past, present, and future practices

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EXTENDED ABSTRACT
Indonesia is the second largest rubber producing country after Thailand. The area of rubber in 2018 was about 3.7 million hectares with the total production of 3.6 million tons. Among those areas, 88.13% were owned by smallholders, and the rest belongs to private estate (5.16%) and government estate (6.7%). Productivity is still become the problem at smallholders' level. Some efforts have been conducted in order to improve the productivity of smallholders. The concept of agroforestry has become increasingly relevant in recent days as they introduced new commercial opportunities to smallholders. Agroforestry, with its multiple environmental and economic benefits, can help the agriculture and forestry sectors find innovative solutions to present-day problems: including low profitability, environmental impacts, and negative public perception This paper presents the implementation of rubber agroforestry system at the smallholders' level since the past, current situation and future scenario for agroforestry in order to support the sustainability of rubber smallholders.

Keywords: Agroforestry, rubber, smallholders

The competitiveness of the natural rubber by exporting country in the global market

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EXTENDED ABSTRACT
Natural rubber commodity is an important raw material for various industries in the world. This also encourages the increasing demand for natural rubber from year to year. Trademap data for 2021 shows that the world's demand for natural rubber has increased by approximately 61 million USD per year from 2001 to 2019. The high demand for natural rubber in the world provides an opportunity for natural rubber exporting countries to be able to compete in meeting this demand. Until now, there are 3 countries with the largest natural rubber suppliers in the world, namely Thailand, Indonesia and Malaysia. On the other hand, the comparative level of export competitiveness of the three countries is not yet known. Therefore, this research was conducted to determine the export competitiveness of the natural rubber exporting country in the world.

The data in this study used secondary data from 2001 to 2019 sourced from Trademap. Furthermore, the data were analyzed using the RCA (Revealed Comparative Advantage) index to determine comparative competitiveness and EPD (Export Product Dynamic) to determine the position of each exporting country in the world market. The results of the analysis show that the highest export competitiveness shown by the RCA index is Indonesia, followed by Malaysia, and Thailand. Even though the competitiveness of Indonesia and Malaysia is better than Thailand, this country has a declining RCA trend. The Indonesian RCA index has decreased relatively by 1.31 per year and the RCA index for Malaysia has decreased relatively by 0.98 per year. The results of the EPD analysis show that the position of Indonesia's natural rubber export performance is in the lost opportunity category, while Thailand and Malaysia are respectively included in the rising star and retreat categories.

Indonesia has the potential to lose its share in the world natural rubber market. This can be seen from the export performance which is included in the lost opportunity category. In addition, the trend of the competitiveness of Indonesia's natural rubber exports has also decreased. The same thing happened to the export performance of Malaysian natural rubber. This phenomenon can be caused by the low production and productivity of natural rubber in Indonesia and Malaysia. In addition, the conversion of rubber plantations to oil palm plantations and other commodities also suppresses natural rubber production. Thailand is noted to have high natural rubber production and productivity, even reaching double the production and productivity of Indonesian natural rubber. Efforts to increase production and productivity can be done by using superior rubber clones, coagulants, and using fertilizers appropriately.

Key words: competitiveness, natural rubber, exporting country

Economic perspective of Indonesian rubber on agroforestry development

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EXTENDED ABSTRACT

Agroforestry is a land-use system by combining forestry components with other activities such as agriculture, particularly plantation crops. Rubber is one of the plantation crops integrated in agroforestry and it creates employment in rural areas. Thus, the farmers relay on this commodity for their daily livelihood.

Rubber price decrease results in relatively lower farmers' purchasing power and welfare of farmers [1]. Low rubber price affects farmers' income, investment ability to establish improved rubber plantations, purchasing power of primary and secondary goods, and income sources to other ones. There is also change in land use from rubber farming to other more prospective crops [2]. A study conducted by the Fair Rubber Association revealed that unstable world rubber price affecting rubber farmers in all rubber-producing countries, e.g. Indonesia, Thailand, Vietnam, and India [3].

Intensive economic linkages nearby the plantations will affect rubber commodity development in agroforestry areas. Rubber agroforestry needs to take account global trade as it drives the development of agroforestry itself. In general, the purpose of this paper aims to describe the rubber international trade. This paper specifically aims: (1) to identify and to classify the factors affecting the Indonesian rubber economy, and (2) The development of Indonesian rubber agroforestry.

Data used in this paper is the secondary data consisting of national and global data, especially those from the member countries of the International Tripartite Rubber Council (ITRC) forum, such as Indonesia, Malaysia, and Thailand. The analysis method uses Principal Component Analysis (PCA) which is expected to provide an overview of the conditions of the national rubber economy development. In addition, PCA statistically can help to solve the multicollinearity problem between the analyzed variables and present data with a simpler structure without losing the essence of important information contained in it. Thus, the efficiency and effectiveness of data handling problems can be improved [4].

PCA analysis begins with collecting variable data related with the rubber economy. Data will be processed by transforming the matrix multiplication and make it orthogonal. Results of the PCA analysis is a new data structure. The result of score factor calculation is obtained from matrix multiplication.

PCA analysis using 48 variables of basic data produces 7 major components as shown in Table 1. Variables group of major components generated by PCA analysis are: (1) Indonesian rubber economic performance; (2) input and output prices trend; (3) the world's rubber producers trend; (4) rubber consumption for downstream industry (especially that of tires) in the country; (5) plantation labor wages; (6) world's synthetic rubber price; (7) Indonesia's natural

rubber export to America. The five first components of the main seven components can explain the existence of Indonesia’s rubber economy. Initial Eigenvalues cumulative in the model is 86.75 percent indicate that Indonesia’s rubber economy can be explained by the variables in the existing model.

The first component, namely performance of Indonesia’s rubber economy, has Initial Eigenvalue of 53.343 percent. It shows that Indonesia's rubber economic trend has been export-oriented. The second component, with Initial Eigenvalue of 13.704 percent, shows that the rubber economy in Indonesia is affected by price movements, both input and output prices. The third component, namely rubber producers trend in the world, explains 8.561 percent of Indonesia's rubber economy. An interesting finding in this group of variables is that global production will negatively affect rubber acreage in Indonesia. The Indonesia’s rubber economy from a global perspective is explained in the main component of the variables group, namely rubber consumption for the downstream industry (especially that of tires) in the country (4.667 percent), wages of plantation workers (4.477 percent), world synthetic rubber prices (2.878 percent), Indonesia’s natural rubber exports to America (2.236 percent). The remaining is explained by other variables not included in the model.

Fulfillment of the world's demand for natural rubber has been largely derived from rubber produced from smallholder plantations with a monoculture system. Domestic production and productivity of natural rubber are still the main problems because most of Indonesia's rubber trees are old enough and require replanting. Natural rubber production produced from agroforestry still requires innovation and assistance to match the quality of the monoculture rubber cultivation system.

