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# Natural rubber systems and climate change

**Proceedings and extended abstracts from the online workshop, 23–25 June 2020**

Salvatore Pinizzotto, Datuk Dr Abdul Aziz b S A Kadir, Vincent Gitz, Jérôme Sainte-Beuve, Lekshmi Nair, Eric Gohet, Eric Penot, Alexandre Meybeck

International Rubber Study Group
International Rubber Research & Development Board
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CGIAR RESEARCH PROGRAM ON Forests, Trees and Agroforestry

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The CGIAR Research Program on Forests, Trees and Agroforestry (FTA)

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# Contents

# Acknowledgements

This report gathers the extended abstracts of the presentations from the joint technical workshop on Natural rubber systems and climate change, organized by IRSG, IRRDB, CIRAD, CIFOR-ICRAF and FTA. The workshop was held online from 23rd to 25th June 2020.

We wish to acknowledge the essential role of all the chairpersons in moderating and managing sessions and sub-sessions of this workshop: Datuk Dr Abdul Aziz b S A Kadir, Vincent Gitz, Eric Gohet, James Jacob, Lekshimi Nair and Salvatore Pinizzotto.

We also want to thank the technical team who made the online event possible, including its recording and online posting: Gusdiyanto, Vito Gama Kaparang, Mokhamad Edliadi, Ashley Sam and Dinny Dwi Hadi Saputri; and the editorial team for laying out this publication: Vidya Fitrian, Rumanti Wasturini and Gideon Suharyanto.

Particular thanks go to Fabio Ricci for coordinating the logistics of the event and the publication, and to Alexandre Meybeck for reviewing the extended abstracts.

The Scientific Committee who prepared the workshop and selected the presentations is composed of:

- **Salvatore Pinizzotto**, Secretary General, IRSG
- **Datuk Dr Abdul Aziz b S A Kadir**, Secretary General, IRRDB
- **Vincent Gitz**, Director, CIFOR, CGIAR Research Program on Forests, Trees and Agroforestry (FTA)
- **Jérôme Sainte-Beuve**, Rubber Value Chain Correspondent, CIRAD
- **Lekshmi Nair**, IRSG
- **Eric Gohet**, CIRAD
- **Eric Penot**, CIRAD
- **Alexandre Meybeck**, CIFOR/FTA

# Summary

Climate change is already impacting rubber production. There is an urgent need to understand how global natural rubber production can be safeguarded and sustainably increased on a lasting basis under climate change, while contributing to climate mitigation goals. Climate action needs to be grounded in science, in a common understanding of issues and means to address them.

This is why the International Rubber Study Group (IRSG), with the International Rubber Research and Development Board (IRRDB), the CGIAR research program on Forests, Trees and Agroforestry (FTA) led by the Center for International Forestry Research (CIFOR), and the French Agricultural Research Centre for International Development (CIRAD), organized an open digital workshop on natural rubber systems and climate change on 23–25 June 2020. The purpose of the workshop was to review recent research results on impacts of climate change on natural rubber production, potential means of adaptation and contribution to mitigation of climate change, and to identify knowledge and research gaps as well as recommendations for action.

The workshop comprised five sessions that considered successively the impact of climate change on natural rubber systems and potential changes in the geography of production (session 1), the role of natural rubber systems for climate mitigation and adaptation (session 2), situated natural rubber systems in the broad perspective of climate change and sustainability policies (session 3) and in the international discussions on climate change (session 4) in order to reflect on a way forward for the sector (session 5).

**The first session** considered knowledge about climate change impacts on natural rubber production systems now and in the future. It was composed of three sub-sessions.

The first sub-session, chaired by Dr James Jacob, Director, Rubber Research Institute of India (RRI), tackled the question: what do we know about climate change that is meaningful for rubber production? Most of the current rubber plantations are localized in areas where mean annual temperature ranges from 26°C–28°C and almost nothing is known about rubber cultivation at higher temperatures. Climatic margins of rubber cultivation are mainly determined by two rather independent climatic factors (temperature and rainfall), which in turn will be affected differently in the different types of climates under which rubber is currently cultivated. The impacts of climate change are different in the different natural rubber-producing regions, some traditional areas becoming less favourable because of drought, some marginal areas becoming more favourable thanks to warming.

We know little about the direct effects of higher temperatures on rubber tree physiology. A key research topic is the interactions between climate changes and tapping systems. Higher temperatures will likely reduce latex flow and therefore latex per tapping day. There is more available knowledge about water stress thanks to the numerous studies about the adaptation to drier conditions in marginal areas. Presentations highlighted the impacts of rain on tapping and stimulation, impacts of drought delaying growth and increasing the immature period as well as on latex yield.

Of particular concern are also increased risks of fungal attacks. Weather parameters have an important role in triggering and spreading

pests and diseases in natural rubber which implies that climate change will modify patterns of rubber diseases and pests' distribution. Changes in severity and pattern of occurrence have already been observed.

The discussion highlighted the potential of improvement in the management of tapping and to adapt it to local conditions including by integrating a resting period without tapping, thus reducing days of tapping and associated costs while preserving annual yield. There are a lot of useful results from the research conducted these last 10–15 years with important findings for adaptation through management and breeding. Two types of complementary strategies are available for adaptation of rubber cultivation to climate change: implement climate-resilient agronomic practices and develop climate-resilient, high yielding clones through breeding and genomic marker assisted selection. The use of modern technologies can fast-forward breeding. International cooperation is key for multinational clone exchanges and for testing.

The second sub-session, chaired by Datuk Dr Abdul Aziz b S A Kadir, Secretary General of the IRRDB, showed country experiences.

Typhoons cause serious physical damage to the rubber trees. Trunk snaps and broken branches that occur within a short period of time cause irreversible changes to the plantation. The experience in Hainan Island in China has demonstrated the great potential of using satellite images to monitor the loss due to wind damage. The use of remote sensing for wind damage assessment will enable timely monitoring of disasters caused by typhoons in rubber plantations and other crops in the future.

One presentation illustrated the main challenges faced by an estate manager to achieve rubber production targets: rain, brown bast, and *Pestalotiopsis*. It showed means to address them and ways to optimize the use of the workforce on the plantation. Rain guards can play an important role in protecting the bark and increasing the number of tappable days. The management of the plantation plays a very important role to achieve production targets by adopting good agricultural practices.

With climate change, we see increasing incidence of major leaf diseases such as abnormal leaf fall caused by *Phytopthera*, *Corynespora* outbreaks and more recently the increasing incidence due to *Pestalotiopsis*. All the major leaf diseases cause reductions in yield. A study on the outbreak of the *Pestalotiopsis* epidemic of *Hevea* in South Sumatra showed the role played by climatic factors. Long or abnormal dry seasons caused by El Niño in 2019 reduced the disease incidence significantly. A second presentation described management strategies to control a *Pestalotiopsis* outbreak in a commercial rubber plantation in North Sumatra Indonesia. With climate change, the incidence of *Pestalotiopsis* has spread to Malaysia, Thailand and also Sri Lanka. This is a cause for concern.

The national adaptation plan (NAP) of Sri Lanka has identified four adaptation needs for the natural rubber sector: (a) enhancing the resilience of the rubber sector against heat and water stress, (b) minimizing the risk of crop damage due to biological agents, (c) minimizing the impact on export earnings due to erratic changes in precipitation and (d) enhancing the resilience of export crops and agro-ecosystems to extreme weather events. The NAP details activities to address these issues.

The challenges faced by the plant breeders in improving productivity and profitability are numerous. The main objectives are to produce vigorous clones which are high-yielding in both latex and timber and also resistant to the major diseases. For example, white root disease is a major killer of young replantings and tapping panel dryness reduce yields of mature trees significantly. Smallholders also face the problem of extended immaturity periods leading to delays in tapping their trees. Reducing the immaturity period of the rubber clones will enable them to enjoy early returns on their investment.

The third sub-session considered the potential impact of climate change on rubber production in both traditional and new areas and was chaired by Dr Vincent Gitz, Director of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA).

A first presentation described the potential of the rubber tree in relation to climate change as well as for the achievement of the sustainable development goals (SDGs). The potential impact of climate change on rubber production in both traditional and new areas is a crucial question for the future localization of rubber plantations, renewal of plantations and extension in marginal areas. What the conditions for rubber will be in 30 years determines the decision to renew plantations or to plant elsewhere, and with what type of genetic material and management practices. Parts of the rubber plantations are due to be renewed. It is important to be able to give smallholders and investors the appropriate information, technical solutions and incentives. There are already many results from research that can be used for marginal areas and for adaptation.

Soil quality can have a strong positive effect on the functioning of a rubber plantation. The role of soils for adaptation to climate change and for the sustainability of rubber plantations needs to be appropriately recognized and integrated in management practices. There is a marked difference between the immature and mature stages of rubber, with the soil quality gradually improving during the mature phase. Further works showed how some agricultural practices could protect or improve soil quality. The results clearly showed that the risk of soil erosion increased when the soil was bare even in a mature plantation with a dense tree canopy. Other works highlighted the benefits of cover cropping with legumes. Another option is being tested, which is to leave part of or the entire tree biomass in the inter-rows. First results showed a positive effect on soil quality index and tree growth only 18 months after the logging of the old plantation.

Climate information and projections are critical. Projections can help answer the question of the distribution of rubber in traditional and marginal areas in the future. Observed climatic data could be analysed and used for plantation management, such as calculation of the need for irrigation water and estimation of some disease risks.

Broadening the genetic base of cultivated rubber can open perspectives for adaptation as well as for other breeding objectives. The wild Amazonia germplasm constitutes a repository of genes of interest for breeding to resist abiotic stress like drought and cold, and biotic stress like diseases by various pathogenic fungi.

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**Session 2**, titled “Rubber and climate change mitigation and adaptation,” was chaired by Dr Eric Gohet (CIRAD, France). It considered how rubber can contribute to climate change mitigation and the role of rubber systems for adaptation.

Rubber plantations can also contribute to alleviating some climate modifications. Rubber can bring local climatic effects, namely cooling (reduction of soil surface temperature) induced by evapotranspiration, in comparison with grass land covers. The effects of rubber plantations on other meteorological variables and microclimate (e.g. rainfall, air humidity) should be further investigated in order to be better documented.

It has been shown that intercropping using fruit crops, vegetables, legumes, perennial crops, medicinal plants and ornamental plants or even maintaining the natural flora have positive effects on soil quality and fertility. Field experiments conducted in Kerala and Tripura states regions showed positive effects of such practices on soil moisture, erosion, soil chemistry (improvement in soil pH, exchangeable bases and nutrients, especially C, N, K, Ca and Mg). In the case of maintained natural flora, biological soil properties like soil respiration as well as earthworm populations were improved as well.

The use of the LUCIA (Land Use Change Impact Assessment) model, applied to the Surumer project (2011–2016 Yunnan, China), allow carbon sequestration by rubber plantations (biomass and soil), soil erosion, soil degradation and runoff to be described at the watershed level, depending on land management and IPCC scenarios. Observations on eucalyptus and rubber cover show the effects on atmospheric carbon dioxide emissions (eddy covariance approaches).

A presentation described some of the processes that can be used to increase the potential of natural rubber as a green substitute to synthetic materials, using physical and chemical modifications of natural rubber (deproteinization and epoxidization). Such processes can enlarge the range of potential applications of natural rubber for specialty clothing and shoes, sonic isolation, flooring, paints and adhesives.

Research can further develop the possibilities of using rubber germplasm for climate change adaptation, using especially SNP markers for new genetic selection from three different *Hevea* species (*H. Nitida*, *H. Spruceana* and *H. brasiliensis*).

The role of rubber in increasing the resilience of farming systems and small holders was illustrated by two presentations. The first one showed that rubber plantations, even established in marginal (warm and dry) areas of Sri Lanka, enhanced the environmental and social resilience of farms, especially through poverty alleviation and livelihoods improvements in the rural populations. The expected impact of a new carbon offset development project in two provinces of Eastern Sri Lanka was presented as well. The second presentation focused on the role of rubber agroforestry in farming systems and its effect on households and farmers livelihoods, based on a long-term follow-up in Indonesia and Thailand. In the context of low prices, those systems result in income diversification for farmers and improved social and economic resilience. Possible advantages and trade-offs as well as knowledge gaps, in the context of climate change, were presented and discussed.

The final discussion concluded that the potential opportunities of natural rubber for climate change adaptation and mitigation, in traditional as well as marginal areas, are numerous and raise many R&D questions. These include plant physiology and ecophysiology, carbon and soil sequestration, new genomic selection methods with optimized use of the germplasm (looking especially to other *Hevea* species), improved land management through optimized agricultural practices including agroforestry, carbon offset projects, as well as new developments in the downstream sector by promoting new applications of natural rubber as a green substitute to synthetic rubber.

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**Session 3** considered the “opportunities for better integrating natural rubber in broad climate change and sustainability policies, including economic and social dimensions,” reviewing some broad initiatives as well as mechanisms to strengthen sustainable production and consumption that are linked to production of wood and other tree commodities.

Natural rubber, as a renewable material, and because of its contribution to the livelihoods of millions of smallholders, has considerable potential to contribute to sustainable development in its three dimensions: economic, social and environmental. It offers a good opportunity to be part of future economic development trends towards a circular, forest-product-based bioeconomy. It is a natural product with many positive characteristics which make it an essential part of plastic substitution and future uses in industry, textiles/footwear, and construction. The Sustainable Wood for a Sustainable World (SW4SW) initiative aims to strengthen sustainable wood value chains by enhancing and promoting their social, economic and environmental benefits from production through to consumption. The development of forest law enforcement, governance and trade (FLEGT) and other mechanisms to promote wood trade legality and prevent deforestation show the growing interest of importing and exporting countries in promoting mechanisms that can guarantee sustainable sourcing to consumers. There is growing interest in jurisdictional approaches to reducing deforestation and promoting sustainable livelihoods. Such approaches can support the coordination of initiatives and actors in a landscape.

It has been acknowledged that the physical climate risk is ever-changing and nonstationary and as such, decision-making based on experience may prove unreliable. Furthermore, the direct effect of physical climate risk must be understood in the context of a geographically defined area. The social impact of climate change risk should not be underestimated as the poorest communities and populations of the world will be the most vulnerable.

The discussion highlighted the importance of balancing the three Ps: people, planet and profit. There is a risk of smallholders exiting rubber production if it is not profitable anymore. It is important not to create additional constraints and costs for smallholders. They need to be supported and to have a voice in discussions on sustainability. The social dimension is too often ignored. There is in fact a lack of data on social issues in many countries. Certification might not be the best way to promote sustainability for tyres as consumers do not directly buy their tyres and tyres are not the main environmental concern when thinking about cars. It is also very difficult to implement traceability for sustainability schemes, particularly for smallholders, and even more so if there is no additional benefit. It is particularly important for all actors to work together to improve the sustainability of the rubber sector. It would, for instance, be good to have the private sector supporting efforts for conservation of genetic resources and breeding research conducted in producing countries and that ultimately benefit the whole sector. There is considerable potential for new uses of rubber and modified rubber, including to replace plastic. There is a need to strengthen research capabilities and there are opportunities for the private sector to get engaged.

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**Session 4**, titled “Rubber and climate change in the international fora ”, was chaired by Mr Salvatore Pinizzotto, Secretary General, IRSG. It explored the possible pathways to raise the importance of the rubber sector at international level in relation to Climate Change.

The first presentation provided an overview of the main international discussions (UNFCCC, NDCs, Katowice Climate Package, Green Climate Fund, Harvested Wood Products, etc.) related to forests and plantations. It discussed various opportunities to increase the visibility and integration of natural rubber in the international climate change negotiation processes and how the rubber industry could seize these opportunities, by providing strong scientific evidence including reliable data on carbon emissions reduction, job creation and material usage in the natural rubber value chain. Was then discussed the importance of the nationally determined contributions (NDCs) and the national adaptation plans (NAPs), and the opportunity to integrate natural rubber into these national processes.
The presentation emphasized that land use is the most frequently mentioned sector for synergies between adaptation and mitigation as well as for co-benefits with SDGs, opening opportunities for the rubber sector. It concluded by suggesting potential pathways by which rubber could be better integrated into the NAPs. The last presentation highlighted the urgency in addressing climate change and its impacts in the global rubber industry. It listed shifts in business models towards sustainable production and consumption of rubber, which allow embracing the circular economy and boosting efficiency in raw material to reduce carbon emissions, from sustainable production and consumption of rubber to

the recycling of end-of-life rubber products, highlighting various policies and actions that could be undertaken. A strong partnership among stakeholders in the natural rubber value chain can bring discussion on integration of rubber in mitigation policies, measures, and adaptation policies in the wider climate dialogues.

The discussion highlighted that national-level institutions, inter-governmental organizations such as IRSG and various research institutes should play key roles in initiating, engaging and bridging different parties in the rubber industry to the climate change discussion. It also emphasized that the way to move forward actions in an organized fashion and effective corporation between various stakeholders are critical.

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**Session 5**, a panel discussion on “The way forward: Short-term actions and long-term plans” was chaired by Dr Lekshmi Nair (Head of Economic & Statistics, IRSG).

The panel discussion started by taking stock of the takeaways of the panellists from the workshop. The role of collaborative research was highlighted as well as the importance of a systematic approach in understanding how bio-physical conditions could combine with possible technological itineraries in the rubber industry and how that could interact with the labour component in the rubber value chain. The importance of the social dimension was stressed. Smallholders do not have the necessary financial means to carry out replanting under the current circumstances, with rubber prices having been persistently low. Furthermore, the industry is becoming less attractive to younger generations. The industry should consider not only *Hevea brasiliensis* but also other natural rubber species. There are gaps in scientific knowledge regarding the relation between natural rubber and climate change, and these gaps need to be addressed urgently. The industry needs actual and real-time data about the welfare of smallholders so that the social-economic aspects could be reinforced in the framework of discussion and meaningful projects could be initiated. The rubber industry could set priorities for research and development.

The panellists then shared perspectives on how to address the issues raised during the workshop. It was emphasized that the participating organizations in this workshop need to build on from the proceedings of the discussion and to agree on a follow-up agenda and an action plan to bring this agenda forward. The rubber industry needs to identify areas to initiate actions immediately. Participating organizations need to identify shared priorities and search for organizations to fund priority research projects. There is also a need to leverage on the private sector in the climate change discussion for the rubber industry. The industry should bring rubber as a discussion topic to the United Nations Framework Convention on Climate Change (UNFCCC). The participating organizations should fully utilize the outcomes of this workshop and seize the opportunities in various climate change events in 2021, such as the UNFCCC COP26 in Glasgow, and the World Forestry Congress in 2022. The workshop ended by stating the urgent need for an action plan and the importance of communication and collaboration between different parties in the rubber industry.

Natural rubber has a key role to play for both adaptation and mitigation of climate change. It is an important land user, a producer of renewable materials (rubber and wood), and a major economic activity in many countries, supporting the livelihoods of millions of small holders. However, this role is not properly accounted for. This workshop, by reviewing existing knowledge, identifying gaps and bringing relevant information to the climate change community and to decision makers, can play a major role in raising the visibility of natural rubber.