Development of rubber agroforestry rubber requires support from the business actors involved as well as the government and the private sector. Thus, it is urgent to anticipate the challenges ahead and to synergize development of rubber cultivation both monoculture and agroforestry plantations which will support each other in an integrated agribusiness system for meeting the global rubber demand.

Women involvement in smallholder rubber management in Ogan Komering Ilir and Banyuasin District, South Sumatra

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EXTENDED ABSTRACT

Smallholder rubber is one of livelihood options in South Sumatra. Twenty four of 34 villages sample that we surveyed in the Peat Hydrological Unit (PHU) of Sungai Sugihan – Sungai Saleh and Sungai Sugihan – Sungai Lumpur in Ogan Komering Ilir and Banyuasin District during December 2020 – February 2021 mentioned that smallholder rubber is important source of income for community. Focus Group Discussion at village level that participated by man and women farmers was done during data collection. Managing smallholder rubber that included land preparation, planting, fertilizing, controlling pest and disease, land management, harvesting, after harvest processing and marketing, not only part of man activity, but also involving women in all process. Generally, the proportion of women involvement is varied depend on the activities and village condition. Highest involvement of women in smallholder rubber management is in harvesting process, in balance with man at 50%. Women actively involved in rubber tapping. Less involvement of women is in land management such as weeding and controlling pest and disease at about 10%. Most of this activities done by man. Women involvement in land preparation, planting and fertilizing is about 20%, however, role of women increase in post harvesting and marketing at about 30%. Moreover, based on village type that categories from village position to the forest, there are: close to protected forest, production forest and non-forest land, shown that women involvement in smallholder rubber management in non-forest is tend to low in average at 15%, but higher involvement at 29% in protected forest and 33% in the area where close to production forest.

The profitability analysis of rubber plantation in Batang Hari Regency and Sanggau Regency (Study case: Penerokan Village and Semoncol Village)

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EXTENDED ABSTRACT
During 2009-2012 the price of rubber increased sharply, on the contrary during the 2012-2018 period the price decreased, even the price of rubber at the farm level in 2018 was lower than the average in 2009. The decline in rubber prices had an impact on the income of rubber farming. This study aims to determine the profitability of rubber farming in Batang Hari Regency and Sanggau Regency. The main data used is the ICASEPS' Patanas data base for 2009, 2012 and 2018. This study took cases in Penerokan Village (Batang Hari Regency, Jambi) and Semoncol Village (Sanggau Regency, West Kalimantan). Data analysis using RC ratio and profitability. The results showed that the average price of rubber during 2009-2012 increased from Rp7.961 / kg to Rp12.968 / kg or increased by 62.9%, but in 2018 this price decreased by an average of 45% to Rp6.875 / kg and tended to decreased. Revenue from rubber farming during 2009, 2012 and 2019 in Penerokan Village was IDR 12,974,000 respectively; IDR 10,843,000 and IDR 7,878,000 with an R/C ratio of 1.67; 1.87 and 1.67. Revenue from rubber farming in Semoncol Village 2009, 2012 and 2019 in Penerokan Village was IDR 10,656,000 respectively; IDR 15,990,000 and IDR 10,950,000 with an R/C ratio of 1.50; 2.00 and 1.29. Total household income during 2009, 2012 and 2018 was IDR 20,604,000 respectively; IDR 48,317,000 and IDR 41,744. The R/C ratio of rybber farming in both village are more than 1, indicating that the rubber farming is still competent to be labored. Household income in both loction still dominated by agricultural activities.

Economic prospects of a large scale rubber agroforestry in Nigeria

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EXTENDED ABSTRACT
Studies to develop a profitable economically viable Rubber based Agroforestry (RAF) for Nigeria was initiated by the Rubber Research Institute of Nigeria (RRIN) more than two (2) decades ago. The results showed the positive effects of the systems on soil characteristics, rubber growth rates, food crop production and cash flow for farmers. The systems were widely adopted by smallholder, but there is some resistance among the estates in Nigeria in adopting the technologies. This paper attempts to demonstrate the economic potentials of RAF in a typical rubber estate in Nigeria. Data collected from the model farm were analyzed using farm budgetary technique. The study showed that the economic benefit of Rubber intercropped with food cropsgenerated additional income to the farmers and it also limit the effects of financial stress on rubber farmers during the immature phase of rubber. The project worth for the rubber intercropped system options have higher positive net return (25%, 32% and 29% for Rubber + Maize, Rubber + Maize + Water Melon and Rubber + Cassava systems respectively) compared to 19% in the sole rubber system option . Policy conclusion follows that farm income could be increased through provision of subsidies for farm inputs to reduce cost of production and enlightenment campaigns in form of trainings, workshops and seminars.

Key words: Intercropping, profitability, farm income, rubber, Nigeria

Socio-economic benefit of rubber agroforestry system for improved livelihood in Edo State, Nigeria

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EXTENDED ABSTRACT

Rubber Agroforestry System (RAS) is an innovative farming system contributing significantly to the livelihood of smallholders in Edo State. Data for this study were collected from 120 rubber smallholder farmers having a contiguous 2 hectares farmland with the aid of structured questionnaire using multistage sampling technique with a 3-stage design. Data collected were analyzed using descriptive, inferential, and budgetary analysis. The result revealed that RAS farmers had some level of education, they attained secondary and tertiary education (34.17 % and 29.17 %) respectively. Majority, (90.83 %) of the respondents were male, with an average age of 47 years. Furthermore, the total annual revenue earned by the respondents was ₦992,500 with a mean annual net income of ₦527,003 while the return per naira invested was ₦2.69. This shows that for every ₦1 invested in the cropping combination in the RAS, there was a return of ₦2.69 in the study area. Thus, RAS provides income and employment for smallholder community to be self-sufficient and economically independent. This study concludes that respondents valued RAS as an innovative sustainable agroforestry system capable of generating income and employment. Government therefore should leverage through adequate fiscal policy to enable easy credit facility by farmers

Keywords: Rubber Agroforestry System (RAS), Profitability, Livelihood, Smallholder’s farmer

Sub-Theme: Agroforestry, Food Crops, and Food Security

A review of land use land cover change in the catchment area of Musi Hydropower Plant in Bengkulu Province

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EXTENDED ABSTRACT
This research was conducted to review land use land cover change in the catchment area of Musi Hydropower Plant in Bengkulu Province. The data used in this research is land use land cover map year 2000 to 2018 from Ministry of Environment and Forestry of the Republic of Indonesia. The analyse was done by overlaying time series map of land use land cover map from 2000 to 2018 on the map of forest area. The result show that primary dryland forest degradated significantly, around 568 ha less than 20 years. In the other side, settlements and built-up area significantly increase, 1.331 ha in 20 years. Meanwhile, the land use of agricultural dry land mixed with shrubs, in agregat decreased by 1.078 ha. The area of agricultural dry land mixed with shrubs was increase during period of 2000 to 2014, and then slightly decrease in the period of 2014 to 2018. Land use changes on the catchment area have negative impact on the quality of environmental services, such as erosion and sedimentation on the reservoir of Musi Hydropower Plant. Intervention needed to reduce the negative impact of the land use change on ecosystem services.

Key words: catchment area, forest degradation, Musi Hydropower Plant

Effect of intercropping on the development of rubber saplings in an acid sand in southern nigeria

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EXTENDED ABSTRACT
A study to evaluate the effect of rubber-based cropping systems on the growth and yield of rubber saplings and maize and cassava as well its effect of the physic-chemical properties of the soil was carried out at the Rubber Research Institute of Nigeria. The study was organized in a randomized complete block design (RCBD) with each treatments replicated three times. The treatments were; rubber + natural vegetation fallow (Control), rubber + Puereria phasioloides, rubber + maize, rubber + cassava and rubber + maize + cassava intercropping systems. Data were generated on effects of rubber based cropping systems on the physico-chemical properties of the soil, development of rubber saplings (plants height, girth, leaf characteristics, rubber sapling biomass and yields of the component crops (maize and cassava). Changes in physico-chemical properties of the soils were not significant when compared with values before cropping except for available phosphorus, where intercropping resulted in increased P levels compared with the pre-cropping values. Young rubber intercropped with maize resulted in more robust girth (5.08cm) and height (103.0cm) in the second year of planting compared with those in other treatments. Intercropping with maize also resulted in higher rubber growth rate (3.7 g2/day) compared with those planted with cassava alone. Morphological and physiological properties of rubber sapling intercropped with pueraria were consistently lowest compared with the other cropping systems. Rubber sapling biomass was significantly influenced ($P \leq 0.05$) positively intercropping with food crops. Total dry matter of rubber saplings was highest in the rubber + cassava cropping systems (503.6 kg ha-1) in the second year followed by rubber + maize (482.9 kg ha-1). The study showed that intercropping rubber saplings with maize and cassava showed comparative advantage when compared with planting of rubber with pueraria and rubber + natural vegetative fallow as serve as source of additional food and income supply to farmers.

Keywords: Rubber saplings, intercropping, cassava, maize, Pueraria phaseoloides, cropping systems, Nigeria

Ecosystem services of indigenous Kaliwu agroforest system in Sumba, Indonesia

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EXTENDED ABSTRACT

Agroforestry is an environmentally friendly approach towards land resource management, adopted by most farmers worldwide. Furthermore, differences in individual ethnic, geographic, and socio-economic backgrounds have influenced the model diversity. This results from the varied perspectives and actions of each community while addressing and managing the respective biophysical environment. The corresponding situation encourages agroforestry developmental approaches towards land resource management, including the indigenous agroforest system.

Indigenous agroforest systems result from socio-economic and ecological adaptation processes, as well as a reflection of the local community experience and knowledge [1]. These systems take various natural resource management forms, including conservation of springs [2], soil and water [3], as well as plants utilization [4,5,6]. Thus, an understanding of ecosystem services's characteristics and values from indigenous agroforest systems, are reuired to build synergies on specific environmental and land resource conservation approaches [7,8]. In addition, understanding each Indigenous agroforest system's nature and specifications are bound to facilitate management policy formulations. Numerous studies have been conducted on agroforestry, including biodiversity conservation [9], land management innovations [10], food sources [11], ecosystem services [12], landscape conservation [13], food and wildlife security [14], as well as land fertility [15]. However, research specifically related to Indigenous agroforest system pratices are currently limited.

Indonesia as a country with up to 1,331 ethnic groups [16] has an abundance of agroforestry-based land resource management models, for instance, the Indigenous Kaliwu Agroforest System (IKAS) on Sumba Island. IKAS is a land resource management model based on timber plants, non-timber forest products, and various food crops types, generally developed in hilly areas adjacent to residential regions. The IKAS management dynamics have been on-going for a long time, as a land resource management model with direct benefits for the surrounding community's livelihoods. The strong relationship between the community and IKAS underlies the study related ecosystem services' contributions to supporting community livelihoods and the surrounding environment's conservation.

In this study, the IKAS study was carried out in Central Sumba Regency, Sumba Island. Observation and literature study approaches were used to obtain relevant data and information. Also, data collection was carried out through several stages, including random sample determination to obtain 7 sample village units, determination of household heads as respondents, through proportional random sampling in each village. Subsequently, an inventory of potential respondents was conducted and 10 household heads/villages units

were randomly designated as respondent sample units for field data collection, structured and semi-structured interviews regarding management, as well as field observations at IKAS management units.

Valuable information regarding the system's provision services' significant role in supporting rural community livelihoods, including support for conservation of land resources and flora biodiversity, were obtained. The IKAS provision services as a source of foodstuffs were discovered to have a contribution value of about 39.46% - 40.91% (tuber group) and 66.49% -69.09% (fruit group), to household needs. In addition to foodstuffs, this also plays a role in providing a source of fuelwood to the community, with a contribution reaching 74-86% of household needs. The cultivation of timber plants also has implications for the periodic provision services in fulfilling carpentry wood requirements, and this ranges from 59-97%. Generally, the period of carpentry wood use is about every 15 years, including the benefits of using 50-100 bamboo plant stalks to build or renovate houses. Furthermore, IKAS ecosystem service provision plays an important role in supporting the traditions of Sumba people, generally raising livestock as an economic reserves. This is indicated by the system's contribution of 31-32% to animal feed needs.

Ecologically, the IKAS development has a role as a replication model for natural forests in the community-built environment, as seen in the high plant species diversity at each site. This plays an important role as a habitat for 145 plant species developed by the community [17], with 40 species of timber and non-timber fruit-producing plant groups. In terms of food crops, there are 11 tuber-producing and 22 fruit-producing species [18]. These plants have a varied distribution at each IKAS site, ranging from 04.29% -100% [19], including 7 fiber-producing plant species. Therefore, this plant biodiversity management system has introduced multi-aspects, and most of these have a dual function as sources of fuelwood, building wood, animal feed, medicinal plants and environmental services, for land conservation. The multi-benefits obtained by the community support the potential for sustainability through plant regeneration in the IKAS ecosystem with high performance. This was proven by the plant density, dominated by seedlings (85.92%), followed by saplings (11.44%), and trees (2.62%). The dominance of understorey and sapling groups indicates the IKAS ecosystem's potential for sustainable plant regeneration is maintainable and improvable in the future.

Furthermore, understorey and saplings are to replace the tree-level plants cut down by the community in future. According to the data on IKAS land potential reaching 125.49 ha in Central Sumba [20], there are at least 106,102 tree plantations cultivated by the community. This indicates the management system is a strategic resource requiring large scale development to support community livelihoods and biodiversity conservation.