# Introduction

The International Rubber Study Group (IRSG), with the International Rubber Research and development Board (IRRDB), the CGIAR research program on Forests, Trees and Agroforestry (FTA) led by CIFOR, and the French Agricultural Research Centre for International Development (CIRAD), ran an open digital workshop on natural rubber systems and climate change on 23–25 June 2020, attended by more than 500 scientists and stakeholders.

The purpose of the workshop was to review recent research results on impacts of climate change on rubber production, potential means of adaptation and contribution to mitigation of climate change, and to identify knowledge and research gaps as well as recommendations for action.

This document brings together the extended abstracts of the presentations and summaries of the discussions held during the workshop.

The recordings of the workshop and the presentations are accessible online at: https://www.foreststreesagroforestry.org/fta-event/natural-rubber-systems-and-climate-change/ and www.rubberstudy.org from the "Sustainability" page.

# Agenda

Names represent speakers. List of coauthors of each presentation can be found in the abstracts.

## Welcome address

Salvatore Pinizzotto
Secretary General, IRSG

Vincent Gitz
Director, CGIAR Research Program on Forests, Trees and Agroforestry (FTA)

Datuk Dr Abdul Aziz b S A Kadir
Secretary General, IRRDB

Jérôme Sainte-Beuve
Rubber Value Chain Correspondent, CIRAD

## Session 1: Impact of climate change on rubber and potential changes in the geography of production

### Sub-session 1.1 – What do we know about climate change that is meaningful for rubber production?

*Chairperson: James Jacob*

James Jacob
Director, RRI India
Impact of climate change on natural rubber cultivation in India

Eric Gohet
CIRAD
Worldwide climate typologies of rubber tree cultivation: Risks and opportunities linked to climate change

Philippe Thaler
CIRAD
Climate change and rubber tree ecophysiology, what do we know?

Tajuddin Ismail
IRRDB Fellow
Impact of climate change on latex harvesting

Nguyen Anh Nghia
IRRDB, Liasion Officer for Plant Protection
Climate change: Effect of diseases and pest outbreaks on rubber productivity

Q&A
Wrap-up by the Chair

**Sub-session 1.2 – Country Experiences**
*Chairperson: Datuk Dr Abdul Aziz b S A Kadir*

Chen Bangqian
CATAS, P.R. China
Tornado disaster assessment of rubber plantations in Western Hainan Island using time series images of Landsat and Sentinel-2

Ashdeepak Singh
Estate Manager, Peninsula Forest Management Sdn Bhd, Selangor, Malaysia
Climate change: A planter's experience with disease outbreaks and the challenges to achieve productivity targets

Tri Rapani Febbiyanti
Indonesian Rubber Research Institute
Climate change and its impact on the outbreak of *Pestalotiopsis* epidemic of *Hevea* in South Sumatra

Zaida Fairuzah
Indonesian Rubber Research Institute
Management of *Pestalotiopsis* outbreak in a rubber plantation in North Sumatra

Wasana Wjiesuriya
Rubber Research Institute of Sri Lanka
Preparedness of the Sri Lankan rubber sector to minimize the impact of climate change

Q&A
Wrap-up by the Chair

**Sub-session 1.3 – What is the potential impact on rubber production in both traditional and new areas?**
*Chairperson: Vincent Gitz*

Kenneth O. Omokhafe
Rubber Research Institute of Nigeria
The place of the rubber tree (*Hevea Brasiliensis*) in climate change

Frédéric Gay
CIRAD
Managing soil fertility to improve sustainability of rubber plantations, what do we know?

Ramli Othman
IRRDB Fellow
Breeding Clones for non-traditional areas

Thomas Wijaya
Indonesian Rubber Research Institute
Climatic monitoring and analysis to optimize rubber cultivation

Q&A
Wrap-up by the Chair

## Session 2: Rubber and climate change mitigation and adaptation

*Chairperson: Eric Gohet*

### Sub-session 2.1 – How can rubber systems contribute to climate change mitigation?

Yann Nouvellon
CIRAD
Effects of large scale tree plantations on local climate: What potential for rubber tree plantations?

Jessy, M.D.
Rubber Research Institute of India
Improving biodiversity in rubber plantations: a low input strategy to mitigate drought and sustain soil health

Fatima Rubaizah
Malaysian Rubber Board, Malaysia
Product from specialty natural rubber as an alternative material to synthetic rubber towards application of naturally sustainable resources

Sergey Blagodatskiy
Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute), University of Hohenheim, Germany
Modelling the impact of rubber expansion on carbon stocks in the mountainous of Southwest China

Minami Matsui
CATAS, RIKEN Center for Sustainable Resource Science Tsurumiku, Yokohama, Japan
Transcriptional regulation on rubber biosynthesis and comparative analysis between *Hevea Brasiliensis* and *Hevea* species

Q&A

### Sub-session 2.2 – What is the role of rubber systems for adaptation?

Lakshman Rodrigo
Rubber Research Institute of Sri Lanka
Rubber cultivation for enhancement of the environmental and social resilience to climate change in drier climates in Sri Lanka

Eric Penot
CIRAD
The role of rubber agroforestry in farming systems and its effect on households: Adaptation strategies to climate change risks?

Q&A
Wrap-up by the Chair

## Session 3: Integration of rubber in a broad climate change and sustainability policies, including economic and social dimensions

*Chairperson: Datuk Dr Abdul Aziz b S A Kadir*

Salvatore Pinizzotto
IRSG
Natural rubber: A strategic material for a sustainable world

Christopher Martius
CIFOR
Towards circular bioeconomy: A research initiative

Michael Brady
CIFOR
The Sustainable Wood for a Sustainable World initiative and its relevance to the rubber and climate change agenda

Paolo Cerutti
CIFOR
FLEGT and other mechanisms to promote wood trade legality and avoided deforestation

Amy Duchelle
CIFOR
Jurisdictional approaches to land use change and managing competition between rubber sector and other uses

Panel discussion: How can these mechanisms be of interest for natural rubber?

Q&A
Wrap-up by the Chair

## Session 4: Rubber and climate change in the international fora

*Chairperson: Salvatore Pinizzotto*

Vincent Gitz
CIFOR/FTA
Opportunities for natural rubber in international climate change negotiations and mechanisms

Alexandre Meybeck
CIFOR/FTA
Opportunities for natural rubber in national determined contribution (NDC) and national adaptation plan (NAP) processes

Lekshmi Nair
Head of Economics and Statistics, IRSG
Climate risks: What 1.5°C pathway for rubber fora?

Panel discussion?

Q&A
Wrap-up by the Chair

## Session 5: The way forward: Short-term actions and long-term plans (panel discussion)

*Chairperson: Lekshmi Nair*

*Panelists:*

Salvatore Pinizzotto
Secretary General, IRSG

Vincent Gitz
Director, CGIAR Research Program on Forests, Trees and Agroforestry (FTA)

Datuk Dr Abdul Aziz b S A Kadir
Secretary General, IRRDB

Jérôme Sainte-Beuve
Rubber Value Chain Correspondent, CIRAD

Q&A
Conclusions


Photo by Lucy McHugh/CIFOR

# Opening

Mr Salvatore Pinizzotto, Secretary General, International Rubber Study Group (IRSG) opened the workshop on “Natural Rubber Systems and Climate Change” welcoming all speakers and participants.

The idea of organizing this workshop arose during the economic and social crisis derived from the COVID-19 pandemic that has led to significant global changes. The pandemic and climate change both present potentially devastating global problems with a need for rapid and immediate intervention. The latest report of the Intergovernmental Panel on Climate Change (IPCC 2018) stresses the importance of limiting global warming to 1.5°C instead of 2°C by the end of the century to avoid tipping points and irreversible changes in our environment. Already, climate change is clearly making the weather more extreme. Super-powerful storms have become more common, and there are more days of heavy rainfall and extreme heat. These changes could have serious implications for the natural rubber economy. There is the urgent need to understand how global natural rubber production can be safeguarded and sustainably increased on a lasting basis by strengthening climate resilience and successfully contribute to climate mitigation goals. For us, the best way to start working on these questions is through science – to put science and scientific knowledge as the basis of this dialogue. What do we currently know about climate change and its impact on natural rubber systems? Is there missing information? In which direction do we need to focus future research? Knowledge exchanges underpin learning and evidence-based decision making. The work on science is the precondition for a correct decision-making process with the goal to preserve and prosper the natural rubber economy worldwide. To put correct decisions in actions that have beneficial economic, social and environmental impacts, we need to identify a set of policy recommendations that could facilitate the work for all the stakeholders in the natural rubber value chain. This is the ultimate goal that the organizers of this event would like to achieve with the support of all the organizations that see natural rubber as a strategic raw material for our societies. In conclusion, I would like to thank the co-organizers of this event (CIFOR-FTA, CIRAD and IRRDB) for all their support and hard work and the staff of the IRSG Secretariat for all their efforts to make this workshop a success.

Vincent Gitz, Director, CGIAR Research Program on Forests, Trees and Agroforestry (FTA) has highlighted that the international community has committed in 2015 to ambitious sustainable development goals and, with the Paris Agreement, to ambitious climate change goals. The land use sectors, agriculture and forestry, are central to the achievement of these goals. This workshop is particularly welcome at the moment when countries and sectors need to implement measures to achieve these commitments.

The CGIAR Research Program on Forests, Trees and Agroforestry (FTA) is the world’s largest research for development program focused on the role of forests, trees and agroforestry in sustainable development, food security and addressing climate change. We aim to support countries and the international community to achieve their ambitious goals by providing evidence and science for decision. I just want to recall some key points that frame the way we look at all land use activities in their relations to climate change.

According to the IPCC, human activities have already caused approximately 1.0°C of global warming above pre-industrial levels. It is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. One more reminder of the urgency to act, for both mitigation and adaptation. Effects of climate change are increasingly visible. Considerable progress has been made in terms of projections of climate change: on regional projections, on extreme events and on changes of precipitation patterns. So, we now have a clearer picture of what to adapt to in the 30 years to come. There is growing agreement that meeting the global temperature targets of +2°C or even +1.5°C will not be possible without the land use sectors. Land-based activities are also the only possible option to achieve, in the short term, negative emissions, through afforestation and reforestation, soil carbon sequestration, sustainable forest and land management.

Natural rubber has a key role to play for both adaptation and mitigation of climate change. It is an important land user, a producer of renewable materials (rubber and wood), a major economic activity in many countries, supporting the livelihoods of millions of small holders. However, this role is not properly accounted for. Neither the IPCC Fifth Assessment Report nor its Special Report on Land Use mention rubber. Nor is rubber mentioned in international discussions on climate change.

This workshop, by reviewing existing knowledge, identifying gaps and bringing relevant information to the climate change community and to decision makers can play a major role in raising the visibility of natural rubber. It is particularly appropriate to do so now as: the IPCC is preparing its Sixth Assessment Report, to be published in 2021; countries are implementing their nationally determined contributions and preparing their revision, developing countries are preparing their national adaptation plans. I wish us all a very productive workshop.

Datuk Dr Abdul Aziz S.A. Kadir, Secretary General, IRRDB, welcomes all speakers and participants. Natural rubber sustains 13 million smallholders and 40 million people including their families. They account for 90% of global rubber production. Climate change has resulted in reduction of productivity due to the increasing incidence of serious leaf diseases such as *Pestalotiopsis*. In addition, heavy rainfall contributed to reduced productivity through the reduction of tappable days.

The rubber tree is also very efficient in stocking carbon and the unique annual wintering has been shown to improve soil fertility. Natural rubber fits in well with the socio-economic activities of the rural communities. Research is focused on producing clones which are high yielding in both latex, timber and resistance to diseases and grows well under marginal conditions.

Jérôme Sainte-Beuve, Rubber Value Chain Correspondent, CIRAD noted that climate change is already impacting rubber production. The main objective of this workshop is to identify research questions linked to the risk of climate change on this commodity chain. For the moment, there is little reliable data concerning the impact of climate change on the development of the rubber tree and it is very important to obtain more data to understand this complex phenomenon. The two main research questions are linked to the adaptation of rubber trees to rapid changes in the climate (increase in average temperature, decrease in precipitation, etc.) but also to the contribution of rubber to mitigation of climate change. The first answers cannot be provided without working in collaboration with all the national and international research institutions.


Photo by Deanna Ramsay/CIFOR

1

# Session 1

# Impact of climate change on rubber and potential changes in the geography of production

The purpose of this first session was to take stock of the knowledge about climate change impacts on natural rubber production systems, now and in the future. It was composed of three sub-sessions. The first one, chaired by Dr James Jacob, Director, RRI India, answered to the question: what do we know about climate change that is meaningful for rubber production? It was followed by a sub-session showing country experiences, chaired by Datuk Dr Abdul Aziz b S A Kadir, Secretary General of the IRRDB. The third sub-session considered the potential impact of climate change on rubber production in both traditional and new areas, and was chaired by Dr Vincent Gitz, Director of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA).

## Sub-session 1.1
## What do we know about climate change that is meaningful for rubber production?

Chairperson: **James Jacob**
*Director, RRI India*

Photo by Deanna Ramsay/CIFOR

# Impact of climate change on natural rubber cultivation in India

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## i. Climate change in rubber growing regions over the decades

Most of the areas in the world, particularly in South and Southeast Asia where natural rubber is cultivated, are highly vulnerable to the adverse effects of climate change. In India there are three types of regions where rubber is grown:

- Traditional region of production in Kerala and Tamil Nadu with a moderate equatorial climate
- Non-traditional areas in north Konkan and central India with a very hot and prolonged dry season climate
- Non-traditional North Eastern Region of India with very cold winter and prone to frequent cyclones

From the data collected from the traditional regions, it is obvious that the average temperature has gone up during the last 60 years, by almost 2.2°C and the mean maximum by 2.6°C.

The mean temperature has been progressively warming ($T_{max}$ by 0.04°C $yr^{-1}$ in traditional regions and 0.024°C $yr^{-1}$ in the North Eastern Region) and the rainfall pattern changing in an unpredictable manner in the NR plantation belts of the country. Both $T_{max}$ and $T_{min}$ have increased throughout the rubber-growing regions. In general, the number of hot days and warm nights in each month has gone up in the traditional region. The number of bright sunshine hours per day showed a decreasing trend. The mean amount of annual rainfall did not show a clear trend, but rainfall distribution has become more unpredictable. The number of extreme weather events such as heavy rainfalls, droughts, heat waves, break in monsoon, cyclonic storms etc. and their severity are on the rise.

## ii. Impact on natural rubber cultivation

Climate change, particularly climate warming and unpredictability in rainfall have severely impacted natural rubber production and productivity. The impact of climate change is different in the different natural rubber producing regions of India. For example, 1°C rise in temperature will have a more significant negative impact on productivity in traditional regions and hot non-traditional regions (Kerala and north Konkan regions) than in the North Eastern Region. As climate warming continues, more areas in the North Eastern Region where cold winter is presently a major limiting factor for growth and yield of rubber may become suitable for growing rubber, but traditional areas may become less suitable. Non-traditional areas like north Konkan and central India where high temperature is already a limiting factor for cultivating rubber are likely to become extremely difficult for cultivating this crop with the present warming trend .

Future problems likely to affect natural rubber cultivation are:

- A decrease in field survival of young plants, particularly in the first year.
- Slow growth rate, long gestation period
- Yield depression
- A shift in climatically favourable areas of NR cultivation
- An increase in impacts of disease/ pests with possibly new disease/pests emerging

**GEOSPATIAL DISTRIBUTION OF RUBBER PLANTATIONS IN INDIA**

Satellite-drived extent of rubber area
(age three years and above)

| Sl no. | State/District | NR acreage (ha) |
|---|---|---|
| | **Traditional area** | |
| 1 | Kerala | 536,652 |
| 2 | Kanyakumari district (TN) | 21,948 |
| | **Konkan area** | |
| 3 | Karnataka | 31,232 |
| 4 | Goa | 424 |
| 5 | Maharashtra | 1,133 |
| | **North-eastern states** | |
| 6 | Tripura | 76,954 |
| 7 | Assam | 30,804 |
| 8 | Megahalaya | 7,950 |
| 9 | Nagaland | 10,730 |
| 10 | Mizoram | 874 |
| 11 | Manipur | 1,062 |
| 12 | Arunachal Paradesh | 718 |
| | **Others** | |
| 13 | Andhra Paradesh | 239 |
| 14 | Odisha | 560 |
| 15 | West Bengal | 250 |
| 16 | Andaman & Nicobar Island | 910 |
| | **Total** | **722,440** |

State boundary of India    Rubber area distribution

Data source: IRS RI & II LISS III, LISS IV
Cartosat PAN, Landsat 8 OLI, Sentinel 2A/2B
Year: 2012-2013, 2015-2016, 2017, 2018 (Feb/March/April)
Ground truth data, SOI maps
Project by: RRI, Rubber Board, Kottayam
Partner Intitution: RRSC, ISRO, Bengaluru

Rubber Research Institute of India
Ministry of Commerce & Industry, Govt. of India

0 250 500 Km

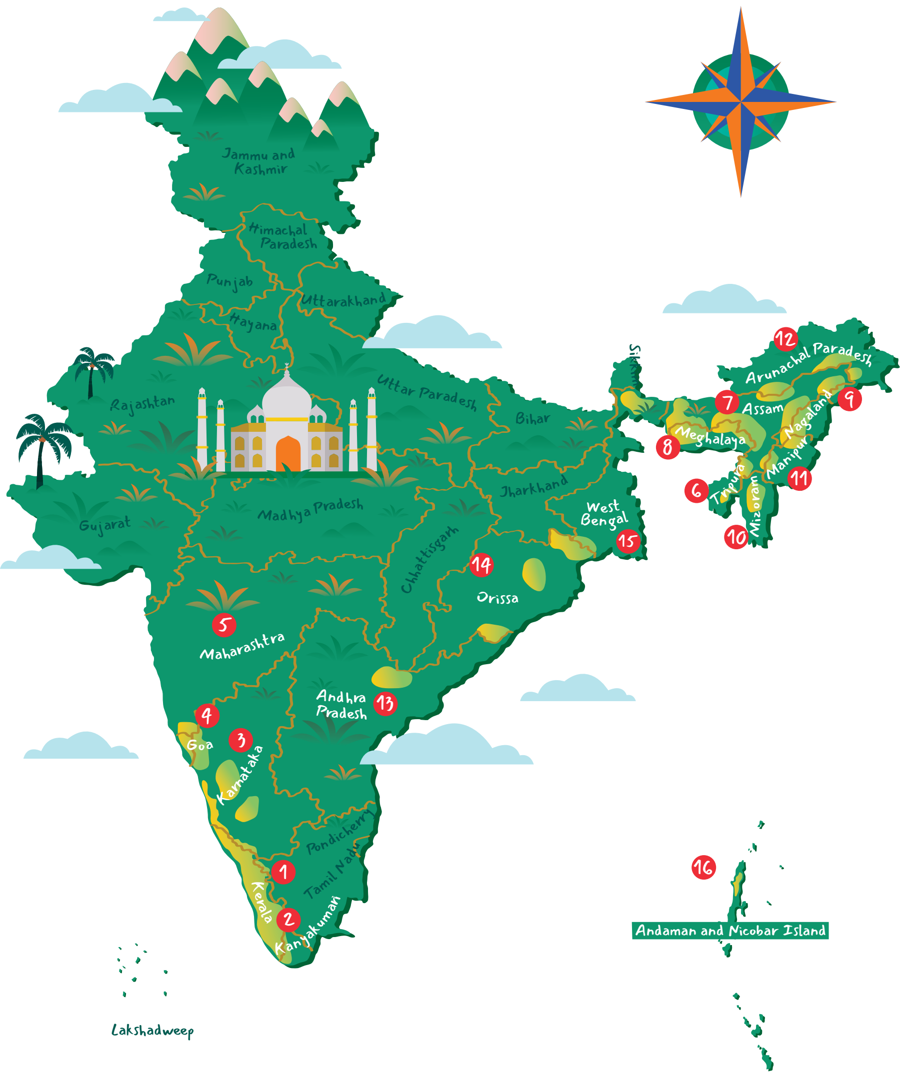


**Figure 1. NR growing regions of India**

**Table 1. Variations in production for 1°C rise in temperature, as per observed data in stations of different producing regions.**

| Station | Change in productivity (%) for 1˚C increase |
|---|---|
| North Eastern Region | -1.2 to +1.5 |
| North Kerala | -8.7 |
| North Konkan | -11.4 |
| Central Kerala | -17.4 |

In Kerala there is already an increase in areas affected by drought. Young rubber plants are drying in summer under the combined effects of higher temperature, drought and high light stress. As a result, lifesaving irrigation, which was not a common practice earlier was practiced in 18% of the holdings in the traditional area during the summer season in recent years.