IKAS' high level of ecosystem services ought to be considered by policymakers, to integrate the system's development with government programs relevant to environmental conservation. The IKAS management spirit's integration into community forest development, community forestry, and community-based reforestation movements is possible. Also, the system needs to simultaneously integrate the strengthening of agricultural cultivation, forestry, animal husbandry and environmental conservation. The high plant species and multi-strata diversity are bound to support IKAS' function in maintaining the ecosystem services' production stability and productivity. Therefore, efforts to manage and develop the

Indigenous Kaliwu Agroforest System need to be carried out by strengthening society's meaning and importance, according to social, economic, and ecological realities. A socio-economic approach in the development is expected to facilitate the strength of community initiatives, to facilitate management as a unique local ecosystem, with a strong sociological foundation accepted by the community. This approach strengthens the system's unit management as a crystallization of public knowledge in managing and conserving the environment through superior local IKAS ecosystem units.

The IKAS model ought to be an for several government programs to consider plant specie diversity because the model's sustainablity has been tested. The model's existence is also expected to inspire forestry and environmental development approaches, thus, this ought to start develop in the community. This means superior local ecosystem management model units in each region ought to be encouraged as regional branding, in promoting community-based environmental conservation approaches. Therefore, IKAS is an example of best practice replication and represents forest plant community models cultivated in the built environment, as a superior local ecosystem management model.

Key words: Biodivesity, Food, Feed, Fuelwood, Livelihood and Timber

Sustainability status of agroforesttry systems in Timor Island, Indonesia

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EXTENDED ABSTRACT
Agroforestry systems can be considered as sustainability concept. They are able to provide ecological, economical dan sosiological benefit. In order to help policy makers and stakeholder decide what action should be taken to make agroforestry sustainable, the identification of the sustainability status is needed. One of the tool to evaluate the sustainability is Multidimensional scaling (MDS) which firtsly employed by Pitcher and Preikshot (2001) and known as Rapid Apprasial for Fishery (Rapfish). Numerous studies modified that this tool to estimate other fields, e.g. livestock, farming, forest - Rapforest, community forestry-RapCF; Nandini et al., 2016). This study aimed to evaluate the sustainability status of agroforestry systems (RapAgro) in Timor Island, one of the relatively small islands in Nusa Tenggara Timur Province, eastern Indonesia.

The data was collected through combination of field observation and interviews with 38 respondent with purposively selected in three dominant agroforestry systems, i.e: mixed-garden (upland area), mamar- traditional agroforestry (downland area) and silvopasture (combination of tree and fooder). The data was analysed by using MDS RapAgro was used to analyse the sustainability status of agroforestry systems based on five dimensions (ecology, economy, social, institutional and technology) as well as 26 attributes. The attribute valuation was in ordinal scale based on sustainable criteria of each dimension. The criteria were ranked from 0 (the lowest) to 3 (the highest). The assessment of sustainability status was classified into: not sustainable (0-25%), less sustainable (25-50%), moderate sustainable (50-75%) and good sustainable (75-100%).

The result revealed that the sustainability of all agroforestry systems were in moderate sustainable with the average sustainability status of 54% (mixed-garden); 52% (mamar) and 51% (silvopasture). Based on the results, the typology dimension of mixed-garden and silvopasture almost similar (Figure 1). In mamar types, the ecology dimension were classified as good sustainable, but for the institutional dimension they have lowest value of sustainable status.

Based on individual evaluation on each atributte, atribute of contribution of agroforestry income, knowledge of traditional rule and harvesting give high contribution to economic, intitutional and technoogy dimension in all agroforestry systems (Table 1). In mamar system, vegetation diversity give the highest contribution to ecological dimension. The evalution of sustainabe status indicated that the sustainable status of agroforestry systems in Timor Island were categorized as moerate sustainable level.

Dynamics of soil properties on post shifting cultivation in natural forest

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EXTENDED ABSTRACT
Shifting cultivation in tropical forest was presumed as the major cause of soil degradation and soil nutrient depletion, and need several years --namely forest-fallow periods-- to recover. Soil dynamic monitoring has been done at one, five and 10-year after abandonment, and compared to natural forest, to predict the time for soil recovery in term of calcium (Ca), magnesium (Mg), Potassium (K), natrium (Na) content and cation exchange capacity (CEC). The soil properties status can be beneficial for rehabilitation activities practicing agroforestry by forest dwellers. The results showed that soil properties (i.e. Ca, Mg, K, CEC) were significantly different among soil depth ($P<0.05$), but not for Na. Highest value of Ca, Mg, K and Na were observed in the soil surface (0-20 cm), while CEC varied among the soil depths. The nutrient contents in soil were significantly changed with the time of abandonment, and the highest values were found in five years after the abandonment, even higher than in the reference plots of natural forest. It suggested that soil nutrients were distributed in the soil surface that probably composed from litter of pioneer trees. The research suggested that soil recovery was probably occurred during early fallows, and agroforestry can be practiced at five year after the abandonment.

Keywords: forest rehabilitation, rubber agroforest, swidden agriculture, soil properties

Sub-Theme: Ecosystem Services and Environmental Issues

Relationship between economic and environment of the natural rubber industry in major producers

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EXTENDED ABSTRACT
Thailand, Indonesia, and Malaysia are the major producers of natural rubber to date. Aside from oil palm, natural rubber has become the second largest export commodity in these countries. It creates job opportunities for the smallholders as well as contributes to the national economy growth. However, the large-scale of plantations results in environmental issues such as the carbon dioxide emission which is obtained from converting forest land to cropland. This study uses the Environmental Kuznets Curve (EKC) to examine the relationship between economy and environment from the natural rubber industry in the major producers. The carbon dioxide emission, as for the representative of environmental degradation, will be regressed with the exported value of natural rubber products which represents economic activities. Results found that 1) the carbon dioxide emissions obtained from natural rubber plantations in three countries are gradually increasing and 2) there is an inverted U-shape curve from the relationship between the carbon dioxide emissions and the exported value of natural rubber products. Hence, this study is in line with the EKC's hypothesis. Some suggestions are made related to the adoption and implementation of technological advancements.