Climate change will seriously alter the NR landscape of the country and NR supply in coming years. Supply will not be able to satisfy the growing demand.

### iii. Strategies for adaptation to climate change

There are two types of strategies for adaptation of rubber cultivation to climate change.

The first one is to implement climate-resilient agronomic practices:

- To prevent excess light falling on leaves, partial shade is advised in nursery plants (30% shade) and in the field during the first two years
- Mulching immature plants to conserve soil moisture
- Allow natural weed flora (dicots) to co-exist with rubber
- Efficient nutrient management
- Life-saving irrigation in non-traditional areas (150 L water$^{-1}$ tree$^{-1}$ week$^{-1}$ during summer)
- Partial irrigation (0.5 or 0.25 ET) in water deficit areas in mature plantation (north Konkan, etc.)
- Intercropping young rubber with banana, etc., which gives partial shading

The second one is to develop climate-resilient, high-yielding clones through breeding and genomic marker-assisted selection.

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# Worldwide climate typologies of rubber tree cultivation: Risks and opportunities linked to climate change

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## Extended abstract

Natural rubber (NR) is a “green” substitute to petrol-made elastomers, representing in 2020 about 47% of the global elastomer market. It is a strategic raw material as there is currently no credible or sustainable substitution by other compounds, due to specific adhesive properties and high resistance to physical constraints (pressure, heat, etc.). These specific properties make natural rubber an essential industrial product used in the tyre industry (car radial tyres, truck/plane/bulldozers tyres) as well as for anti-vibration systems, anti-seismic equipment and medical equipment. Actually, a shortage of natural rubber would result in a civilization shock driven by freight and transport disruption. As a consequence, adaptation in case of changes in climatic production conditions is a must.

The climate marginality due to warm temperature has until now never been described, as rubber trees have until now never been planted in areas where average mean annual temperatures are above 28°C. Most of the current rubber plantations are localized in areas where mean annual temperature ranges from 26 to 28°C. This raises uncertainty about the future, in a context where temperatures are expected to increase by 2°C–3°C following IPCC scenarios. At the moment, almost nothing is known about the growth and adaptation of rubber clones under these upcoming high temperatures. Even less is known about the impact on the yield under those conditions of increased temperatures. Latex flow after tapping (duration of flow especially) is linked to internal turgor pressure in the latex vessels, and this is the reason why all rubber planters tap at night or in the early morning, when the daily temperature is the lowest and turgor pressure is the highest. What will happen if the temperature rises by 2°C or 3°C at the time of tapping is totally unknown. Increases in air temperature will also lead to higher vapor pressure deficit (VPD), and altered stomatal conductance, tree transpiration and water status. Changes in temperatures will also affect photosynthesis, respiration, carbon allocations, and the physiology of the latex vessels. Some knowledge is available at leaf scale (Kositsup et al. 2009) but needs to be integrated at tree and plot scale. As the latex production totally depends on carbohydrate availability and tree water status (latex itself is composed of about 60%–65% of water, as a cytoplasm), there are large uncertainties. As other aspects linked to climate change (rainfall amount and distribution, frequency of extreme events as typhoons, possible development of new diseases/pests, increases in atmospheric $CO_2$ concentration, etc.) may also strongly impact latex production, they have to be anticipated by ad hoc research. Moreover, changes in temperature and rainfall conditions due to climate change can clearly modify the epidemiology of diseases

(appearance and outbreak of new diseases). However, it is yet too early to assert that the recent development of *Pestalotiopsis* disease, which emerged in South Sumatra in 2018 and thereafter spread to northern Sumatra, Malaysia, southern Thailand, Sri Lanka and India, is actually linked to climate change or not. This assessment will require observational and experimental research along climatic gradients, as well as modelling work under current or simulated IPCC climate scenarios to account for interactions between climate, soil conditions (particularly soil texture, depth and fertility), and agricultural practices.

Current rubber-growing areas can be classified in a four-legged climatic typology (Gohet et al. 2015):

- **Class 1**: Traditional areas (warm/humid): temperature 25°C–28°C, annual rainfall above 1500 mm. Most Asian and African rubber production areas.
- No or only limited climatic limitation for rubber growth and production
- **Class 2**: Marginality warm/dry: temperature 25°C–28°C, annual rainfall 1100–1500 mm (Esan in Thailand, north-western Cambodia, Nzi Comoue in Côte d'Ivoire).
- Climatic limitation for rubber growth and production due mainly to water stress.
- **Class 3**: Marginality cold/humid: temperature 23°C–25°C, annual rainfall above 1500 mm: (northern Thailand, Laos, Yunnan, Hainan, southern Brazil, Gabon, south-eastern Cameroon)
- Climatic limitation for rubber growth and production due mainly to cold temperature, without water stress.
- **Class 4**: Marginality cold/dry: temperature 23°C–25°C, annual rainfall 1100–1500 mm (Mato Grosso, Brazil)
- These scarce areas are the ones presenting the current highest climatic incidence on rubber growth and production, as cold temperature and water stress are found together.

The complexity of climate change impact is that rubber cultivation marginality is mainly determined by two rather independent climatic factors: temperature and rainfall. However, it can be anticipated that overall increases in temperatures induce a risk, or at least uncertainty, in climate classes 1 and 2. The sustainability of rubber production in such areas will depend on the concurrent evolution of rainfall. In this context, the areas of class 2 are likely to be the first affected if temperatures higher than 28°C are confirmed as detrimental to rubber growth and production. Increases in temperatures in the class 2 areas (warm and dry) might also exacerbate water stress due to increased vapor pressure deficit (VPD). By contrast, plantations status in areas with current cold marginality (classes 3 and 4) might improve under climate change. Class 3 areas (cold and humid) would conversely very probably become the best areas for rubber cultivation if temperatures increase by 2°C–3°C by 2050. This might be a possible cause for land use change and it should be very closely monitored to avoid future land grabbing and deforestation, as these areas are currently still covered by forests.

However, up to now, these likely impacts of climatic changes are just theoretical as the actual effects of increased mean temperature above 28°C on rubber production and growth have not yet been observed, studied or modelled as there has never been rubber planting in such conditions. Maybe the rubber trees will be adaptable to it, maybe not. That is the question, and there is anyway a risk, which must be evaluated through research and modelling, regarding clonal adaptation and incidence on growth and production. Modelling approaches developed for similar tropical plantations should be adapted to rubber (Vezy et al. 2020). Research has been carried out to model the incidence on growth and production of cold climate (temperature 23°C–25°C) and dry climate (increased length of dry season from four to six months; Gohet et al. 2015). Under climate change, water stress is expected to increase in these areas, which will probably strongly affect rubber production, especially in areas where the soil is not deep.

Setting up multidisciplinary research programs (associating breeding, physiology, ecophysiology, technology, climatology, bioclimatology and socioeconomics) appears as a priority to guarantee the sustainability of the NR supply chain in this context of global climatic change, in order to:

- Fill the numerous knowledge gaps and improve the downscaling and reliability of forecasts at local/regional levels;
- Adapt the good agricultural practices (GAPs) to the new growing conditions (technical packages);
- Generalize the adoption of the climate-smart agriculture (CSA) concept for climate change adaptation and mitigation.
- Orient decision making and planting policies on scientifically sound criteria.

Together with other global challenges (labour shortage risk), it should be the main goal of natural rubber research in the next decades.

**Key words:** climate change, temperature, rainfall, natural rubber, climate typology, good agricultural practices (GAP), growth, production, physiology, ecophysiology, climate smart agriculture (CSA).

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# Rubber tree ecophysiology and climate change: What do we know?

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## Extended abstract

The first and most direct climatic factor that will affect rubber cultivation is the rise in mean air temperature. This rise, well predicted by global climate scenarios synthetized by the Intergovernmental Panel on Climate Change (IPCC), will induce changes in rainfall patterns and evaporative demand. It will also trigger more frequent heat waves, storms and floods. Such extreme events, together with an irregular and unpredictable climate (particularly rain patterns) will increase risks as a whole for rubber cultivation, as presented in other interventions of this workshop.

Here we focus on the direct effects of mean air temperature and water stress on rubber tree functions and latex yield.

The first requirement is to forecast with enough confidence and precision the future climate in all the natural rubber producing areas. The global climate scenarios will translate differently locally, under the influence of sea streams, landforms, etc. Reliable methodologies for such downscaling work are available and some good results are already published, for instance in Xishuangbanna Dai Autonomous Prefecture, Yunnan, China (Zomer et al. 2014). However, this has to be generalized or updated.

Regarding the direct effects of climate change on rubber tree physiology, we know very little and significant research efforts at international level are necessary to fill the gaps.

At leaf scale, we know that carbon assimilation by photosynthesis will decline sharply above the optimum of 29°C. We are able to forecast the main parameters ($V_{cmax}$ and $J_{max}$) used for modelling photosynthetic activity under future air temperature (Kositsup et al. 2009). However, to forecast the whole tree and whole plantation carbon assimilation, we need much more knowledge about stomatal conductance, regulations at canopy scale and phenology. It is likely that under higher temperatures, actual photosynthesis will be reduced through lower stomatal conductance and that leaf will live shorter.

The ways forward are:

- to analyse the $CO_2$ and water exchanges measured at plot scale by eddy covariance flux towers (Giambelluca et al. 2016; Chayawat et al. 2019) together with accurate microclimatic data over several years. Such analyses are undergoing to draw equations linking temperature to net photosynthesis (NEE), ecosystem respiration, gross primary production (GPP, biomass accumulation) and evapotranspiration (water use).
- To include such equations, specifically calibrated for rubber trees, into functional models such as MAESPA (Duursma and Medlyn 2012) to simulate future carbon

assimilation, carbon and water balance and water use efficiency (WUE) of rubber plantations under different climatic scenarios.
- To improve in plantation models (e.g. LUCIA, Yang et al. 2019) the functions linking primary productivity and climate to latex yield through equations that will include plantation management options, particularly regarding tapping systems.

A key point is the allocation of carbon within the tree, as latex yield competes with growth, maintenance and reserves. Isotopic methodologies are now available for field experiments and the first results (Duangnam et al. 2020) show the importance of carbohydrate reserves (starch located in the trunk wood) to sustain latex regeneration.

A key research topic is the interactions between climate changes and tapping systems. Low tapping frequencies will likely develop to cope with the shortage of skilled manpower (Gohet et al. 2016). As compared to current systems, such reduced frequencies will induce less regular patterns of latex flow and carbon demand for latex regeneration (peak at each tapping day, followed by long inactive periods). We have to assess how these systems will behave under climate change. For instance, in addition to the issues linked to irregular rainfall patterns described in other presentations, higher temperature will likely reduce latex flow and therefore latex per tapping day. Higher predicted night temperature may be particularly detrimental (Yu et al. 2014).

There is more available knowledge about water stress thanks to the numerous studies about the adaptation to drier conditions in marginal areas, mainly in India and north-eastern Thailand (review by Carr 2012). However, most studies focused on drought, whereas climate change may as well induce excesses of water and waterlogging issues that are poorly documented.

Recent works allowed the effects of air dryness (higher water pressure deficit due to higher temperature) to be better distinguished from the lack of water resources in the soil. Isarangkooll et al. (2011) showed that even when there is enough soil water, rubber trees close their stomata and limit their transpiration when the evaporative demand is too high.

This has important implications. First, it shows that current water use and therefore the impact of rubber tree plantations on water resources are overestimated in many published studies and models (Guardiola et al. 2008), second that rubber tree tend to avoid water loss and be more tolerant to water stress than expected from its equatorial origin. However, that also means that rubber tree growth will be limited in such conditions, therefore prolonging the duration of the immature phase and finally the yield potential.

Together, this shows the importance to better understand rubber tree hydraulics, water regulation and growth patterns. Recent work in Thailand showed that there is a promising genetic variability among the existing commercial clones for breeding drought tolerant clones (Isarangkool Na Ayutthaya et al. 2017).

To conclude, there are risks of adverse effects of climate change on rubber tree growth, survival and yield and little scientific knowledge to understand the physiological responses of the trees to such conditions. Improving the functions describing the ecophysiology of the rubber trees (carbon assimilation, water use, growth, latex flow and latex regeneration) in integrative models is a priority and could constitute a relevant cooperative research project.

**Key words:** High air temperature, water stress, photosynthesis, hydraulics, modelling.

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# Impact of climate change on latex harvesting

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## Extended abstract

Latex harvesting is a very important part of rubber (*Hevea brasiliensis)* plantation operations as it directly determines the yield of latex obtained from the tapped trees. The latex harvesting operations are affected by climatic factors or issues in a number of ways. Climate change causes tapping operations to be interrupted and needs to be effectively taken into account to ensure latex yield is not reduced.

The main issues related to climate change that have an impact on latex harvesting are the intensity, amount, time and duration of rainfall. Abnormal and unpredicted rainfall especially during early morning hours delays the commencement of tapping. This will lead to delay in completion of tapping into mid-day and this will cause shorter latex dripping time. Rain during or after tapping operation is completed will lead to partial or total loss of latex. Rains also interrupt the time and frequency of stimulant applications. All these interruptions together with frequent rains during the peak yield months will significantly reduce the obtained yield. Partial or total crop loss can happen when unexpected rain falls while tapping is still in progress or latex is still dripping into the cups. Total number of normal tapping days is reduced due to frequent rain interruptions.

In early 2018, Indonesia and Malaysia experienced severe secondary leaf fall due to fungus attack on young rubber leaves initially infected by *Oidium and/or Colletotrichum.* Under heavy and frequent rainfall, the diseased matured leaves are attacked by *Pestalotiopsis* fungus causing secondary leaf fall, significant reduction in canopy density and drop in rubber yield. Subsequently in 2019 and 2020, India, Thailand and Sri Lanka also suffered a similar bad experience. To date, the total area affected by the secondary leaf fall in the five NR-producing countries is around 400,000 ha.

The secondary leaf fall caused canopy reductions of 50%–90% and yield drops of 15–50%. Figure 1 illustrates the significant yield reduction caused by secondary leaf fall due to *Pestalotiopsis* attack at a plantation in Pulau Belitung, Indonesia from January to May 2020 compared to the corresponding months in 2017 prior to the secondary leaf fall incidence.

On the other hand, climate change results in lengthened dry seasons combined with higher temperatures, and therefore an increased contrast between seasons (rainy/dry). This is likely to result in a decrease in growth during immature period, and therefore in a delayed opening time, reducing the economic efficiency and delaying return on investment of plantations.

The latex is a cytoplasm composed of about 60% of water. Any factor limiting the water uptake (decrease in rainfall, drought, increased temperature resulting in a break of leaf transpiration…) by the tree will have also a direct depressive effect on the latex yield. Any water deficit will immediately result in a drop in latex regeneration capability (combined with increasing temperature and VPD, leaves stomata closure will result in a blockage of all water transport). Lengthened

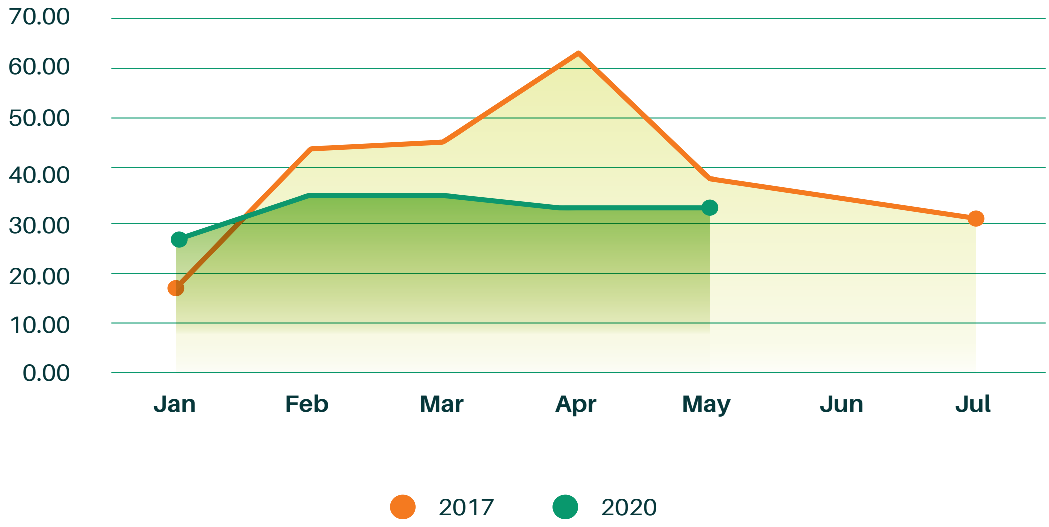


**Figure 1. Yield of rubber after *Pestalotiopsis* attack in 2020 compared with normal yield in 2017**

dry seasons will have also a strong and negative interaction with efficiency of stimulation in case of reduced tapping frequencies, by reducing the possible time window where stimulations can be used. There is therefore an urgent need for adaptation of good agricultural practices under these new conditions. The annual tapping stop during wintering and dry months should be lengthened when the dry season length and severity are increased. In case of reduced tapping frequencies, intervals between stimulations should be decreased, in order to stimulate only during wet months. The annual number of stimulations applied should be reduced as well in order to compensate an increased climatic stress.

Regarding the effect of global warming, it is worth recalling that the latex flow after tapping (duration of flow especially) is linked to the internal turgor pressure of the latex vessels. This is the reason why all rubber planters tap at night or in the early morning, as temperature is then the lowest and latex turgor pressure is the highest (negative relation T°C /turgor). What will happen if the temperature raises by 2°C–3°C at the time of tapping is totally unknown, as rubber tree has never been planted and therefore tapped in areas where mean annual temperatures are above 28°C. Before thinking of possible adaptation measures, there is an urgent need of research on the effects of higher temperatures on the biology of the tree and on the physiology of the latex system in order to assess their possible impacts on yield and to set up GAPs under these new conditions.

**Key words:** Latex harvesting, climate change, secondary leaf fall, *Pestalotiopsis*, rain interruptions, temperature, natural rubber, growth, production, physiology

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# Impact of climate change on diseases and pest outbreaks on rubber tree

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## Extended abstract

Climate change is nowadays a globally recognized fact. The changing climate not only influences crop growth and development but also has serious impacts on diversity, distribution, incidence, reproduction, growth, development, and phenology of diseases and pests (Pareek et al. 2017). It is likely to alter stages and rates of development of the pathogens, modify host resistance, and result in changes in the physiology of host-pathogen interactions. It is expected that the range of many insects and diseases will expand or change and new combinations of pests and diseases may emerge when current natural ecosystems respond to altered temperature and precipitation profiles (Desai 2010).

A plant disease is the result of interaction among a susceptible host plant, a virulent pathogen, and the environment. Changes in any of the components of the disease triangle can dramatically affect the magnitude of disease expression in a given pathosystem (Shtienberg and Elad 1997; Scholthof 2007). Therefore, it is not surprising that disease patterns have already changed and will continue to change in response to the effects of climatic changes on pathogens and hosts.

The weather parameters have an important role in triggering and spreading pests and diseases in natural rubber. It implies that climate change will modify patterns of rubber diseases and pests' distribution. It may increase or decrease the incidence of some diseases and pests by changing the conditions that would trigger an outbreak (Mathew et al. 2010).

Almost all the pests and diseases known to affect natural rubber have long existed. However, some that were minor in nature have become major and some that were prevailing only in nurseries are now occurring also in mature trees. Changes in severity and patterns of occurrence have also been noted (Mathew et al 2010). Some rubber diseases changed their relative importance, such as *Oidium* secondary leaf fall (OLF) and *Corynespora* leaf fall (CLF) with more severe outbreaks under climate change. *Phytophthora* abnormal leaf fall (PLF) occurred in new rubber planting areas where this disease had not been recorded. Recently, unexpected diseases, e.g. *Pestalotiopsis* leaf fall, have occurred.

With respect to OLF, changes in the rainfall regime, increasing temperatures, mist and high humidity can increase the incidence of this disease. The disease is more serious under conditions of high humidity (97%–100%) and between temperatures of 25°C–28°C. OLF can result in rubber yield losses of up to 45%. Therefore, OLF is a significant limiting factor for rubber production areas throughout the world, especially in high-humidity areas. The occurrence of OLF is increasing rapidly. Climate change is one reason for this as it increases the possibility of climatic conditions that allow for epidemic levels of OLF outbreaks (Liyanage 2016).

The favourable weather conditions for CLF are saturate humidity and high temperature (26 °C–30°C). Therefore, CLF usually occurs and develops in rainy and hot conditions, such as at the end of the dry season and beginning of the rainy season (April–June).

The CLF in Vietnam is one example of this. It was first detected in 1999, and an outbreak began 10 years later due to favourable weather conditions such as high temperature and high humidity occurring at the same time. More than 20,000 ha were affected (Dung and Nghia 2011). The weather conditions affected by global climate change, such as warmer temperatures, erratic rain are favourable conditions for CLF recurrence. Nowadays, CLF has emerged in almost all rubber-growing areas in Vietnam. CLF has become one of the most threatening diseases of rubber in Vietnam now and in the future.

Climate change is also one of the factors that contributed to the outbreak of a new disease which was believed to be caused by *Neofusicocum sp.* and could now be due to *Pestalotiopsis* sp., *Colletotrichum* spp. and/or some unknown fungi. The first outbreak of the disease was in Indonesia and Malaysia in 2017. Later it became more serious in Indonesia, Malaysia then appeared in Sri Lanka, India and Thailand. At the end of 2019, the total infected area was above 520,000 ha. It severely affects the health of the rubber trees and is causing a significant reduction in latex yield (Tajudin 2020).

Rubber trees are also attacked by a variety of pests; however, pests cannot digest and absorb latex, so levels of damage are lower than for other crops. Several pests have been found on rubber trees; however, only some of these pests could significantly damage the trees such as termites (*Globitermes sulphureus* and *Coptotermes curvignathus*), cockchafers grubs (larvae of family *Melolonthidae*, order *Coleoptera*: *Psilopholis vestita*, *Leucopholis rorida*, *L. tristis*, *L. nummicudens*, *Lepidiota stigma, Holotrichia bidentata*, *H. serrata, Exopholis hypoleuca,* etc.), spidermites (*Tetranychus* sp. and *Hemitarsonemus latus*); scale insects (*Pinnaspis aspidistrae*, *Saissetia nigra*, *S. oleae* and *Lepidosaphes cocculi*), bark feeding caterpillar (*Aetherastis circulata*) and mealy bug (*Ferrisiana virgata*). Although pest incidence on rubber trees is relatively low, it is also found to be on the rise because of warming temperatures in recent years (Mathew et al. 2010).

In conclusion, climate change may alter the current situation of diseases and pests on the rubber tree. These changes will certainly have effects on productivity. Therefore, studying the impact of climate change on important plant diseases and pests is essential to minimize yield and quality losses, helping in the selection of strategies to work around problems.

Interdisciplinary approaches, preferably by international programmes, must be adopted to assess the effects of climate change on diseases and pests on the rubber tree. The complexity of the processes involved and their relationships require communication between professionals in the various areas concerned.

**Keyword:** climate change, diseases, pests, rubber tree

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## Conclusion from the chair

The impacts of climate change are different in the different natural rubber-producing regions of India, some traditional areas becoming less favourable because of drought, some marginal areas becoming more favourable thanks to warming. Two types of strategies are available for adaptation of rubber cultivation to climate change: implement climate-resilient agronomic practices and develop climate-resilient, high-yielding clones through breeding and genomic marker assisted selection.

Dr Eric Gohet presented a worldwide climate typologies of rubber tree cultivation to orient the analysis of risks and opportunities linked to climate change. He noted that most of the current rubber plantations are localized in areas where mean annual temperature ranges from 26°C–28°C and almost nothing is known about rubber cultivation at a higher temperature. Rubber cultivation marginality is mainly determined by two rather independent climatic factors (temperature and rainfall) that will be affected differently in the different types of climates under which rubber is currently cultivated.

Dr Thaler noted that we know little about the direct effects of climate change on rubber tree physiology. A key research topic is the interactions between climate changes and tapping systems. Higher temperature will likely reduce latex flow and therefore latex per tapping day. There is more available knowledge about water stress thanks to the numerous studies about the adaptation to drier conditions in marginal areas. Improving the functions describing the ecophysiology of the rubber trees (carbon assimilation, water use, growth, latex flow and latex regeneration) in integrative models should be a priority area of research.

The impact of climate change on latex harvesting was further explored by Tajuddin Ismail. He highlighted the impacts of rain on tapping and stimulation, impacts of drought delaying growth and increasing the immature period as well as on latex yield. Of particular concern are also increased risks of fungal attacks.

Nguyen Anh Nghia explored the impact of climate change on diseases and pest outbreaks on the rubber tree. He noted that weather parameters have an important role in triggering and spreading pests and diseases in natural rubber which implies that climate change will modify patterns of rubber diseases and pests' distribution. Changes in severity and pattern of occurrence have already been observed.

The discussion highlighted the potential of improvement in the management of tapping and to adapt it to local conditions including by integrating a resting period without tapping, thus reducing days of tapping and associated costs while preserving annual yield.

There are a lot of important useful results from the research conducted these last 10–15 years with important findings for adaptation through management and breeding. Of particular importance is breeding, including for disease resistance. The use of modern technologies can fast-forward breeding. International cooperation is key for multinational clone exchanges and for testing.

# Sub-session 1.2
# Country experiences

Chairperson: **Datuk Dr Abdul Aziz b S A Kadir**
*Secretary General, IRRDB*

Photo by Icaro Cooke Vieira/CIFOR

# Tornado disaster assessment of rubber plantation using multi-source remote sensing data: A case study in Hainan Island, China

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**Extended abstract**

As a typical non-traditional rubber planting area, China's natural rubber industry has been facing severe natural disasters, such as wind damage and cold injury (Chen et al. 2012; Liu et al. 2015; Huang et al. 2019). Typhoon disasters are the worst on Hainan Island – China's second largest rubber planting area – and Guangdong Province, which account for almost half of the total rubber planting area in China. Typhoons bring serious physical damage such as fallen leaves and branch and trunk breakage to rubber plantations in a short period of time, causing long-term and irreversible changes. Compared with traditional ground surveys (Feng et al. 2020), the use of remote sensing for wind damage assessment has the advantage of large coverage, higher efficiency, and lower economic costs. Rapid assessment using remote sensing is of great significance to guide post-disaster production recovery (Luo et al. 2013; Zhang et al. 2014; Liu et al. 2016), insurance compensation (Huang et al. 2019; Shang et al. 2019), and scientific research (Delphin et al. 2013; Mitchell 2013; Shiels and González 2014; Vogt et al. 2014).

This study takes the tornado that hit the western part of Hainan Island in 2019 as an example, and explores the potential of jointly using Landsat and Sentinel-2 time series images to assess wind damage in rubber plantations, from the prospective of data availability (Zhu et al. 2015; Qiu et al. 2019), image composite methods, and selection of disaster assessment indicators (Lee et al. 2008; Wang et al. 2010; Hu and Smith 2018). The maximum, median, mean, minimum, and latest value composite method were respectively used to generate cloud-free images before and after the tornado. Then, the image difference method was used to find the difference before and after the tornado.

The results show that: 1) Cloud-free Landsat ETM+/OLI and Sentinel-2 MSI images can cover more than 90% of the study area at least once within 20 days before and after the disaster, and almost cover the whole area within 30 days. At pixel scale, the average coverage reaches three times in 30 days and six times in 60 days. 2) Maximum value composite method before the tornado and medium value composite after the disaster were recommended to generate a cloud-free image for damage assessment, where the difference values is the most significant and stable. 3) The monitoring effect tends to be stable since a time window of 40 days, showing slight differences with the results estimated from images of a 90-day time window. Considering some other factors,

we recommend using a 60-day time window to assess the disaster. 4) The enhanced vegetation index (EVI) of the damaged rubber plantation changes the most during the disaster, followed by normalized burn ratio (NBR), land surface water index (LSWI), normalized difference vegetation index (NDVI), near-infrared (NIR) and shortwave infrared (SWIR1 and SWIR2) bands. In term of percentage change, the LSWI and SWIR2 changed the most after the tornado, significantly higher than NBR, EVI, NIR and SWIR1. However, the spatial variation of LSWI is significantly lower than that of SWIR2. Therefore, we recommend to use EVI or percentage value of LSWI to assess the tornado disaster. 5) the tornado severely damaged about 645 ha (average value from two algorithms) of rubber plantation in western Hainan Island. As a long-term crop of about 30-year economic life cycle, the loss is very serious.

The coverage of cloud-free optical images in tropical area has greatly improved since the launch of Sentinel-2 A/B satellites, especially combining with satellite data coming from Landsat 7 and 8 (Claverie et al. 2018). This study has demonstrated the great potential of using images of these two satellites to monitor the loss of wind damage in rubber plantation, providing insights to timely monitor typhoon disasters in rubber plantations and other crops in the future.

**Keywords**: Rubber plantation, Long time series images, Image composite method, Time window, damage assessment index

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# A planter's experience with disease outbreaks and the challenges to achieve productivity targets

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**Extended abstract**

This presentation illustrates the main challenges faced by an estate manager to achieve rubber production targets: rain, brown bast, and *Pestalotiopsis*. It shows means to address them and ways to optimize the use of the workforce on the plantation (Febbiyanti 2019).

The rubber plantation project site is located in Malaysia, about 60 km to the north of Kuala Lumpur, 20 km from the town of Kuala Kubu Bharu, Selangor and about 10 km south of Tanjung Malim Perak town, hugging both sides of the north-south highway. The best access to the area is through the highway exit at Lembah Beringin Selangor, a semi-abandoned township bordering the rubber plantation. Currently, the plantation has successfully planted 1,530 ha of rubber (TLC), planted from 2009 to 2011 with different clones: PB 350, PB 260, RRIM 2025, RRIM 3001, RRIM 901.

Rainfall is recorded using a rain gauge to calculate the number of rainy days and amount of rain. As shown in table 1 there are around 180 rainy days per year, with rainy days per month varying from 6 to 23, with a total annual amount generally above 3,000 mm.

During the raining season there are specific challenges. The rain makes it impossible to tap which reduces the number of tapping days. There is a risk of washout (unless latex coagulant is applied immediately after tapping for field coagulum, also known as rubber cup lump in lay mans' term). Workers tapping without appropriate knowledge during the raining season may cause brown bast (panel dryness) by overexploiting the trees. Brown bast is the second most serious threat to rubber estate after *Pestalotiopsis* from an estate's perspective. There is a risk of not being able to achieve the monthly production and fail to fulfil yearly targets. Rubber tapping will be done vigorously during the dry months to compensate for raining days. However, this method has been known to cause critical stress to the rubber trees resulting in fast decrease in the tree's latex production or ending up with brown bast. When earning of tappers is low during raining season, it will lead to workers running away or becoming free birds. This will further increase the shortage of workers in the rubber industry which currently is already a major problem for most of the rubber industry in Malaysia.

A rain guard is a very efficient way to reduce these impacts of rain. EasyGuard is designed to divert rainwater running down the tree tapping panel, which prevents the water from touching the tapping panel and keep the panel dry. It was invented and patented by Gaincrest founder in 2003 to overcome the problem of rain. It protects the panel (where latex is collected) and diverts the rain water. For instance, if tapping starts at 3:00 AM and it had rained at 9:00 PM a day earlier, the tapper will be able to tap the tree because the panel is still dry. However, the rain guard is not effective against a heavy downpour of rainfall. The estate supervisor must determine whether the panel is dry and safe for tapping. The rain guard has been helpful to achieve

**Table 1. Rainfall data by month, from January 2017 to May 2020, for Lembah Beringin, Selangor, Malaysia**

| Month | 2017 | | 2018 | | 2019 | | 2020 | |
|---|---|---|---|---|---|---|---|---|
| | *Raining Days* | *Rainfall (mm)* | *Raining Days* | *Rainfall (mm)* | *Raining Days* | *Rainfall (mm)* | *Raining Days* | *Rainfall (mm)* |
| January | 14 | 346 | 16 | 308 | 12 | 147 | 5 | 237 |
| February | 9 | 260 | 6 | 45 | 14 | 152 | 5 | 105 |
| March | 23 | 542 | 12 | 209 | 10 | 94 | 14 | 191 |
| April | 21 | 380 | 14 | 147 | 16 | 221 | 21 | 329 |
| May | 18 | 426 | 22 | 443 | 14 | 320 | 14 | 363 |
| June | 10 | 176 | 9 | 174 | 12 | 347 | 5 | 155 |
| July | 6 | 90 | 7 | 137 | 11 | 180 | 0 | 0 |
| August | 16 | 105 | 6 | 83 | 12 | 160 | 0 | 0 |
| September | 17 | 153 | 26 | 422 | 10 | 166 | 0 | 0 |
| October | 13 | 206 | 25 | 431 | 27 | 621 | 0 | 0 |
| November | 19 | 412 | 22 | 390 | 18 | 343 | 0 | 0 |
| December | 19 | 285 | 21 | 331 | 17 | 160 | 0 | 0 |
| **Total** | **184** | **3,381** | **186** | **3,121** | **173** | **2,911** | **64** | **1,381** |

higher tapping days for my plantation. The cost of the material is MYR 0.61 per tree. Labour costs for fixing EasyGuard are MYR 0.45 per tree. The breakeven point is after two tapping days.

Brown bast, or tapping panel dryness, is a physiological disease of the tree characterized by a greyish-brown or greenish-brown discolouration of the inner bark near the tapping cut and a stoppage in the flow of latex (Jacob et al. 2006). When a tree is affected by brown bast, we will let the tree rest for six months and try tapping after six months with one round booster of 1.25% of ethereal application (Schweizer 1949). Brown bast can be a major problem if we have unskilful tappers and contract tappers who prioritize the money taken back rather than taking care of the rubber tree. Stressing the tree for higher output is what we should avoid taking into consideration the lifespan of the rubber tree which should be able to be tapped for 20 years (Vijayakumar et al. 2006). If the tree is over-exploited it may only survive for 10 years. So, it is not worth over-exploiting the rubber tree.

*Pestalotiopsis* affected the plantation in 2019 and 2020. In 2019 in the area affected production was reduced by 25% due to *Pestalotiopsis*. In 2020 the production in the affected area is estimated to fall by 40% due to *Pestalotiopsis*. There is about 30% leaf left which can be seen on the branches. The areas affected are treated by repeated mechanical spraying.

Increasing productivity of the plantation requires careful management of the tappers including for recovery of days lost because of the rain. Monitoring of working hours for tappers is essential. To achieve the highest yield tappers are advised to start tapping at 3:00 AM, and to avoid tapping after 9:30 AM, avoid tapping during daylight because the panel will dry and the latex flow will be very slow and not worth the effort. Stressing the tree may also lead to panel dryness and brown bast. To do recovery tapping, the management can have a policy to carry out recovery tapping on very rainy days by tapping in the evening or by switching from D3 (third daily) to D2 (alternate daily) tapping. For instance, on Monday Section A was to be tapped but it started raining at 1:00 AM; section A can be tapped in the evening and the next day Section B can be tapped so that tapping days are not lost. Another method of recovery tapping is to switch from D3 to D2; tappers can tap 1.5 task per day to recover the lost days. The number of trees per task must be considered as well. When deducting Sundays and 11 public holidays, there are a total of 300 days per year available for tapping. This gives the possibility of 100 tappings per year per tree with D3 or 150 tappings per year per tree with D2. However, achieving approximately 95% out-turn of tappers or 280 tapping days is a good result. The management of the plantation plays a very important role on how the recovery plan is executed. A rain guard plays an important role, as explained above.

**Key words:** Rubber, tapping, rain, rain guard, brown bast, *Pestalotiopsis*

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# Climate change and its impact on the outbreak of the *Pestalotiopsis* epidemic of *Hevea* in South Sumatra

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**Extended abstract**

*Pestalotiopsis* leaf fall disease was first detected in Indonesia in 2016 in the North Sumatra region, then spread to South Sumatra in the end of 2017 and continues to be an outbreak until now. This disease causes a decrease in production of more than 30%. Symptoms begin to appear sporadically on mature leaves and finally the leaves fall.

This leaf fall disease is an airborne disease which spreads very fast and makes defoliation of leaves continuously (Febbiyanti and Fairuzah 2019). The disease has spread to several regions in Indonesia, namely North Sumatra, South Sumatra, Central Java, East Java and Sulawesi with diferent disease severity (Febbiyanti 2019).