Key words: environmental degradation, environmental kuznets curve, economic growth, natural rubber

Understory and soil macrofauna diversity under the three young native species in a drained peatland of Pelalawan-Riau, Indonesia

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EXTENDED ABSTRACT
As the second country that has highest number of biodiversity, Indonesia faces many challenges that threat their own flora and fauna. Moreover, the biodiversity loss is an important global issue which many researchers have been giving their focus on this issue. One of those issues is the existence of Acacia crassicarpa that is not originally from Riau and mostly planted by pulp and paper industries in Riau`s peatland. Most studies mentioned that A. crassicarpa belongs to invasive species that could threat the native biodiversity. In order to respond that issue, we conducted a study that covers the understory and soil macrofauna diversity of three native tree species, namely mahang (Macaranga pruinose), skubung (Macaranga gigantea) and geronggang (Cratoxylum arborescens) and an exotic species namely krassikarpa (Acacia crassicarpa). This study was conducted at desa Lubuk Ogong, Pelalawan, Riau during March 2014 to December 2014. Understory vegetations were calculated by arranged five plots of 2 x 1 m for each of native tree species and A. crassicarpa plots. For each species, replications were done for five times. Hence, we had 25 plots for each tree species. Plots were determined by systemic random sampling. Furthermore, structure of macrofauna were analyzed by pitfall trap method. For each tree species has 15 replications and were determined by systemic random sampling. Macrofaunas` samples were analyzed up to family level. Anova was conducted to find the highest value of flora and fauna biodiversity. Results revealed that there were two species that belong to fern group, namely Neprolephis biserrata and Stenochlaena palustris that dominated the understory vegetation in all tree species. In addition, there was no significant different of diversity index in vegetation structure between those four tree species. Moreover, vegetation coverage density of A. crassicarpa has a significant percentage compare to all native tree species. On the other hand, formicidae and rhinotermitidae were dominant in M. gigantea and A. crassicarpa. Meanwhile, formicidae and blattidae were high in M. hypoleuca and C. arborescens. Furthermore, diversity index of macrofauna were significantly low at A. crassicarpa`s understory compare to other three native species. This study informed that the introduce of A. crassicarpa give significant effect on the level of local biodiversity especially on macrofauna`s diversity level.

Key words: M. gigantea, M. hypoleuca, C. arborescens, A. crassicarpa, diversity of understory and soil macrofaunal

Roles of rubber agroforestry to support the sustainability of protection forest through community forestry program

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EXTENDED ABSTRACT
Rubber agroforestry is one of the planting patterns that is commonly found in Forest Management Unit (FMU) of Bukit Punggur, Way Kanan District in Lampung Province. Community forest with the majority of rubber agroforestry can only be found in this particular FMU and managed through social forestry scheme namely Community Forestry (CF) program due to its location as protected forest. The usage limitation of forest product from protected forest by local community in the area pushes them to be more innovative to fulfill their family needs and keep the forest functions at the same time. This research is conducted in Mangga Mulya CF, Bukit Punggur FMU, Way Kanan District, Lampung in October – December 2018. The research results are required because rubber is considered as an important commodity in this district and the economic benefit is very expected by community also district government. Another perspective is that the ecology function of the protected forest to keep water preservation and its function should be maintained. This research aims to analyze economic and ecology role of rubber agroforestry in supporting sustainability of protected forest which is managed by Mangga Mulya CF, Bukit Punggur FMU, Way Kanan District, Lampung Province.

Key words: Rubber agroforestry, Community forestry, Social and ecological roles, forest sustainability

Promoting carbon trading scheme for natural rubber plantation as a potential way for having a better environmental conservation and sustainability

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EXTENDED ABSTRACT
The current discussions related to the plantations' expansion have been associated widely with forest conversion, habitat damage and biodiversity loss, and unclear land rights. This study elaborates on the solution to have a better environmental conservation and sustainability scheme in the natural rubber sector. This review finds that the natural rubber tree has favorable characteristics that can support ecosystem conservation and Sustainability. The main characteristic is that rubber trees can absorb CO2 roughly 34,5 tons/ha/year and release O2 roughly 13 tons/ha/year. Besides, the land area with rubber trees is useful as a water catchment area. The increase in carbon sequestration level for multiple cropping system because of Samanea saman and other plants' existence was 9.3% or around 0.92 tonnes/ha/year CO2, higher than that in a monoculture rubber plantation. Besides having the potential to be one of the buffer areas for conservation areas and carbon trading, in contrast with its favorable characteristics, the issue of smallholders' welfare within the economic pillar of Sustainability does not seem to have equal recognition and space on the natural rubber sustainability agenda than the social and environmental pillar. This should be a concern since rubber has been the primary livelihood source for more than 2 million rural families in Indonesia as the second top producing country in the world. Collectively, the smallholders are responsible for more than 85% of the total national rubber production with an average of two hectares for the land ownership area. In fact, a long depressed price in the past several years which continuous declines of the rubber price from a peak of nearly USD 6/Kg in 2011, has thrown many rubber families below Indonesia's poverty line. This carbon trading scheme will potentially become a solution to reduce poverty, conserve the environment, and give smallholders incentive to manage a more sustainable plantation system for natural rubber.

Key words: Carbon trading, natural rubber, Sustainability, smallholders' welfare, scheme, Indonesia

Impact of forest fragment on bird community at the Bukit Kuantan rubber forest plantation

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EXTENDED ABSTRACT

Realizing the potential of expanding rubber forest plantations in Malaysia and the increasing awareness of biodiversity, the Bukit Kuantan rubber forest plantation portrays its eco-friendly nature through several initiatives such as conservation of natural forest fragment within the plantation landscape. By using birds as an indicator, this work aims for a favourable outcome from conservation of the forest fragment and investigate bird diversity in relation to distance from the forest fragment into the rubber forest plantation area. The number of bird species recorded was high in the forest fragment i.e., 45 species, however, the number steadily declined with distance. Likewise, species diversity was high in the forest fragment, H' = 3.404 but declined with distance. Fourteen (14) species were exclusively found in the forest fragment. Through the findings, it can be deduced that the presence of forest fragment helps to increase bird diversity in the rubber forest plantation, although continuous research is still required to understand how the presence of forest fragment sustains the biodiversity within a rubber forest plantation landscape.

Key words: rubber forest plantation, bird fauna, forest fragment, environmentally friendly plantation

Potential of agroforestry system on peat land to enhance food security and environmental sustainability

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EXTENDED ABSTRACT

Indonesia is a country with the largest tropical peatlands in the world. Utilization of peatlands has been widely associated with fires and environmental issues like carbon dioxide emissions because of the highest land-use. The average carbon accumulation rate in Kalimantan's peat swamps is around 0.74 ton / ha / year with a carbon stock of 11.3 Gt. The reduction or loss of the peat forest ecosystem for the development of dry land plants on a massive scale has reduced the quality of the environment, so that the function and benefits of the peat ecosystem as a hydrological buffer for the surrounding area are disturbed. Agroforestry systems can be an effective buffer in peatlands in fire control because the peat stabilization process requires control materials to maintain the elemental composition, carboxyl (COOH) and OH-phenol functional groups, so that the peat conditions become stable.

This paper aims to qualitatively synthesize all research results to explore the potential for developing agroforestry systems on peatlands in an effort to increase food security and environmental sustainability.

This review paper uses the Qualitative Review Systematics method [1]. The stages of the method used are: 1) formulation of questions about agroforestry systems on peatlands and their relationship with efforts to increase food security and reduce GHG emissions, 2) conducting a systematic literature search, 3) screening and selecting appropriate research articles, 4) analyzing and synthesizing qualitative findings, 5) presenting finding.