In Indonesia, global climate change has resulted in abnormal rainy season or dry season. Abnormal rainy season is a season where the monthly rainfall is above normal and the number of wet months increases or is called a prolonged rainy season. Meanwhile, the abnormal dry season is a season where the monthly rainfall is below normal and the number of dry months increases; this is called a prolonged dry season (Manurung and Basuki 1992).
The prolonged rainy and dry seasons in Indonesia have had a very detrimental impact, especially for agriculture including rubber plantations, where the impact of these seasonal changes has resulted in significant economic losses. The prolonged dry season has resulted in stunted plant growth by 20%–58% and decreased latex production by more than 30%. The prolonged rainy season has resulted in disruption of tapping, inundations in some areas and damages to garden roads (Manurung and Basuki 1992; Thomas et al. 1994).

The effect of El Niño in 2019 resulted in the development of *Pestalotiopsis* leaf fall disease being inhibited, the conditions of long dry months and low humidity resulting in disease events being delayed up to 2–3 months so that peak production could be reached to the natural wintering. Based on observations in 2019, rain began to occur in early December 2019, and if rainfall exceeds 100 mm per month and daily humidity exceeds 80%, the severity of the disease will start to be high. The severity of the disease will be higher if rainfall exceeds 300 mm per month and humidity daily exceeds 85%, as daily humidity conditions in the garden greatly affect the development of the disease.
As a result of this El Niño, the pathogen *Pestalotiopsis* is inhibited, canopy survives well and does not fall off for 2–3 months, and production increases by 20%–40% according to the target at the peak of production.

During their development, pathogens generally require suitable biotic (plant) and abiotic (climatic, environmental, and agronomic) conditions. The biotic conditions required by disease-causing pathogens are usually the susceptibility and critical phases of the plant. If one of these factors does not support, the pathogen does not cause significant damage (Agrios 2005). Long or

abnormal dry seasons with dry periods of three months or more will result in reduced attack of pathogens. Leaf disease is usually very lacking or completely absent because in the period of formation of young leaves, which is a critical condition for pathogens, there are no rain or dry conditions, which results in pathogenic spores being unable to germinate and mycelia in the tissue will be stunted. Even air spores or mycelia that live saprophytic in leaf tissue will die from drought, resulting in a drastic reduction in the pathogen population.

**Keywords:** *Pestalotiopsis*, leaf fall, diseases, *Hevea*, climate

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# Management of *Pestalotiopsis* outbreak in a rubber plantation in North Sumatra

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## Extended abstract

Global climate changes have greatly influenced rubber plants lately. The temperature has increased by 0.3°C since industrialization, accompanied by a significant increase of the amount of rainfall in a year resulting in increasingly humid environmental conditions in the rubber plantation area (Case et al. 2007). High humidity in the rubber plantation area highly favors pathogenic fungi causing a disease explosion.

There was no dry month and a high frequency of rain in 2017 in North Sumatra, which triggered an explosion of secondary leaf fall in rubber plantations of Sumatra and had an impact on decreasing production (Junaidi et al. 2017). Symptoms of circular patches with clear brownish-white borders and gradually black appeared on the leaves were later identified as *Pestalotiopsis* leaf blight disease (Febbiyanti and Zaida 2019). The leaves turned yellow in the canopy of the plant and fell instantly. The leaves fell throughout the year, especially in the rainy season. Almost all rubber plantation in North Sumatra were attacked by this disease.

The management strategies to control this disease had been conducted in a commercial plantation in North Sumatra, Indonesia, using PB 260 clone planted in 2013. Experimental field plots were established in Simalungun Regency in Feb–Apr 2020. Hexaconazole was applied every two months and was not applied to the control plot. The method used in the application of hexaconazole was fogging to the plant canopy using a thermal fogging machine in the night to avoid the wind and also to get the support from mildew for sticking the fungicide at the surface of the leaves. This research consisted in comparison of two treatments (treatment and control plot) with three replications. The observation method of the canopy was based on Jayasinghe (2019). In the treated plots the disease occurence was only 13.33% and in the control plot 26.11%. *Pestalotiopsis* spores were found only in the control plot using spore traps at the height of 0.5 and 5 m from the ground surface. In the treatment plots, light intensity at 12:00 Western Indonesia Time was only 32,070 lux and in the control 53,670 lux, showing that the canopy in the control area was thinner than in the treated area. More fallen leaves infected by *Pestalotiopsis* were found in leaf traps in the control plot than in the treatment plot after a one-week installation. The cost for this treatment was about IDR 120,577 (USD 8.19) per hectare for the fogging method. Yield in the treatment plot after two months was about 21.86 g $t^{-1}$ $t^{-1}$ and in the control plot was 19.1 g $t^{-1}$ $t^{-1}$, so the yield difference was 2.76 g $t^{-1}$ $t^{-1}$.

**Keywords:** Management, *Pestalotiopsis*, outbreak, rubber plantation

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# Preparedness of the Sri Lankan rubber sector to minimize the impact of climate change

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## Extended abstract

Sri Lanka, an island with a tropical climate, is highly vulnerable to adverse impacts of climate change. National-level actions have to play a critical role, while international cooperation is also important. Identifying this responsibility, the Government of Sri Lanka (GOSL) has launched a national initiative to face the impacts of climate change. There are several national initiatives, such as the National Climate Change Adaptation Strategy for Sri Lanka 2011–2016 prepared in 2010 and the National Climate Change Policy (NCCP) adopted in 2012. The National Adaptation Plan for Climate Change Impacts in Sri Lanka (NAP) is the next logical step of the national initiatives for meeting the adverse effects of climate change.

The NAP covers adaptation needs at two levels; namely, adaptation needs of key vulnerable sectors and cross-cutting national needs of adaptation. Nine vulnerable sectors were identified, and among them the one which is related to the rubber sector is export development. This document identifies adaptation options that can fulfill these needs and actions necessary to achieve these adaptation options with responsible agencies and key performance indicators and constitutes a sectoral plan for each vulnerable sector together with interventions.

Vulnerabilities of rubber plantations to climate change have been identified and the Rubber Research Institute of Sri Lanka (RRISL) is being involved in research in various disciplines in developing adaptation measures to adverse climate change impacts and also in the process of developing the knowledge base for carbon sequestering ability to prove the prospects of rubber plantations in receiving carbon credits. These research areas have been among the priorities of the institute’s research and development plan even before the NAP has been documented and launched.

According to the NAP, there are four relevant adaptation needs for the natural rubber sector. They are: (a) enhancing the resilience of the rubber sector against heat and water stress, (b) minimizing the risk of crop damage due to biological agents, (c) minimizing the impact on export earnings due to erratic changes in precipitation and (d) enhancing the resilience of export crops and agro-ecosystems to extreme weather events.

Germplasm improvement and improvement of nursery and plantation management practices are the key areas for enhancing the resilience of the rubber sector against heat and water stress. Breeding of new clones is one of the key areas of research conducted by RRISL. This activity includes multiplication, establishment and scientific evaluation of the *Hevea* germplasm, molecular level screening to identify drought tolerant clones and RRISL-smallholder collaborative trials for evaluation of adaptability and performance under sub-optimal environmental conditions.

With respect to improvement of nursery and plantation management practices, RRISL focuses on promoting suitable operational and management techniques for nursery and planting and also developed improved

cropping system models. Research and development activities are therefore focused on improved planting material, priming of seeds to improve germination success, application of botanical, physio-chemicals, and irrigation practices to reduce moisture stress, studies on potting media for root trainers, bio-fertilizer development, use of organic fertilizer, bio-char application, introducing intercropping systems, and soil-moisture conservation practices with the objective of avoiding stress situations.

Minimizing the risk of crop damage due to biological agents, the second of the identified adaptation needs identified in the NAP is also of great concern to the rubber industry. Therefore, actions are being taken in terms of developing recommendations on best practices for pest and disease management through improvements in nursery management and crop sanitation. Monitoring and surveillance of pests and diseases is also of concern for early detection of new diseases and pests and developing a system of forecasting risks of pests and diseases are the relevant actions under this adaptation option.

In terms of economics, minimizing the impact on export earnings due to erratic changes in precipitation is the third area under the NAP. For this, several strategies have been focused on by RRISL. They are: establishment of a climate information management and communication system and minimizing the effect of interference to tapping operations of rubber. Timely application of rainguards is of importance in escaping from rain interference. Adopting low-frequency tapping systems may be considered another way of escaping from rainfall events.

The fourth adaptation need in the NAP is enhancing the resilience of export crops and agro-ecosystems to extreme weather events. Introducing suitable cropping systems with rubber and land suitability assessments are important in this regard. It is also necessary to identify, monitor and forecast droughts which is a basic necessity in decision making in rubber cultivation.

The research and development programmes of RRISL adequately address the adaptation needs, options and activities according to the National adaptation plan for climate change of Sri Lanka. Yet several research projects are still ongoing and at the initial stages to develop recommendations to the industry in future. Before the recommendation a serious thought should be given on the economic aspects and the environmental benefits. Overarching all the said strategies, it is important to make the planters and smallholder farmers aware of the adaptation needs and proposed strategies to build resilience of the rubber sector to anticipate climate change and overcome its adverse effects.

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## Conclusion from the chair

The challenges faced by the plant breeders in improving productivity and profitability are numerous. The main objectives are to produce vigorous clones which are high yielding in both latex and timber and also resistant to the major diseases. For example, white root disease is a major killer of young replantings and tapping panel dryness reduce yields of mature trees significantly. Smallholders also face the problem of extended immaturity period leading to delays in tapping their trees. Reducing the immaturity period of the rubber clones will enable them to enjoy early returns on their investment.

With climate change, we see increasing incidence of major leaf diseases such as abnormal leaf fall caused by *Phytopthera, Corynespora* outbreaks and more recently the increasing incidence due to *Pestalotiopsis*. All the major leaf diseases cause reduction in yields. Climate change has resulted in increasing incidence of severe weather. Strong winds are capable of causing damage due to trunk snaps. This leads to reduced stands of trees in their already uneconomic sized holdings.

Currently, rubber is also being cultivated in marginal areas where weather is a major concern. Excessive rain leads to flooding and extended drought is detrimental to the growth of the rubber trees. When we consider that rubber has been replanted three times, smallholders are unable to implement good agricultural practices. This leads to poor growth of trees in soils deprived of nutrients and fertility. Therefore, climate change is an obstacle to our effort in reducing poverty among the smallholder community.

# Sub-session 1.3
# What is the potential impact on rubber production in both traditional and new areas?

Chairperson: **Vincent Gitz**
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# The place of the rubber tree (*Hevea brasiliensis*) in climate change

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## Extended abstract

Climate change is as old as creation, as the Earth, with its atmosphere in particular, has witnessed phases of stability and instability. The Earth attained relative stability before the advent of man on Earth, called the Holocene about 11,700 years ago, and especially the Industrial Revolution that commenced in the middle of the 18th century. The industrial activities affected the composition of gasses in the atmosphere leading to the greenhouse effect, increases in temperature, irreversible changes in weather factors and climate change. In spite of the global efforts at mitigation and adaptation, climate change will be more severe on communities in developing countries. In this case, it is necessary to apply local approaches that will be compatible with the environment of community dwellers in developing countries. This is where the rubber tree fits in to provide holistic solutions to climate change and meet basic needs of the farmers. Secondly, there is the problem of land degradation such as loss of the rainforest transitioning to grassland, called derived savannah. There is a loss of trees in the humid savannah leading to increased aridity and arid savannah. In both cases, there are further challenges of social dislocation with threat to livelihoods, avoidance by social service workers, migration, high-profile crimes and hence vulnerable communities. This is prevalent in many rubber-producing countries and the rubber tree is therefore a ready crop for livelihood and economic empowerment. In addition to adaptation to climate change, the application of the rubber tree in various ways can sequester carbon, provide means of economic empowerment as an economic crop, food and enhanced nutrition through intercropping and mixed farming in agroforestry practices. There are many countries that have a common agroecology with the rubber-producing countries and have the challenge of derived savannah and loss of trees in the humid savannah. The rubber tree can benefit from Reducing Emissions from Deforestation and Forest Degradation (REDD+) programmes with focus on the wild rubber groves especially in South America. Many of these non-traditional and non-rubber producing countries are promoting use of trees as response to climate change and the rubber tree will be a suitable component of tree planting practices in these countries. In this regard, the following options of the use of the rubber tree for climate change adaptation are hereby presented: tree farming, forest restoration, afforestation, reforestation, agroforestry, silviculture, protection of rubber groves and carbon credits. These will also address some aspects of the Sustainable Development Goals (SDGs) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 9 as an industrial crop, SDG 10 (reduced inequality), SDG 13 (climate action), SDG 14 (life below water) for fisheries under rubber tree canopies, SDG 15 (life on land), and SDG 17 for partnerships. The rubber seed oil is a source of biodiesel for SDG 7 (clean and affordable energy). The dual relevance to climate change and the SDGs is to the advantage of the rubber tree. The objective of this paper was to present the trend of climate change to the place of the rubber tree in climate change adaptation, mitigation and socio-economic factors of forest communities.

**Key words:** *Hevea*, rubber tree, climate change, SDGs

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# Managing soil quality to improve sustainability of rubber plantations, what do we know?

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**Extended abstract**

Understanding the relationships between the functioning of rubber plantations and the functioning of soils is integral to the issue of the sustainability of natural rubber systems in the context of climate change. Soils play a major role in mitigating and adapting cropping systems to climate change. On the one hand, soils contribute to carbon sequestration in ecosystems through their capacity to store organic carbon. They are also important in the regulation of emissions of other greenhouse gases like methane and nitrous oxide. On the other hand, soils support the productivity of agricultural lands through the regulation of nutrient and water cycles that depend a lot on the activity of the organisms living at the soil surface or in the soil layers.

Most of the recent scientific literature about rubber plantations and soils mainly deals with the negative effects on soils of the land use change related to the conversion of natural forests to rubber plantations. For instance, de Blecourt et al. (2013) showed a strong decrease in soil carbon stocks in the Xishuangbanna Dai Autonomous Prefecture of China, while Guillaume et al. (2016a, 2016b) provided a broader view of soil degradation after conversion of forests to plantation systems in Indonesia. Deforestation is indeed an important issue but our objective in this presentation is to consider the role of soils in the sustainability of rubber plantations after the deforestation had happened. We have identified several issues that must be addressed. Rubber plantations are perennial systems with a lifespan of 25 years or more and a forest-like functioning (i.e. annual production of above and belowground litter). Therefore, we can wonder i) if rubber plantations can improve the soil quality after intensive annual crops known to deplete soil resources (e.g. cassava in Thailand), ii) if soil keeps degrading after forest conversion or if there is any room for soil function improvement. From the point of view of an agronomist, the main questions are iii) about the sensitivity of the performances of a rubber plantation, in particular yield, to soil quality and iv) about the good agricultural practices that can help to improve soil quality.

In the following, we are bringing some answers to these questions based on the works CIRAD and its partners have carried out over the last years. Part of these works is based on the use of the Biofunctool method

(Thoumazeau et al. 2019a, 2019b), which is a new methodology for assessing soil quality. According to Karlen et al. (1997), this method has been developed on the premise that soil quality is the capacity of soils to function and to deliver ecosystem services. Concretely, it means that we cannot assess soil quality only through the measurement of nutrient stocks or basic physical parameters such as soil texture. We need indicators of the main functions of soils. In this respect, the Biofunctool method assesses three main soil functions following the conceptual framework proposed by Kibblewhite et al. (2008): carbon transformation, nutrient cycling and maintenance of soil structure. For each function, we selected low cost in field indicators, with the idea of building an affordable and user-friendly tool for assessing soil quality. The current version of the Biofunctool method includes nine indicators which are aggregated in one soil quality index.

The life cycle of a rubber plantation is commonly divided into two phases of unequal duration. The immature phase spans from the set-up of the plantation to the beginning of latex harvesting that occurs between five and seven years old after the planting of the trees. The mature phase that follows can last up to 30 years and corresponds to the period of tree tapping for latex. Our recent works highlighted the specificities of these two phases with respect to response to fertilization, nutrition of the trees and soil quality. The immature phase is characterized by a rapid growth of the trees, high nutrient requirement and a significant and positive response to fertilization or soil fertility (Vrignon-Brenas et al. 2019; Perron et al. 2021). During the mature phase, growth of the trees and nutrient export are low, and response of yield to fertilization is unclear (Chotiphan et al. 2019). Regarding the soil quality, Thoumazeau et al. (2019a) showed that the Biofunctool soil quality index (SQI) is low during the immature phase and did not improve much after the conversion of cassava fields to rubber plantation in Thailand. During the mature phase, the SQI improved significantly and was getting closer to the SQI of local forests.

Further works showed how some agricultural practices could protect or improve soil quality. The studies carried out in Thailand by Clermont-Dauphin el al. (2016), Thoumazeau et al. (2019b) and Neyret et al. (2020) illustrated the importance of soil cover management. Neyret et al. (2020) compared runoff and soil detachment between maize fields, mature rubber plantations with intercrops between the tree lines and mature rubber plantations in which herbicides were used to eliminate the natural vegetation cover growing between trees. The results clearly showed that the risk of soil erosion increased when the soil was bare even in mature plantation with a dense tree canopy. The two other works highlighted the benefits of cover cropping with legumes. First, Clermon-Dauphtin et al. (2016) showed the strong influence of growing *Pueraria* on the growth of the trees. In this study the nitrogen fixation by the leguminous crops was estimated to more than 200 kg of nitrogen per hectare. In the second study in the same region, Thoumazeau el al. (2019b) looked at the effect of *Mucuna* cover on the soil quality assessed with the Biofunctool method. The results show that the soil quality of a four-year-old plantation with *Mucuna* cover was significantly higher than a four-year-old plantation with cassava intercropping, and was similar to the soil quality in a nine-year-old plantation.

Most recently, we studied the impact of the long-term cultivation of rubber tree on soil quality. In southern Thailand, we showed a continuous loss of soil organic matter (SOM) in a chronosequence of forest and rubber plots set up to mimic a 75-year sequence equivalent to three successive rubber plantations after deforestation (Paklang et al., *in prep.)*. From this study, it appears that SOM losses occurred mainly at the renewal of the plantation, between the logging of the old plantation and the planting of the new trees. In Thailand, like in most rubber-producing countries, part or all of the tree biomass of the old plantation is exported before setting up a new one. In some countries, trunks and bigger branches are used as timber representing an alternative source of revenues for farmers, but in other countries, residues are simply burnt. In an experiment in

Ivory Coast, we are testing another option, which is to leave part or the entire tree biomass in the inter-rows. First results from this experiment showed the positive effect of this practice on the Biofunctool SQI and tree growth 18 months only after the logging of the old plantation.

The objective of this communication was to put forward the role of soils for the sustainability of rubber plantations. First, we saw that soil quality can have strong positive effect on the functioning of the rubber plantation. Therefore, managing soil quality must be taken into account in strategies for the adaptation of rubber plantations to CC. In this respect, it is important to keep in mind that soil quality naturally improves in mature plantations. In the meantime, good agricultural practices can be adopted to avoid soil degradation or further improve its quality. Soil cover and logging residues management are examples of the importance of adding organic matter, alive or dead, to the soil. Lastly, besides experimental works to enrich our knowledge of the relationship between practices, soil quality and plantation performances, it is also important to work on the factors that can contribute to the adoption of these practices by smallholders. That is certainly the main bottleneck to address in the future.

**Key words:** Rubber plantation, soil sustainability, soil quality index, Biofunctool, good agricultural practices.

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# Breeding rubber clones for non-traditional areas

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**Extended abstract**

Rubber tree (*Hevea brasiliensis*), which originated in the Amazon Basin in Brazil, was first introduced to the East from seeds collected by Henry Wickham. He collected about 70,000 seeds in Boim near the Tapajos River in 1876. The surviving 22 seedlings introduced to Singapore and Malaya in 1877 became the progenitors of the commercial planting materials in Malaysia and other rubber growing countries.

The natural rubber industry was indeed founded on a very narrow genetic base. The plant breeders felt that there was a need for an extensive programme to continuously and systematically collect wild *Hevea* materials from its origin in South America. Broadening the genetic base was much needed for a successful rubber breeding program.

This led to a joint expedition by the International Rubber Research and Development Board (IRRDB) member countries and the Brazilian Government in 1981, to collect wild *Hevea* germplasm seeds in three western states of Brazil mainly in Acre, Rondônia and Mato Grosso. This prospection succeeded in collecting a total of 64,736 seeds and 1,522 meters of budwoods of *H. brasiliensis*.

In 1995, the Rubber Research Institute of Malaysia (RRIM) and the Brazilian Government conducted an expedition to collect seeds of various species from the upper Amazon, Brazil (Tabatinga, Atalaia do Norte, Benjamin Constant, Sao Paulo de Olivença and Manaus). A total of 50,231 seeds were successfully planted, evaluated, conserved and utilized under the breeding program in Malaysia.

Besides latex production, *Hevea* wood has gained significant importance as a raw material in the timber-based industry. This is due to the creamy colour and good timber working quality as well as abundant supply from the smallholders and estate sector. More than 70% of high-value furniture exported from Malaysia is made from *Hevea* wood. Considering the tremendous prospects of *Hevea* wood, emphasis has now shifted to breeding of quick-growing clones with high latex and timber production, referred as latex timber clone. These clones are suitable for rubber forest plantations.

Indeed the IRRDB 1981 germplasm has broadened the much-needed Hevea genetic base and will help the breeding program to reinforce the addictive genetic component for yield, girth and other important characters. These germplasm materials have been the important source for the development of location-specific clones capable of withstanding various diseases, cold, drought and wind damage.

The wild Amazonia germplasm acts as a depository of genes for specific attributions, especially tolerance to abiotic stress like drought and cold, and biotic stress like diseases by various pathogenic fungi. As such the IRRDB has planned a new germplasm collection mission to the Peruvian Amazon in the coming years. This will create a greater impact towards *Hevea* improvements for both traditional and the non-traditional planting areas.

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# Climate monitoring and analysis to optimize rubber cultivation

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## Extended abstract

Climate is a resource for growth and yield of rubber and many other crops. Climatic elements need to be recorded, analysed and used for better rubber cultivation or management. Climate data could be used for land suitability assessment, making relation between climate fluctuations and crop performance, and it is possible to make cultivation adjustments based on climate fluctuations.

In this paper, the use of climatic data for rubber cultivation is presented. Climatic elements could be measured by conventional meteorological stations designed by the World Meteorology Organization including pan evaporation, wind speed, air temperature, and solar radiation. But currently, there is an automatic weather station that would make weather observation much easier as data can be stored automatically by setting the time of recording and there is no need for special weather observers.

El Niño and La Niña are known and could be anticipated three months earlier so that dealing with drought and wet condition can be anticipated in rubber plantations by making lag correlation between the Southern Oscillation Index and rainfall three months ahead (Nicholls 1991, Rimmington and Nicholls 1993). The observed climatic data could be analysed and used for calculation of the need of irrigation water by knowing potential evapotranspiration, which can be estimated from a pan evaporation, and by the estimation of stored soil moisture or available water to be maintained by watering to avoid water stress of plants in the nursery. Leaf disease caused by *Colletotrichum* could also be prevented by observing the rainfall pattern during the first 10 days of new leaf formation and spraying of fungicide when rainfall is conducive to disease development (Parawirosoemardjo 2007). Timing of rainfall will affect latex collection, where rainfall occurring in the early morning would make the tapping panel become wet, requiring to wait until it is dry before tapping can be done, while rainfall during afternoon would wash late drip of latex. Installing rain guards could reduce the latex being washed by rainfall and could minimize yield loss (Wijaya and Solichin 2010).

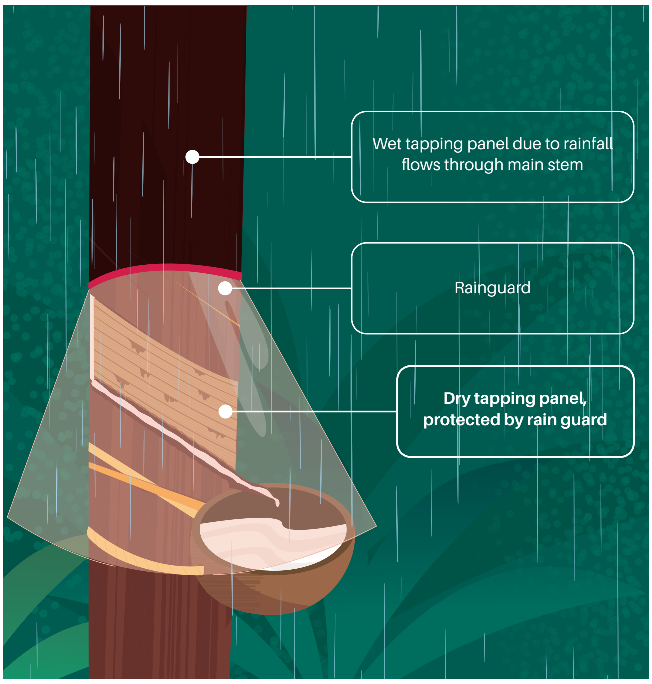


**Figure 3. Effect of rain guard on tapping panel**

Planting time of rubber can be more secure when taking account of rainfall probability of at least 75% (three years out of four) instead of using average of monthly rainfall or the probability of 50% receiving rainfall. The great variation of rainfall from year to year at the beginning of the rainy season in Indonesia may lead to a risk of drought for newly planted rubber trees and it would be better to take account of rainfall probability of at least 75%. By knowing relationships between climate and rubber growth, potency of rubber growth in a particular area can be estimated using a crop model.

**Keywords:** climate, monitoring, analysis, rubber cultivation, rubber plantation

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## Conclusions of the chair

The potential impact of climate change on rubber production in both traditional and new areas is a crucial question for the future localization of rubber plantations, renewal of plantations and extension in marginal areas. What will be the conditions for rubber in 30 years determines the decision to renew plantations or to plant elsewhere, and with what type of genetic material and management practices. Parts of the rubber plantations are due to be renewed. It is important to be able to give smallholders and investors the appropriate information, technical solutions and incentives. There are already many results from research that can be used for marginal areas and for adaptation.

Climate information and projections are critical. There are examples of crops and countries where such projections are used to orient plantations, like in Brazil for coffee, and the development of associated extension services and value chains, like in Korea for apple trees as part of its first adaptation plan. Projections can help answer the question of the distribution of rubber in traditional and marginal areas in the future. Observed climatic data could be analysed and used for plantation management, such as calculation of the need of irrigation water and estimation of some disease risks.

The question of future distribution of rubber needs to take into account competition and complementarity with other land uses, including protection of primary forests, competition for land, with palm oil for instance, the issue of soil quality, and the potential role of rubber for the sustainable development and adaptation to climate change of landscapes and communities. It is also one of the points that are the most important when thinking about the mitigation potential of rubber as land use change can be a major source of emissions.

The role of soils for adaptation to climate change and for the sustainability of rubber plantations needs to be appropriately recognized and integrated in management practices. Soil quality can have a strong positive effect on the functioning of the rubber plantation. It naturally improves in mature plantation and should not be lost when renewing trees.

Broadening the genetic base of cultivated rubber can open perspectives for adaptation as well as for other breeding objectives. The wild Amazonia germplasm constitutes a repository of genes of interest for breeding to resist abiotic stress like drought and cold, and biotic stress like diseases by various pathogenic fungi.


Photo by Axel Fassio/CIFOR

2

# Session 2
# Rubber and climate change mitigation and adaptation

The purpose of session 2, chaired by Eric Gohet, from CIRAD, was to consider the role of natural rubber systems to mitigate climate change and to adapt to it. The first sub-session focused on how natural rubber systems can contribute to mitigating climate change. The second sub-session considered the role of rubber systems for adaptaton.

# Sub-session 2.1
# How can rubber systems contribute to climate change mitigation?

Chairperson: **Eric Gohet**
*CIRAD*

Photo by Deanna Ramsay/CIFOR

# Effects of large scale tree plantations on local climate: What potential for rubber tree plantations?

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## Extended abstract

Large-scale land cover changes are occurring throughout tropical areas in order to respond to the increasing global demand in plant materials such as wood, oil, textiles, food products and natural rubber. In particular, the area of tropical tree plantations have strongly increased over the last decades, reaching about 20 million hectares for fast growing eucalypt plantations (Booth, 2013), or 14.3 million hectares for rubber tree plantations (IRSG 2018), most of them established in Southeast Asia. Such land use changes (LUC) have the potential to impact the local, regional and global climates due to modifications of the albedo (which affects the surface radiative budget), of surface roughness, and canopy stomatal and aerodynamic conductance (which affect the partitioning of available energy between latent and sensible heat fluxes), and of the carbon sources and sinks strengths (which affect the atmospheric $CO_2$ concentrations).

It is well known that the replacement of natural forests by tree plantations leads to large losses of biodiversity and release of $CO_2$ to the atmosphere. In contrast, afforestation of croplands, grasslands and degraded shrublands generally results in increases in landscape carbon stocks, thus contributing to climate change mitigation. Furthermore, tree plantations can contribute to the reduction of fossil carbon emissions, when the wood from the plantations is used as a substitute of fossil combustible, e.g. by replacing the coke by charcoal in the steel industry (Fallot et al. 2009) or in power plants (Waewsak et al. 2020). Similarly, using natural rubber (renewable product) as a substitute to synthetic rubber (produced from fossil carbon) avoids fossil carbon dioxide emissions.

In addition to the global warming attenuation through carbon sequestration and avoidance of fossil carbon dioxide emissions, tree plantations can mitigate warming through evaporative cooling (Peng et al. 2014). This is due to their high actual evapotranspiration (AET) in comparison to other land uses such as crops or grasslands. Although in boreal areas the evaporative cooling of tree plantations can be over-compensated by a warming resulting from low albedo, in tropical areas the cooling by AET generally largely dominates the warming effect of low albedo, thus resulting in a net cooling effect of tree plantations and natural forests (Bonan 2008, 2016; Prevedello 2019). In this presentation we report data obtained in fast-growing

eucalypt plantations in south-eastern Brazil, and in rubber tree plantations in Thailand, and results from previous published studies that confirm the cooling trends of these tropical tree plantations.

In Brazil, the mean AET measured by eddy covariance over a seven-year eucalypt rotation (~1400 mm yr$^{-1}$) represented about 90% of the annual rainfall, and the latent heat flux associated to this high AET represented about 88% of the available energy (net radiation), thus suggesting a high evaporative cooling. Furthermore, comparison of land surface temperatures (LST) derived from satellite images showed lower LST over this plantation and over nearby eucalypt and pine plantations than over grasslands, and soybean and sugar cane plantations, which is consistent with results reported in some previous studies (e.g. Jackson et al. 2008). Among other factors, the high AET of these south-eastern eucalypt plantations was allowed by a good fertilization regime, which increases both tree growth and water use (Christina et al. 2018) and by the ability of eucalypt trees to rapidly develop a deep root system (>10 m deep two years after planting; Pinheiro et al. 2016; Germon et al. 2019) allowing them to get access to large amounts of soil water (Christina et al. 2017).

In rubber tree plantations in Thailand we found AET of about 1150 mm yr$^{-1}$, which falls in the lower range of values reported previously for rubber tree plantations in north-eastern Thailand and Cambodia (1210 and 1450 mm yr$^{-1}$; Giambelluca et al. 2016), and south-western China (Tan et al. 2011). As for eucalypt plantations, the high AET values measured in some rubber tree plantations growing on deep soils could partly result from deep rooting (Pierret et al. 2016; Giambelluca et al. 2016). The mean proportion of net radiation used for evapotranspiration in the rubber plantations (0.73) was similar to that reported by Giambelluca et al. (2016) (0.72). These high values are similar to that reported for tropical rainforests (0.72; Fisher et al. 2009), thus suggesting that well-managed rubber tree plantations might behave similarly to tropical rainforests in term of evaporative cooling and moisture recycling to the atmosphere (Staal et al. 2018; Zemp et al. 2014).

Further studies are required to better assess the biogeochemical and biophysical effects of rubber tree plantations on the local and regional climate, using field measurements, ecophysiological process-based models, and regional atmospheric models. Evaporative cooling, in particular, may contribute to both local warming mitigation (Ellison et al. 2017) and tree adaptation to increased air temperatures, by keeping leaves to physiologically safe temperatures, thus avoiding overheating and thermal damage. Evaporative cooling, however, is only possible when sufficient soil water is available, and might therefore not operate in marginal areas with low precipitation. Research is also needed to better assess the effects of sylvicultural practices on the feedbacks between rubber tree plantations and local climate.

**Keywords:** albedo, evaporating cooling, evapotranspiration, carbon, water and energy cycles, biogeochemical and biophysical effects, climate change mitigation and adaptation, rubber tree plantations, eucalypt plantations

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# Improving biodiversity in rubber plantations: A low-cost strategy to sustain soil health and mitigate drought

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**Extended abstract**

Loss of biodiversity, soil degradation and climate change are important concerns facing agriculture including the natural rubber plantation sector globally. Increasing costs of cultivation and price volatility are also major constraints faced by the rubber plantation industry. Evolving resilient and low-cost strategies for developing sustainable rubber ecosystems is of critical importance for continued viability of the rubber plantation sector without compromising the livelihood security of the rubber growers.

Improving biodiversity in rubber plantations through crop/species diversification for ecological and economic sustainability is a major focus of rubber research in India. Several multispecies rubber ecosystems were evaluated for their effect on the performance of rubber, soil health, climate resilience and income generation. There are lot of possibilities during initial years for intercropping a variety of food crops with rubber, two-tier or three-tier systems harvesting sunlight at different strata simultaneously and sequential intercropping synchronizing light availability within the plantation with the light requirement of crops will maximize returns (Jessy et al. 2005, 2013; Jessy and Jacob 2020). Low light availability within the plantation during the mature phase limits the choice of crops after canopy closure. Shade-tolerant crops like coffee, cocoa, vanilla and certain medicinal and ornamental plants are suitable for cultivating in mature rubber plantations (Jessy et al. 2015, 2017; George and Meti 2018). Judicious crop mixing in rubber plantations either improved or did not influence growth and yield of rubber, sustained or improved soil fertility status and reduced costs of cultivation. Crop diversification also improved soil microbial population in rubber plantations (Vimalakumari et al. 2001).

Natural flora or weeds were generally not permitted in rubber plantations either due to the perception that weeds compete with rubber for natural resources or for aesthetic purposes. Studies have shown that retaining natural flora in rubber plantations reduced soil acidity (Jessy et al. 2013) and improved soil health (Abraham and Joseph 2015). An extensive soil survey conducted in India showed that soil acidity is a major fertility constraint in rubber growing soils (rubsis.rubberboard.org.in) and retaining natural flora is a low-cost and effective strategy for reducing soil acidity. Retaining natural flora also improved soil cation status and carbon stock in rubber plantations (Abraham and Joseph 2015).

Rubber-growing regions also experience increasing drought due to climate uncertainties and rising temperature. Retaining an undergrowth of crops or natural flora improved moisture content during summer and mitigated drought (Jessy et al. 2017; Abraham and Joseph 2015).

Judicious crop/species mixing in rubber plantations has ecological and economic advantages which can be easily exploited

even by the most resource poor growers. A concerted effort among concerned stakeholders is needed for consolidation of data, awareness generation and scaling up of adoption.

**Keywords:** biodiversity, soil health, intercropping

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# Product from specialty natural rubber as an alternative material to synthetic rubber towards application of naturally sustainable resources

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**Extended abstract**

The use of renewable raw materials such as natural rubber (NR) in the production of specialty NR is considered more environmentally sustainable as compared to the non-renewable resources used in the production of synthetic rubber for the same type of rubber products. This is especially true in the case of Malaysia where the NR originated from the replanting cycle and hence is free from the elements of deforestation, habitat and biodiversity destruction as well as being the source for carbon sequestration. NR is one of the known renewable source materials that is used extensively in various products application, e.g. tyres, footwear and automotive products, due to its outstanding properties, namely its elasticity, mouldability into any desired shape and size as well as its adaptability to changes (toughness, chemical and thermal resistance). In order to widen NR applications, its research and development was focused onto modification route to improve drawbacks inherited by the material. With the motivation, development of specialty natural rubber enhanced the NR properties in applications related to damping, oil resistance, gas permeability, wet grip and rolling resistance. These specialty NRs (epoxidized natural rubber and deproteinized natural rubber) expand the NR application market as alternative material from more sustainable resources with properties comparable to the synthetic counterparts.

The advantages of these specialty materials have been extensively exploited in various forms; e.g. dry rubber and latex product applications. The product applications have been substantially explored in pre-commercial settings with various industry involvement. Foam and adhesive are among the products produced which have shown eminent properties. The fabricated specialty latex foam shows excellent sound-absorbing and vibration-damping properties, whereas the water-based adhesive gives an alternative for non-toxic, environmentally-friendly and less odorous adhesive. In order to expand the usage of these specialty rubbers, further modification was also performed via chemical route. Chemical degradation of the specialty latex forms a material to be known as liquid epoxidized natural rubber (LENR). The LENR with lower molecular weight (< MW˜30,000 g $mol^{-1}$) have potential in applications for sound insulation (0.07 sound absorption), toughening agents and processing aids.

**Keywords**: Specialty Rubber, Dry rubber product, Latex product, Renewable raw material

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# Modelling the impact of rubber expansion on carbon stocks in the mountainous landscape of Southwest China

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**Extended abstract**

At present, more than half (57%) of the global natural rubber (*Hevea brasiliensis*) is produced in the Greater Mekong Subregion (China, Cambodia, Laos, Myanmar, Thailand, and Vietnam). The rapid expansion of rubber in the region has been accompanied with the conversion of over 2 million hectares of other land use types to rubber from 2000 to 2010 and continues with lower rates up to now. Recent trends in land use change in the region consist of rubber planting into non-traditional cultivation areas and further expansion into higher altitude and latitude. The shift from tropical forests and traditionally-managed swidden agriculture to large-scale rubber monoculture has greatly improved the livelihood of many smallholder farmers, but it also resulted in a loss of ecosystem services and significant changes in ecological functions and socio-economic conditions. We concentrated in our studies on ecosystem carbon stock dynamics, considering all main components and drivers, such as soil carbon losses caused by erosion and land use change driven plant carbon dynamics.