The approach used in this paper is meta-aggregation [2], namely by elaborating several research topics related to agroforestry systems to produce a conceptual framework supported by the search for relevant research articles to be compared and summarized. . In the meta-aggregation approach, the synthesis result is an "aggregate" of various research results according to the theme being studied

The concept of agroforestry on peatlands

Agroforestry or agroforestry is the planting of various types of annual crops with / without seasonal crops, with / without livestock on the same plot of land to increase income and environmental sustainability. Agroforestry is a technique that can be offered for ADAPTATION because it has a buffer against the effects of climate change, including micro-climate control [3], reducing landslides [4] surface runoff and erosion and reducing losses. nutrients through leaching [5;6], and maintaining soil flora and fauna biodiversity.

Agroforestry management on peatlands can be done by combining agricultural crops and timber crops. Rice can be the main crop and the surroundings can be interspersed with woody plants in peatland. Agroforestry patterns found in peatlands are alley cropping (pineapples are planted together with rubber trees using a tunnel system), trees along the border (pineapple plants surrounded by woody and secondary crops such as rubber, cassava and banana) and mix (pineapple mixed with woody plants. such as rubber, fruit trees and secondary crops, this agroforestry system can contribute to an increase in household income by 41.32% by absorbing 2.39 people per ha of labor.

Agroforestry and climate change on peatlands

The rate of deforestation in Indonesia in two decades, 1990-2000 and 2000-2010, respectively, reached 1.82 million ha / year and 1.02 million ha / year. This incident contributed significantly to the size of national emissions. The application of agroforestry systems on peatlands is a solution to mitigating the accumulation of GHG in the atmosphere [7], because the trees planted by farmers are not only beneficial economically, but also provide ecological value. The carbon content of each agroforestry model varies based on the type and composition of its constituents [8]. Hairiah and Rahayu, (2007) [9] state that the potential for carbon mass can be seen from the biomass of the existing stands. CO2 gas as one of the largest constituents of GHG in the air is absorbed by trees and understorey for photosynthesis, and is stored as C-organic in plant bodies (biomass) and soil for a long time, reaching 30-50 years. Nair (2012) [10] reports that the amount of C in the subsoil in agroforestry systems is greater than that in seasonal crops

Analysis agroforestry system on peat land

The agroforestry pattern that is commonly applied by farmers on peatlands is a combination of forestry components (or woody plants) with agricultural components (alley cropping) using a tunnel system, which has very good prospects for development. Fahruni (2018) [11] reported that planting peanuts as annual crops and rubber as perennial crops in agroforestry patterns on peatlands in Central Kalimantan had a positive effect on the growth of staple crops with an increase in the height of rubber plants (Hevea brasiliensis Muell. Arg.) of 62.78 %.

The results of the financial analysis of the agroforestry pattern of rubber and food crops in kalampangan Central Kalimantan provided a profit of IDR 2,827,000 with an R / C ratio of 2.03 [12]. Tata et al. (2013) [13] also reported that the results of the analysis of the profitability of rubber agroforestry with food crops provided a profit of Rp 7,327,000 / ha, with a labor requirement of 121 people / ha / year.

Framework development agroforestry system on peat land

The conceptual framework for the development of agroforestry system in peatland is presented in Figure 1. The framework is composed of four stages, which can be considered as steps to be followed for its application i.e: (1) Characterization of land and lessons learned, (2) Analysis and synthesis, (3) Optimization of development, (4) implication for development.

Indonesia is a country with the largest tropical peatlands in the world. Utilization of peatlands has been widely associated with fires and environmental issues like carbon dioxide emissions because of the highest land-use. Agroforestry is a technique that can be offered for ADAPTATION because it has a buffer against the effects of climate change, including micro-climate control. Agroforestry management on peatlands can be done by combination of forestry components (or woody plants) with agricultural components (alley cropping). The planting pineapples as annual crops and rubber as perennial crops in agroforestry patterns on peatlands contributed to an increase in household income by 41.32% by absorbing 2.39 people per ha of labor.

For optimizing existing peatland for agroforestry system, precise planning is required including land-soil-water characterization and mapping, landscape and land use design, and an adaptive development approach. These combined efforts can increase productivity of peat land, crop production, and community welfare as well as environmentally friendly.

PRESENTERS: POSTER

Effects of haze period on rubber forest clone's tree productivity

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EXTENDED ABSTRACT
The transboundary haze among South East Asian countries created not only health issue towards human being, but also affecting major food crops like rice and maize. However, there are not many reports regarding commodity crops like oil palm and rubber under this haze condition. However, it is understandable that the haze will likely be affecting the photosynthetic carbon gain as light percentage was reduced. This will eventually be impacting the plant growth and limiting other biological process in the plant. In our study, we are focusing and providing an insight of tree productivity of ten selected rubber clones with high, moderate, and low yielding characteristic that were suggested for rubber forest plantation during the haze period in 2019. The findings indicated that the tree productivity for most of the clones were declining for more than three months during and after the haze period. We furthered our investigation with imitating the haze condition with the used of polybag planting material to measure the photosynthesis rate and observing the stomatal condition. Our report will shed new understanding of rubber forest clones and its yield under haze condition which would be useful in formulating rubber agroforestry system or RAS.

Growth performance of untapped rubber clones planted in rubber forest clone trial using platform system

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EXTENDED ABTRACT

Rubber forest plantation in Malaysia is established with a sustainable and environmentally-friendly approaches to meet the needs and demand of rubber wood supply for rubberwood-based industry. The element of environmentally-friendly adopted in the concept of rubber forest plantation is by embodiment of special management zone, replacing the terrace system with alternative systems with reduced topsoil interference, emphasizing on quality water reserve and management in the plantation as well as enhancement of buffer zone. The contents of paper will focus on the growth performance of untapped rubber clones planted using platform system to replace the terrace system in conventional rubber cultivation in the undulating terrains. Data for this study were collected from a trial established on a 20 ha. area located in Rubber Research Mini Station (RRIMINIS) in Lakai, Negeri Sembilan, Malaysia. The clones tested were RRIM 929, RRIM 2002, RRIM 2014, RRIM 2015, RRIM 2024 dan RRIM 2025. Growth data were collected since the rubber trees reached age of two years old after planting until the complete cycles of 15 years from the date of planting in the field. Results showed that RRIM 2025 clone gave the highest girth at 15 years old after planting with a value of 77.4 ± 1.1 cm. RRIM 2024 clone showed the highest bole height and wood volume of 693.0 ± 21.2 cm dan 0.3 m^3, respectively at 15 years old after planting in the field. In addition, the RRIM 2014 clone showed the lowest percentage of mortality at 24.1%. Through a one-way ANOVA analysis, it was found that the planted trees showed faster girth increment from the age of two to six years compared to that of at seven to 15 years after planting even though the trees were left untapped. The results showed that tree growth recorded as girth increment decreased as the age of the trees increased. The three clones, namely RRIM 2014, RRIM 2024 and RRIM 2025 clones showed good growth in using the platform system in the undulated terrains. It is proposed that further studies in relation to tapping activities to be conducted as a compliment to evaluate the growth performance of tapped rubber on selected clones with analyses on its economic viability.

Contribution of agroforestry plants to farmers' income in Nglanggeran Agricultural Technology Park

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EXTENDED ABSTRACT

Agroforestry is a land use system (usa hata ni) that is both economically and environmentally sustainable. In this system, diversity of plants is created in an area of land so that it will reduce the risk of failure and protect the soil from erosion and reduce the use of crop residues due to recycling of crop residues. Residents in Nglanggeran who are members of the Agricultural Technology Park cultivate the staple crop of cocoa as an agroforestry crop that can generate income for farmers. Of course, the cacao plant is also intercropped with several other plants. The contribution of agricultural products, especially those from cocoa, is very important for farmers in Nglanggeran Agricultural Technology Park [1]. An increase in cocoa production will certainly be proportional to the increased income of farmers. The main factors contributing to this increase were the price of output products, the availability of fertilizers, pesticides, and an increase in marketing channels [2]. Some countries with the highest cocoa production are able to produce 3 tonnes per hectare per leaf [3]. Of course, this must also be followed by the use of the best cocoa varieties [4]. This study aims to determine the composition of agroforestry patterned crops that provide the highest income and welfare levels for farmers.

This study uses a descriptive analytic method based on primary data. Primary data was obtained by interviewing farmers in the Nglanggeran agricultural technology park. The number of interviewed farmers was 60 people with qualifications of farmers who planted agroforestry crops with the main cacao crop. Analysis of the data used in this study was obtained quantitatively to get the income of farmers who use agroforestry plants in the form of cocoa. The total income of farmers per year is obtained from the total revenue per year minus the total production costs per year. Then the income per crop composition is compared to determine the highest income for the farmer.

The Nglanggeran Agricultural Technology Park does not only cultivate cocoa alone in its plant area but by combining it with several cultivable plants. Table 1 explains that there are five categories of intercropping that can be done with the main crop, namely cocoa. Basically, cocoa can be combined with several types of plants, for example, farmers and timber plants. Table 1 explains that the cocoa that is owned and cultivated by farmers in the Nglanggeran Agricultural Technology Park combines with other crops such as mahogany, sengon, farmers, rambutan, guava, and durian. The majority or most of the farmers often combine or intercross the cultivation of cocoa with timber plants in the form of mahogany and sengon. This is because in addition to farmers getting production from cocoa they can also increase other income from the production of their by-products so that farmers hope to have sufficient income.

Categories of intercropping types generate relatively high income compared to others. Table 2 implicitly shows that category VI has the highest income. In this category, farmers cultivate cocoa with timber plants such as mahogany and sengon plus high yielding value crops such as durian and rambutan so that farmers' income does not only come from cocoa but also comes from other agroforestry crops.

Based on this description, it can be concluded that the majority of farmers in the Nglanggeran agricultural technology park cultivate cocoa agroforestry plants combined with other plants such as timber plants in the form of mahogany and sengon. Criterion VI is the criterion that generates the highest income where it shows that farmers intercropping cocoa plants with timber plants in the form of mahogany and sengon plus plants that have high selling value such as durian and rambutan. These criteria have an Average income / household / year of IDR 18,120,430.

Smallholder rubber agroforestry farming in the non-traditional areas of Sri Lanka: An application of assets-based livelihood capital indicator approach

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1. Introduction

Planting food crops as the intercrops in natural rubber (*Hevea brasiliensis* Mull Arg.) lands may contribute to household food security. Approximately 90% of global rubber production comes from Asian countries, and Sri Lanka is the 14th largest producer of Hevea rubber in the world as of the year 2020 (Anon, 2020). The expansion of rubber cultivation into non-traditional areas have been generated several benefits including thinly populated land, high land pressure in the traditional rubber growing areas, low incidences of diseases reported, and improvement of rural livelihood (Wijesuriya *et al*, 2005). Adding food crops cultivation to the rubber lands gives more benefits, except for crop yield such as increasing nitrogen availability in soil, reducing soil erosion, and plant support to control crop pests (Van Noordwijk *et al*. 2004; Khan *et al*. 2000). The livelihood choices are impacted by the livelihood assets of the households and access to livelihood capitals by farm households improves their farm management abilities and boost their entrepreneurial competencies (Mumuni and Oladele, 2016; Wei *et al*. 2019).). Identification of livelihoods of rubber agroforestry farmers is crucial in formulating exact policies and implement effective extension planning to sustenance rubber farmers. This study, therefore, focuses to analyze the implications of livelihood capitals of smallholder rubber agroforestry farmers via creating the Livelihood Capital Index (LCI).

2. Methodology

The Moneragala district was selected as the study area since it was the first District in the non-traditional areas where the rubber agroforestry commenced. The survey sample (220 respondents) was selected based on the number of rubber agroforestry farm households and sampling was done according to the farm households representation in the eight divisional secretariat divisions. Variables falling into five livelihood capitals (Table 1) and sociodemographic information of the farm households were collected. Our indicator approach is in line with the sustainable livelihood framework which was developed by the Department for International Development (DFID). We did normalisation of variables as described in the literature (Kumar *et al*., 2016; Kale, *et al*., 2016; Sendhil *et al*., 2018). Principal component analysis (PCA) was selected to determine the weights of each livelihood capital. The livelihood capital index was calculated is as given in Eq. 1. Where LCI_i is the livelihood capital index of the i^{th} farm household. W_j represents the weight of livelihood capital j. LC_{ij} represents the livelihood capital j of rubber agroforestry farm household i. ANOVA test was performed to find the implication of livelihood capital indicators among the livelihood strategies, rubber agroforestry practices, and the location of the agroforestry practices.

$$LCI_i = \sum_{j=1}^{5} w_j LC_{ij} (i \in 1,2,...220; j \in 1,2,..5) \qquad (1)$$

Table 1 Variables selected for the study

Type	Indicator	Literature cited
Sociodemographic information	Gender, Age. Education	
Livelihood capitals		
Financial	Annual income, Annual investment in farming	Wei *et al*. 2019; Rakodi, 2002
Human	Number of years of formal education, Adult family members	Wei et al. 2019; Ding *et al*., 2018; Bhandari, 2013; Longpichai *et al*., 2012
Natural	Per capita cropland, age of the rubber trees	Wenjuan *et al*., 2016; Bhandari, 2013
Social	Number of societies involved annually, time duration (hours) per month spent with the societies	Mancini *et al*. 2007; Fernandes and woodhouse, 2008
Physical	Distance to a major road, Percentage investment on machinery	Yang *et al*. 2019; You *et al*. 2019
Livelihood strategies	Rubber agroforestry and other agricultural income	
	Rubber agroforestry and non-farm income	
	Rubber agroforestry income	

3. Results and Discussion

descriptive statistics of rubber agroforestry practices. The banana was the most companion crop (36%) cultivated in the Moneragala district followed by cocoa (17%), maize (16%), pepper (12%), groundnut (5%), passionfruit (3%), and dairy cattle (3%). The five livelihood capitals indicate different weights based on the PCA analysis results (Natural = 0.14, Physical = 0.24, Financial = 0.25, Human = 0.3, Social = 0.17). Rubber-based groundnut practice shows the highest average LCI (0.54) followed by rubber-based cattle (0.53), cocoa (0.51), passionfruit (0.51), pepper (0.49), maize (0.49), banana (0.48). LCI of rubber-based agroforestry practices shows in figure 1.