In our study we are answering two main research questions: how do ecosystem carbon stocks vary in a specific landscape experiencing rubber expansion under a changing climate, and how do environmental protection measures or governmental policy impact carbon sequestration? The main method applied was ecological modelling of biophysical and socio-economic processes at landscape level.

We assessed carbon stocks in rubber plantations in Xishuangbanna, Southwest China (Yang et al. 2017, 2019) of various stand age (from six to 35 years), located at different elevations in the landscape. The maximum carbon stock was measured in old rubber plantations with 148 Mg C ha$^{-1}$ at elevations below 800 m. Against a background of global climate change, the impact of different elevations and planting densities on biomass development and latex production of Pará rubber were examined under present and projected future climate scenarios. Using Land Use Change Impact Assessment (LUCIA), we simulated rubber growth and latex production at tree, plot and landscape levels. We report modelling results for cultivation regions higher than 800 m above sea level and planting densities > 500 tree ha$^{-1}$; extending the research and evaluation to the new rubber expansion regions in Xishuangbanna, China. Under future climate change scenarios, high elevations (900–1200 m) are becoming more favourable for rubber growth, owing to warmer conditions and increased precipitation (13% higher than at elevations < 900 m). During a 40-year simulation, the results of the RCP 8.5 climate change scenario suggested that mean total biomass and cumulative latex yield of highland rubber (per tree) increased by 28% and 48% respectively, while in lowland rubber

they increased by 8% and 10% respectively when compared to the baseline. To meet the local livelihood requirement and improve regional carbon sequestration potential, low (< 495 trees $ha^{-1}$) and medium planting densities (495 - 600 trees $ha^{-1}$) would be advisable. Moreover, global climate change scenarios projected on a regional context might fail to reflect the influence of temperature and precipitation, owing to a relatively strong management impact on aspects such as planting density, which were observed to be higher at higher altitudes. Integrated with an intensive ground survey, our spatially explicit LUCIA model proved its capability of continuous simulation of rubber growth and productivity over a whole rotation period.

Surface water runoff and sediment yields were estimated at plot level with the help of Gerlach traps for rubber of different ages. Highest erosion was observed in mid-age rubber plantations (277 g $m^{-2}$), which were 3.5 times and five times larger than in young and old plantations respectively. The spatially explicit model LUCIA was applied to scale plot-level results up to watershed level (Liu et al. 2019). By this means we (i) estimated dynamic change of carbon stock and of anti-erosive effects of rubber plantations with its development; (ii) explored the synergetic effects of carbon stock building and anti-erosive soil conservation in the rubber-based system; (iii) evaluated the impact of rubber plantations' rotation length at different elevations on an integrated assessment of ecological (carbon stock and soil conservation) and economic (latex yield) gains. We successfully simulated erosion using the updated LUCIA model, which incorporates a dynamic, multi-layer plant–weed–litter structure as well as rainfall detachment. The improved model was able to mimic soil loss under different weed management options in rubber plantations during one rotation length (20 years) reasonably well. The modelling highlighted some potential periods of a high degree of erosion under the current common "twice weeding" weed management practice. During the early canopy closing period, depression of weed growth by the tree canopy and insufficient litter supply from rubber led to a low level of soil coverage, and therefore resulted in a high degree of erosion. "Once weeding" and "no weeding" both significantly reduced total soil loss by maintaining a high level of surface cover. The model results further implied that "no weeding" largely protected soil from rainfall detachment by decreasing it to only 1% of total detached soil. However, this management option is unlikely to be adopted by farmers due to the long-term persistence of weeds if there is a high level of surface cover (over 95%). On the other hand, "once weeding" is suggested as a best practice to maintain a high level of surface cover (over 60%) while controlling overgrowth of understory vegetation by keeping weed cover below 50%.

Finally, we propose an optimized land management of rubber plantations in the landscape. The results of this study could serve to achieve a better balance between ecosystem services and economic development.

**Key words:** Rubber plantation, soil conservation, carbon stock, latex production, LUCIA modeling

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# Climate change and *Hevea* species

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## Extended abstract

The background of our research is that we are now facing global warming. The effects of global warming and climate change have brought worldwide concern about decreases in crop yields for staple grains and biomass resources. The development of plants with important added characteristics will contribute to vital global issues such as securing a steady supply of food/resources in spite of climate change. Japan is also affected by global warming. We have now very hot summers and reduced snow in winter. Dry summer affects crop production and we often have Gelila rainfall and thunderstorms that cause water overflow from rivers. To reduce emissions of greenhouse gases (GHG), many countries are trying to shift their lifestyles from petroleum-dependent material production to more environmentally-friendly production using natural resources.

For crops we are trying to obtain data from current farmland and make predictions using climate data. We are also trying to represent climate changes in experimental conditions to collect data such as grain yields. For prediction we are using the d4PDF database. This database contains climate information of the past 61 years. We compare the effects of future climate change using three scenarios: without global warming, with a 2°C temperature increase, and with a 4°C temperature increase. From this data we can make predictions not only in Japan but also in other areas. We evaluate effects stochastically from various ensembles of data and use it for climate, hydrology, electricity, agriculture etc. Worldwide the resolution is 60 km; for Japan and close to Japan, 20 km.

Geoengineering refers to deliberate and large-scale interventions in the Earth's climate system; for instance: control of solar irradiation by applying aerosols in the atmosphere, positive removal of GHG, and carbon dioxide capture, utilization and storage (CCUS).The potential of such techniques is actively discussed using several models but would need social and ethical discussions to be implemented. Tree growing is a practical way to contribute to such geoengineering approaches. It could involve disease resistant clones or high yield clones to capture more CO2.

Our research activity is inscribed in this perspective. It aims to address predicted changes by trying several experiments of combinations of genotype and environment where selected clones will be challenged in the field.

This genome–environment approach was recently proposed by several researchers. Each accession, cultivar, and clone has different characteristics; this is the genome component. They behave differently against various environmental conditions; it is the environment component. We may also apply this strategy for natural rubber. As for genotype we can choose several clones, cultivars. A key parameter is of course the quality of latex. For environment we can choose several temperature conditions and disease-resistance as one needed environmental condition. We selected resistance to the South American leaf blight (SALB) of rubber, caused by the fungus *Microcyclus uloi*, which is a major constraint in South America and a major threat to plantations all over the world. With these parameters in mind we are paying special attention to three *Hevea* species. *Hevea brasiliensis* is the main commercial source of latex but is highly susceptible to SALB. *Hevea nitida* is not infected naturally by SALB but has a latex of poor quality and that has been found to prevent coagulation when mixed with other latex. *Hevea spruceana* has a watery and low quality latex, with a high proportion of resin but, even though susceptible to SALB, is used in breeding programmes to improve the disease resistance of *H. brasiliensis*.

Genome-wide accession study (GWAS) and genomic selection (GS) are powerful methods to overcome environmental challenges, such as drought tolerance, disease resistance, and latex productivity. GWAS identifies the association between DNA variants, such as single nucleotide polymorphisms (SNPs) and traits (drought tolerance, disease resistance, and latex productivity). GWAS aims to find the causable gene using these correlations. GS is also very important especially in agricultural production and breeding. It is a method of predicting and selecting an individual's genetic ability based on information of genotyping data. To perform these analysis with high accuracy, the quality of the original genome data is also important.

The objective is thus to improve *Hevea* clones for sustainable development and climate change. To achieve this we will examine the growth environment of *Hevea* species, examine the characteristics of Hevea species, compare the genome between *H. brasiliensis* and other *Hevea* species and examine SNPs and transcriptome data of *Hevea* species.

# Sub-session 2.2
# What's the role of rubber systems for adaptation?

Chairperson: **Eric Gohet**
*CIRAD*

Photo by Icaro Cooke Vieira/CIFOR

# Rubber cultivation for enhancing the environmental and social resilience to climate change in drier climates of Sri Lanka

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**Extended abstract**

Being a tree crop with negative carbon dioxide emissions, rubber cultivation contributes to climate change mitigation (Kumara et al. 2016). In view of enhancing foreign exchange earnings, the Government of Sri Lanka promoted industries for value addition in rubber. As a result, the rubber products manufacturing sector in Sri Lanka boomed and the status of Sri Lanka changed from an exporter to an importer of raw rubber.

When it was successfully introduced in the country, rubber cultivation was initially confined to the wet regions. Limited land availability in these regions provided no room for further expansion of rubber cultivation; instead, the decline in rubber production was evident in these traditional wet regions due to the allocation of land to higher priority development activities (e.g. industrialization, urbanization with induced land fragmentation, etc.). At present, raw rubber production in the country has been able to cater only about 50% of in-country demand. Therefore, finding new areas for rubber cultivation (i.e. non-traditional areas) is the next target.

Uncertainty in rainfall patterns and extreme weather conditions caused by climate change has built up high level of concerns on the existence of traditional farming systems and impacts on the livelihood of resource poor farmers. Such a situation has been quite apparent in the Eastern Province of Sri Lanka where farmers cultivate short-term crops under rain-fed conditions mainly for subsistence (Rodrigo et al. 2009). In particular, crop loss due to unexpected droughts in the Ampara district of the Eastern Province has been well evidenced with over 146,000 hectares affected during a 34-year period starting from 1974 (DMC 2009).

In view of bridging the above two needs, rubber cultivation was initially introduced to the Ampara district in 2003 with about one hectare. Unlike in the traditional rubber growing area with well distributed annual rainfall of over 2,500 mm, the Eastern province gets about 1,500 mm rainfall with a distinct dry period of about five to seven months. Nevertheless, the area under rubber in this region has gradually increased up to about 400 hectares to date, confirming the agronomic feasibility of its cultivation.

Temperature rise and soil moisture deficits are some of the major environmental concerns caused by climate change. Environmental benefits of rubber cultivation were envisaged with mid-day air temperatures dropping up to 6°C from outside to inside the rubber lands with an average value of 3.7°C for the daytime and also a doubling in surface soil moisture (Rodrigo et al. 2017). Also, this provides the evidence that farmers would have a more comfortable environment working with rubber than with traditional short-term crops.

Being in a highly vulnerable environment, social resilience is of particular importance and it has been shown that rubber farmers have higher levels of social capital and greater capacities to access other livelihood

capital assets than non-rubber growers (Munasinghe et al. 2019). Further, a case study has revealed the indemnity effect of the rubber crop in sustaining inadvertent disabled farmers (Rodrigo 2017). A special project funded by the International Fund for Agricultural Development (IFAD) has been launched to support farmers in cultivating rubber in this region with a target of 2,500 ha. Given the additionality in fixing atmospheric carbon by rubber in this region (Munasinghe et al. 2014), carbon trading in the voluntary market is underway with the rubber grown under this project.

**Key words:** *Hevea*, nontraditional cultivation, rural livelihood, ecological benefits

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# The role of rubber agroforestry in farming systems and its effect on households: Adaptation strategies to climate change risks?

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## Extended abstract

### Introduction

Expectations from rubber agroforestry systems (RAS) are multiple:

1. Income diversification (rubber + fruits + timber, etc.) provide better economic resilience and also economic sustainability,
2. No impact of agroforestry practices on rubber production (kg tree$^{-1}$year$^{-1}$) as long as no trees are above rubber canopy; rubber production is generally not in competition with associated crops,
3. Less soil erosion and better use of water as vegetal biodiversity increases 'forest-like behaviour',
4. Soil fertility maintenance or improvement if soil is covered by grasses and shrubs,
5. Possibility of timber production as rubber farmers might be the very next timber producers as timber can be easily cropped with rubber (up to 50 trees per hectare),
6. Rubber trees do not require high quantities of fertilizers during mature period and almost no pesticides. Rubber is already 'bio-compatible'
7. Reservoir of local biodiversity and 'forest effect' on climate in large areas; environmental impact and positive effect on climate change; potential mitigation but still to be assessed,
8. RAS are more globally environmental friendly where re-internalizing externalities is a real challenge, including impacts of climatic change,
9. Negative effect of high temperatures on physiology of rubber trees and NR production: agroforestry may play a positive role to maintain good climatic conditions and so rubber production

In Indonesia, the Smallholder Rubber Agroforestry Project (SRAP) monitored RAS trials from 1994 to 2007 (Figure 1) with three main RAS systems all based on clonal planting material: RAS1 with secondary forest regrowth (no intercropping during immature period), Figure 2, RAS2 with fruits and timber associated trees (and intercropping during immature period), Figure 3 and RAS3 similar to RAS2 but with fast growing trees and selected cover crops for shading and killing *Imperata cylindrica* (no intercropping), Figure 4.

In Thailand, many RAS systems are developed either for intercropping during immature periods or during mature periods with fruit (durian, rambutan, longkong, etc.), vegetables (pak liang/*Gnetum*) and timber associated trees (teak, mahogany, etc.).

### Impact of oil palm development

In Indonesia, oil palm is now the very first crop for local farmers and estates, even if rubber remains important for local farmers

**Rubber Agroforestry Systems (RAS)**
**= diversification inside one cropping system**

**SRAP research programme 1997/2007 funded by USAID and CFC A CIRAD/ICRAF/IRRI program**

Rubber planting density similar to that of monoculture

| RAS 1 | RAS 2 | RAS 3 |
|---|---|---|
| An improved extensive jungle rubber | An intensive system with intercrops | Rehabilition of *Imperata* grasslands |


Figure 1. RAS systems (SRAP project 1994/2007)

Figure 2. RAS 1, Sanggau/West Kalimantan, 2019

Figure 3. RAS 2 in Kopar/West Kalimantan/Sanggau, 2007.

Figure 4. RAS 3 in transmigration area, Ttimulia/West Kalimantan, 2007

who want to maintain a certain level of crop diversification. A large part of the local jungle rubber area (that covered 90% of the rubber area in 1994) has been converted to oil palm and/or clonal rubber plantation in 2020. Now, most farmers cultivate in average 2 ha of oil palm, 2 ha of rubber (partly clonal and sometimes remaining jungle rubber) and a small area for food crops or other crops. These farmers cannot count on land availability anymore as they did some 25 years ago.

**The lessons learned**

RAS trials in Indonesia came right in time in 1994 with a strong demand from farmers for low cost clonal systems with income diversification: the right time at the right place but oil palm came in 1997 with a very strong pressure from companies (through the policy of concessions) providing an interesting alternative to rubber with full credit (but loss of land) and better return on labour. Interest in agroforestry practices remains high for older farmers but is limited in younger generations. What will be the future of RAS? It is time for rubber replantation (conversion of old jungle rubber to clonal plantation) and the same old story remains: poor access to planting materials, know-how for grafting, cost reductions, and a serious need for training and good technical information on tapping practices. The poor tapping practices in Indonesia limit rubber lifespan to less than 25 years. We also observed a serious impact of root diseases in areas with forest or old jungle rubber before plantation. It is estimated that up to 25% of clonal plantation may be RAS in 2020. RAS remains a cropping system with relatively high biodiversity (Figures 4 and 5).

In Thailand, largely due to the rubber replanting program implemented since the 1960s that promoted clonal rubber monoculture, agroforestry practices during the mature period are very limited. So far, Thai farmers have preferred diversification at the farm and household levels rather than at the plot level. Low rubber prices do not help to maintain interest in rubber but obviously raise interest for agroforestry practices. The Thai government has also started to ease the restrictions for RAS.

**Conclusion**

The question remains: what is the possible impact of agroforestry on climate change adaptation and mitigation? Globally, more trees and more biomass will create a more local humid and probably less hot microclimate at plot level that would be more efficient to adapt to climate change and would limit the decrease in latex production induced by higher temperatures. It is expected and probable, but still has to be measured and verified.

Some trade-offs might arise: i) there may be some competition for water between rubber trees and associated trees or crops, particularly in some areas like north-eastern Thailand for instance, and possibly South Sumatra and Cambodia outside 'red soils' or similar situations, ii) for shade, all associated trees should be below rubber canopy, iii) we may observe the development of some diseases due to moisture (*Phytophtora*) as observed in Jambi in 2005 in RAS 1 systems and iv) eventually, some possible allelopathy between trees require carefully designing tree/tree associations.

In terms of research, we suggest designing RAS adapted to local markets, exploring the intercropping possibilities during immature period linked with the local context and constraints to generate income at a critical period for the farmers. For long-term RAS, it is also necessary to identify the cash crop or timber species adapted to farmers' strategies with various types of rubber density: double spacing might be economically interesting for smallholders based on their strategy.
For institution and development agencies: most farmers are capable to implement RAS but might lack knowledge and initial capital and access to cash crop/timber plants (if poor availability). National regulation should recognize the right of the farmers to sell timber and any forest product (tree tenure policy is unfavourable in Ivory Coast, for instance).

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## Conclusions of the chair

Session 2 was entitled "Rubber and climate change mitigation and adaptation" and was chaired by Dr Eric Gohet (CIRAD, France). The session was split into two sub-sessions:
- Session 2.1 How can rubber contribute to climate change mitigation? (five presentations)
- Session 2.2 What is the role of rubber systems for adaptation? (two presentations)

Presenters from six countries (France, India, Germany, Malaysia, Japan and Sri Lanka) reviewed the different opportunities and knowledge gaps regarding the possible impact of rubber (from plantations to end product) on climate change adaptation and mitigation.

The first presentation by Dr Yann Nouvellon (CIRAD, France) assessed the potential role of rubber plantations for climate modification and improvement. Based on observations at cover scale on eucalyptus and rubber, the main effects described were the global impacts on atmospheric carbon dioxide concentrations (eddy covariance approaches) as well as local effects, namely cooling (reduction of soil surface temperature) induced by evapotranspiration, in comparison with grass land covers. The presentation concluded as well that the effects of rubber plantations on other meteorological variables and microclimate (rainfall, air humidity, etc.) should be further investigated in order to be better documented.

The second presentation by Dr Jessy (RRII, India) concluded that in a context of climate change, low rubber prices and the issues induced by the COVID-19 crisis, improving biodiversity inside plantations was beneficial: intercropping using fruit crops, vegetables, legumes, perennial crops, medicinal plants and ornamental plants or even maintaining the natural flora had positive effects on soil quality and fertility. Field experiments conducted in Kerala and Tripura states showed positive effects of such practices on soil moisture, erosion, soil chemistry (improvement of soil pH, exchangeable bases and nutrients, especially C, N, K, Ca and Mg). In case of maintained natural flora, biological soil properties like soil respiration, earth worm populations were improved as well.

The third presentation by Dr Sergey Blagodatsky (University of Hohenheim, Germany) presented his results obtained from the Surumer project (2011–2016 Yunnan, China), especially obtained after modelling using the Land Use Change Impact Assessment (LUCIA) model. The model is able to describe carbon sequestration by rubber plantations (biomass and soil), soil erosion, soil degradation and runoff, at watershed level, depending on land management and IPCC climate change scenarios.

The fourth presentation by Dr Fatimah Rubaizal (Malaysian Rubber Board, Malaysia) showed processes developed by MRB in order to increase the potential of natural rubber as a green substitute to synthetic rubber, using especially physical and chemical modifications of natural rubber (deproteinization and epoxidization). Potential future applications in tyres, shoes, sonic isolation, flooring, paints and adhesives markets were discussed and are seriously interesting and envisaged.