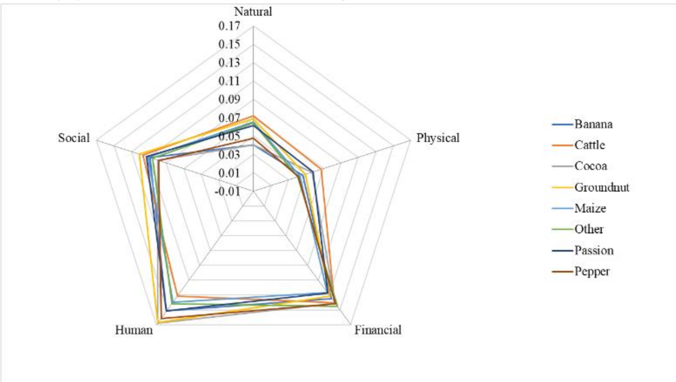

Fig.1 LCI of rubber-based agroforestry practices

Except for the human capital, a statistically significant difference was observed for all the livelihood capital indicators of rubber agroforestry practices. Except for the physical capital, there was a significant difference was observed for livelihood capital indicators with the two groups; rubber agroforest and other livelihood strategies. Also, eight regions were differentiated due to LCI except for the human capital.

4. Conclusions

LCI can be successfully implemented to assess the rubber-based agroforestry practices and better improvement or no difference in terms of livelihood capitals can be observed in rubber agroforestry. The finding of this study can be useful in evidence-based policies and effective extension planning.

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Building Institutional and Innovation Capacities for Enhancing the Socio-economic Impacts of rubber-based agroforestry systems: A study of Rubber Smallholders in India

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Extended Abstract

In India, the policies and institutional interventions for promotion of rubber development over the past seven decades have been greatly influenced by the colonial model of monoculture plantation development strategies. The model was certainly compatible in terms of strengthening the domestic rubber sector by reducing the over-dependence on the rubber producing countries elsewhere. The monoculture-oriented rubber development programmes also seemed to have worked well in terms of a dramatic structural transformation in India leading to the emergence of the smallholder sector with significant economic and social advancement as well as wellbeing achieved by the small rubber producers and the workers (Viswanathan and Bhowmik, 2016).

Nevertheless, the historic achievement that India's rubber sector recorded by way of being the third largest producer in the world along with highest productivity per ha have become events of the past and the country's rubber sector started losing its comparative advantage in many ways. In other words, India's rubber sector has been witnessing increasing pressures emanating from global market integration, which had significantly eroded the economic viability of small rubber farming systems in the country. Challenges of declining domestic prices, continued volatility in prices, shortage of skilled rubber tappers, uneconomic rubber holdings, the vagaries of climate change induced by extreme weather conditions, are reported to be adversely affecting the prospects of rubber production in the country. The crisis in the rubber sector manifest by the lack of remunerative prices and the continued drop in the prices have not been adequately addressed by the Indian Rubber Board, which is the single institutional agency promoting the expansion of rubber in India.

Thus, on the one hand, the sustainable future of the Indian rubber industry calls for concerted efforts from the part of the institutional agency and the industry stakeholders to come together and address the multifaceted challenges confronting the sector by way of external market and trade risks as well as the internal production risks in the face of increasing shortage of skilled rubber tappers as well as the climate change induced losses in yield. At the same time, it is also widely reported that promoting rubber as a monoculture entity as it is done today will have greater consequences to agri-biodiversity as well as ecosystems in the rubber growing regions in the country, both in the traditional as well as non-traditional regions of the country. While there has not been any serious attempt from the Rubber Board to address this issue in terms of understanding the implications of this model of rubber development, it becomes quite essential in the emerging context that rubber be promoted as an cropping system with proper integration of food crops or vegetable crops (especially in the NE region and other new rubber growing states), such that it will have long-term positive

benefit with respect to food security along with ecosystem integrity as well as a balancing effect against price risks of NR.

Reportedly, the Southern Indian state of Kerala, which contributes almost 78 per cent to India's natural rubber production, has been witnessing an alarming change in its rubber production sector. Large number of small rubber farmers are switching to pineapple or other alternative crops such as plantain, coffee, rambutan or mangosteen. Because of declining prices, market volatility, drop in yield and shortage of skilled tappers, farmers are being compelled to shift their traditional crops as had happened in other South East Asian countries where inter-crop of rubber is turning into an alternative crop. According to official estimates, farmers have given up rubber cultivation in over 1,000 hectares on an average during the last few years. This rate of attrition is still continuing, with more rubber farmers either abandoning rubber cultivation permanently or switching over to other agricultural activities.

Though rubber production sector in the traditional region of Kerala had faced a price crisis of the sorts on several occasions in the past, perhaps this is for the first time in the history of rubber planting in the state that the farmers have started responding so vehemently towards the crisis by cutting down rubber trees, replacing/intercropping it with other annual and perennial crops. In this regard, the critical question is: Could India think about an alternative rubber development strategy focused more towards a rubber integrated farming system (RIFS), wherein rubber as a leading crop is integrated with several other crops/crop combinations, consistent with the local agro-ecologies and environs?.

Against this backdrop, this paper tries to explore the emerging rubber integrated farming systems across the traditional and non-traditional regions in India in a comparative perspective, in the wake of the lingering rubber price crisis experienced by the smallholder rubber farmers. Some previous studies undertaken by the scholars (Viswanathan, 2006, 2012; Bhowmik and Viswanathan, 2021) demonstrate the adverse effects of the rubber monoculture system on the one side and the resilience shown by the rubber integrated farming systems during times of rubber price crisis as well as their environmental and ecosystem benefits as also has emerged from several studies reported from the major rubber growing regions in China, Thailand, Indonesia, Lao PDR, etc.

The study undertakes a brief survey of rubber smallholders from Kerala in South India and Tripura in North East India in order to understand the diversity of rubber integrated farming systems and their impacts on the socio-economic wellbeing of the rubber farmers at times of continued commodity price crisis experienced by them in recent years. Based on the analysis, the paper also intends to suggest the policy implications and the potential need for rediscovering the institutional paradigm and innovation capacities for strengthening the rubber sector from an integrated rubber agro-forestry perspective, as a sustainable strategy.

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