In the fifth presentation, Prof Minami Matsui (Riken, Japan) presented the possibilities of using rubber germplasm for climate change adaptation, using especially SNP markers for new genetic selection from 3 different Hevea species (H. Nitida, H. Spruceana and H. brasiliensis).

In the sixth presentation, Dr Lakshman Rodrigo (RRISL, Sri Lanka) showed that rubber plantations, even established in marginal (warm and dry) areas of Sri Lanka, enhanced environmental and social resilience of farms, especially through poverty alleviation and livelihoods improvements in the rural populations. The expected impact of a new carbon offset development project in 2 provinces of Eastern Sri Lanka was presented as well.

Finally, the seventh presentation by Dr Eric Penot (CIRAD, France) showed the important role of rubber agroforestry in farming systems and its effect on households and farmers livelihoods, based on a long term follow up in Indonesia and Thailand. In the context of low prices, those systems result in income diversification for farmers and an improved social and economic resilience. Possible advantages and trade- offs as well as still existing knowledge gaps, in a context of climate change, were presented and discussed.

As a conclusion, the final discussion concluded that the potential opportunities of natural rubber for climate change adaptation and mitigation, in traditional as well as marginal areas, were numerous and could involve many R&D areas. These include plant physiology and ecophysiology, carbon and soil sequestration, new genomic selection methods with an optimized use of the germplasm (looking especially to other *Hevea* species), improved land management through optimized agricultural practices including agroforestry, carbon offset projects, as well as new developments in the downstream sector by promoting new applications of natural rubber as a green substitute to synthetic rubber.


Photo by Rifky/CIFOR

3

# Session 3
## Integration of rubber in broad climate change and sustainability policies, including economic and social dimensions

Chairperson: **Datuk Dr Abdul Aziz b S A Kadir**
*Secretary General, IRRDB*

Session 3, chaired by Datuk Dr Abdul Aziz b S A Kadir, Secretary General of the IRRDB considered the opportunities for better integrating natural rubber in broad climate change and sustainability policies, including economic and social dimensions. Presentations on the potential of rubber for sustainable development and on broad initiatives related to sustainable materials were followed by a panel discussion on how rubber development can benefit from such initiatives.

# Natural rubber: A strategic material for a sustainable world

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**Extended abstract**

Rubber is without any doubt a strategic raw material. It is used in more than 5,000 products and of critical importance in our day-to-day life, such as in the automotive sector and in the healthcare system. Natural rubber, produced mainly in the tropical regions, represents 47% of total world rubber production (IRSG 2020a). Production is highly concentrated, with Thailand and Indonesia producing 62% of world production. The rubber sector is also greatly concentrated on the demand side with the tyre manufacturing sector absorbing 58% of the total rubber (natural and synthetic) produced (IRSG 2020b).

Natural rubber is an important economic and social driver is many countries. Rubber plantations cover around 14 million hectares with a total world production of 13.6 million tons (IRSG 2020a). Around 90% of production comes from the work of smallholders (IRSG 2020a) with natural rubber sustaining 40 million people with their families around the world.

Economically, in the last 10 years, the natural rubber sector has suffered a prolonged period of low prices. The spike in price registered in 2011 has triggered an increase in production as well as an expansion in rubber area of about 3 million hectares that has, over the years, brought an imbalance in the natural rubber supply and demand and concerns about deforestation. Due to the lower level of price, new planting activities have been greatly reduced in the last two to three years (IRSG 2020b).

Recent market developments have been impacted by externalities affecting both world production and demand. In 2019, the outbreak of the *Pestalotiopsis* disease, first in Indonesia and then in Thailand and Malaysia, has led to a reduction in natural rubber production in these countries that has been only partially balanced by increases of production recorded in the Mekong area and in West Africa. At the end of last year, the COVID-19 pandemic started to emerge, first in China and since then has infected 188 countries. Around the world, manufacturing activities have been temporarily closed, many people have lost their jobs or seen their income cut. Unemployment rates have increased across major economies as a result. Demand for oil all but dried up as lockdowns across the world kept people inside. As a result, both production and demand has suffered and showed negative trends. The long period of low prices has also had a negative impact on natural rubber productivity as the share of untapped area increased, farmers left rubber plantations in search for more lucrative jobs and gradually poor agro-management practices have been used.

The need to implement practices raising the sustainability credentials of natural rubber started to emerge in rubber systems. The availability of sustainable material is a key factor for end users; raw materials account for 50% of major end users' tyres and about 12% of the environmental impact occurs during production of raw materials and manufacturing of products (ERJ 2019). Nonetheless, sustainability goes beyond protecting the environment; it must ensure

that stakeholders in the whole value chain, from smallholders to end users, are treated in a socially just and economically valuable way.

Four main areas of intervention are identified for sustainable natural rubber:

- Ensure responsible production and consumption
- Improve smallholders' livelihoods
- Increase transparency in the supply chain
- Promote a circular economy

Major end users have committed themselves to implement sustainability policies in their procurement process, but public–private initiatives will be instrumental to addressing all challenges with the goal to address a broader sustainability agenda.

The International Rubber Study Group (IRSG) is the leading organization on sustainability in the rubber economy. The Sustainable Natural Rubber Initiative (SNR-i), a voluntary and collaborative industry initiative developed under the framework of IRSG, has been the first multi-stakeholder initiative to promote best practices, defining voluntary sustainability standards regarding the broader natural rubber sector. In 2018, the IRSG Secretariat defined a wider sustainability agenda based on nine of the UN Sustainable Development Goals:

- SDG 1: End poverty in all its forms everywhere
- SDG 5: Achieve gender equality and empower all women and girls
- SDG 6: Ensure availability and sustainable management of water
- SDG 8: Promote sustained, inclusive and sustainable economic growth
- SDG 11: Sustainable cities and communities
- SDG 12: Ensure sustainable consumption and production patterns
- SDG 13: Take urgent action to combat climate change and its impacts
- SDG 14: Life on Land – sustainability manage forests, combat desertification, halt land degradation and biodiversity loss
- SDG 17: Partnerships for the Goals

With the goal of making sure that all actions are taken to adapt and mitigate climate change impacts in the natural rubber systems, the IRSG Secretariat has launched the initiative of this workshop organized together with CIFOR/FTA, CIRAD and the International Rubber Research & Development Board (IRRDB).

There is enough evidence that after more than 10,000 years of relative stability, the Earth's climate is changing. Since the 1880s, the average global temperature has risen by about 1.1°C, driving substantial physical impacts in regions around the world (McKinsey 2020). As average temperatures rise, acute hazards such as heat waves and floods grow in frequency and severity, and chronic hazards such as drought and rising sea levels intensify. These physical risks from climate change will translate into increased socioeconomic risks, presenting policy makers and business leaders with a range of questions that will challenge existing assumptions about supply chain resilience, risk models and more.

For centuries, financial markets, companies, governments, and individuals have made decisions against the backdrop of a stable climate. However, the coming physical climate risk is ever changing and nonstationary. Replacing a stable environment with one of constant change means that decision-making based on experience may prove unreliable.

Furthermore, climate hazards manifest locally. There are significant variations between countries and even within countries. The direct effects of physical climate risks must be understood in the context of a geographically defined area.

Climate change can have knock-on effects across regions and sectors through interconnected socioeconomic and financial systems. Supply chains are particularly vulnerable systems since they prize efficiency over resilience. They might quickly grind to a halt if critical production hubs are affected by intensifying hazards.

For natural rubber, the implications are clear:

- 'Business as usual' is not an option. Further research is needed to investigate the real risks posed by climate change to the natural rubber systems. We need data, information and science to play a fundamental role.

- There is the need for a visionary R&D leadership with focus on emerging mass markets and for investments to realize future potential technology. There is a wide gap between knowledge available in the institutional framework and the knowledge converted to effective practice. We need to improve the knowledge transfer process and make it effective.
- Innovative forms of collaboration across national borders and among a variety of actors; governments, businesses, academia and civil society are all needed

Climate change requires urgent, coordinated and consistent action. We need to act now.

**Key words:** Natural rubber, supply chain, climate risk, knowledge transfer, leadership

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# Delivering the circular bioeconomy for low-emissions development: The place for rubber

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## Extended abstract

In face of the climate change crisis, three areas are currently emerging as central challenges of low-emissions development pathways. They relate to the development of the use of bioproducts to substitute non-renewable energy intensive products, needed new thinking about the way we manage the planet's limited resources, and a needed redesign of production cycles in ways that interconnect them into value webs where everything, including co-products, by-products and waste, is used, re-used, recycled, and therefore where waste is ultimately reduced.

These three challenges are not currently highlighted in the perception of policymakers, the public and even most academics. There is much pressure on reducing emissions to control global warming from spinning out of control, and the term 'missing pathways' has been used. Our point here is that these pathways are not missing: they are rather 'pathways ahead,' quite concrete, that need to be underpinned by a joint scientific and policy agenda.

Despite the massive economic crisis triggered by the COVID-19 pandemic, global greenhouse gas emissions continue almost unabated on an annual basis (Le Quére et al. 2020; Liu et al. 2020). The objective to 'build back better' requires a better economic model respecting the planetary boundaries and involving a circular bioeconomy, grounded on sustainable management of land, and in particular of forested landscapes. Productive, diverse landscapes can provide a multitude of bioproducts that deliver food, animal feed, timber, fuels and many other products that, properly managed, could help reducing dependence on fossil fuels and building better livelihoods while sustaining productive landscapes. Humans have always been exploring bio-goods from trees (coffee, tea, cocoa, fruits, rubber, timber and non-timber forest products), and recent innovations offer exciting new ways to substitute non-renewable, energy-intensive goods with more sustainably produced ones (bioenergy, wood-based buildings, etc.). New wood-scrapers can be up to 70 stories high and replace emission intensive cement. Fast-growing bamboo varieties provide many products from furniture to charcoal. Oil-seed trees can be harvested for energy yet permanently restore forest cover in a degraded landscape.

Rubber is one of these forest-based natural products that could become one of the centrepieces of a forest-based circular bioeconomy. The dominant use for rubber is in the car industry, where around 80% of the production goes to producing tyre and non-tyre (tubes, pipes, adhesives, etc.) automotive parts. Non-automotive applications include footwear, industrial goods, construction (door and window siding, floors, etc.), and textiles (latex gloves). Demand for rubber is overall increasing but also suffering competition from polymers, plastics, vinyl, and synthetic rubber which are currently less expensive, readily available across the globe, and sometimes more resistant to abrasion and wear (Fortune Business Insights 2020). However, in the long run, automotive uses might dwindle (think self-driving cars). Tyre

production is currently non-biodegradable, but green biodegradable rubbers and plastics are under development (Mondragon 2017; Micu 2019). Plastic substitution needs will, in the long run, produce a new demand for natural products such as natural rubber. Abandoned or unproductive rubber plantations are being exploited and 'recycled' for bioenergy production (Gibson 2011; Ratnasingam et al. 2015; Riazi et al. 2018). Thus, rubber related production systems are being, or will be, re-engineered in ways that interconnect them into circular 'value webs' where everything is utilized and waste and pollution are reduced.

Working on bioproducts, CIFOR and ICRAF bring in their joint experience of several decades promoting sustainability for people and landscapes in the developing world. We will combine this with new approaches such as the integration of so-far separate production lines into interconnected, low-waste value webs, and with global discussions on production models and objectives. This program has three global thrusts: *Choosing Goals* (global and local societal debates and decisions on consumption patterns, including for food and energy, production patterns, land use, and embedded emissions into produce in view of the planetary boundaries); *Going Green* (developing new biomaterials from forests, plantations and agriculture); and *Weaving Together* (advising communities, businesses and governments on integration across value webs) (Figure 1).

We will pilot this innovative approach with stakeholders, producers and consumers in the context of rural–urban material flows, because these exacerbate the need for circularity (think products entering the cities and the removal of waste and polluted water becoming a problem). Peri-urban areas are highly dynamic 'interfaces' between rural and urban production and lifestyles, making them the ideal environment to bring policymakers, practitioners from business and activists in government and non-government together to realize circular economy principles in specific developing-country contexts.

Futuristic optimism will be underpinned with solid research and pragmatic know-how.

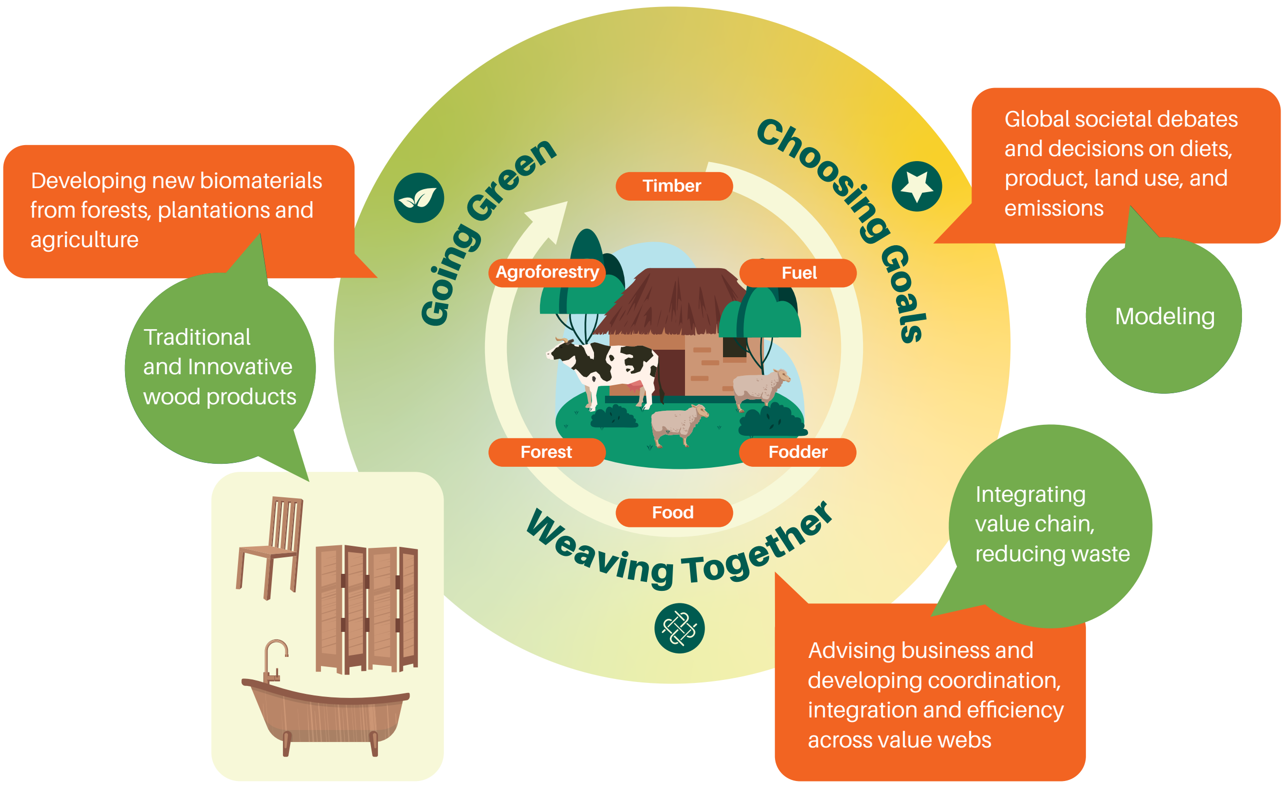


**Figure 1. Pathways to delivering the forest-based circular bioeconomy for low-emissions development. Rubber can play an important role in this transition.**

COVID-19 has displaced many people in developing countries and pushed back many into poverty. It has revealed the vulnerability of major international supply chains. New approaches to the use of land and resources to develop food, materials and products are needed to create new green jobs as part of a sustainable 'build back better' process and to implement circularity in local and also distant production-and-consumption cycles.

Getting it right in these areas could provide novel ways to address the needed reduction in global greenhouse gas emissions in a more connected, circular bioeconomy by developing innovative bio-based products, reducing emissions and land use (this is the bioeconomy), closing production cycles and picking up the many currently wasted open ends in value chains by weaving them into integrated, interconnected value webs. In those webs, the by-product or end-product of a process becomes not waste but the basic product for another process. For example, biomass leftovers from food production becoming a source of bioenergy (this is the circular economy). True to the mission of CGIAR, we intend to develop these pathways in particular to increase the role and participation of developing countries in a global green economy, involving above all the developing world. These new pathways towards sustainable, circular bio-based economies can provide jobs and income for many and lift the living standards of the worlds' poor.

Rubber offers a good opportunity to be part of future economic development trends towards a circular, forest-products-based bioeconomy. It is a natural product with many positive characteristics which make it an essential part of plastic substitution and future uses in industry, textiles/footwear, and construction. It is also quite strongly associated to the fate of the car industry, which warrants including rubber in global trend models for forest-based bioproducts: How long will the automotive demand last? What novel pathways will substitute dwindling automotive uses, and when? How could this change the industry? What would be the effects on small and large producers? How can rubber and rubber tree biomass be included in other forest- and non-forest value chains?

**Key words:** climate change, developing countries, value chains, forest products

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# Sustainable Wood for a Sustainable World initiative and its relevance to the rubber and climate change agenda

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**Extended abstract**

The Sustainable Wood for a Sustainable World (SW4SW) initiative is discussed in a series of short presentations on initiatives and mechanisms that are used for other commodities (than rubber) before considering how it can be of interest to rubber. The SW4SW initiative was adopted in May 2018 as a Joint Initiative of the Collaborative Partnership on Forests (CPF) (FAO 2019). The initiative is jointly led by FAO, with support from its Advisory Committee on Sustainable Forest-based Industries (ACSFI), the Center for International Forestry Research (CIFOR), the International Tropical Timber Organization (ITTO), the World Bank and the World Wildlife Fund (WWF). The initiative aims to strengthen sustainable wood value chains by enhancing and promoting their social, economic and environmental benefits from production through to consumption. It targets primary wood value chain stakeholders, industry associations, small and medium enterprises (SMEs), policymakers, governments, the financial sector, non-forest sectors, consumers, multilateral mechanisms and opinion shapers. This includes rubber wood and associated rubber latex as a non-timber forest product (IUFRO NTFP Task Force 2019).

Once considered of low value with limited uses, over the past several decades rubberwood has seen many new uses and gained in value. While primarily managed for latex production, rubber wood is also being explored for its role in vegetation carbon stock management and climate change mitigation. Total vegetation carbon stock (above and below ground) has been measured at 105.73 Mg ha$^{-1}$ (30–40 years), which is more than many tropical forestry and agroforestry systems across the world (Brahmana et al. 2016). Considering the economic value of plantation management through latex production and its capability to sequester substantial stocks of carbon, restoring degraded and secondary forests through this species can improve livelihood security and advance climate change mitigation strategies.

Rubberwood and latex non-timber forest product (NTFP) value chains are important elements of the bioeconomy (Figure 1). The SW4SW initiative is ensuring sustainability of wood and NTFP management, governance and contribution to people's livelihoods. This includes upscaling to make better use of what we already use and promoting future uses of NTFP for what we do not use yet.

**Key words:** Sustainable wood, Wood-based bioeconomy, non-timber forest products, carbon sequestration, climate change mitigation, rubber plantations

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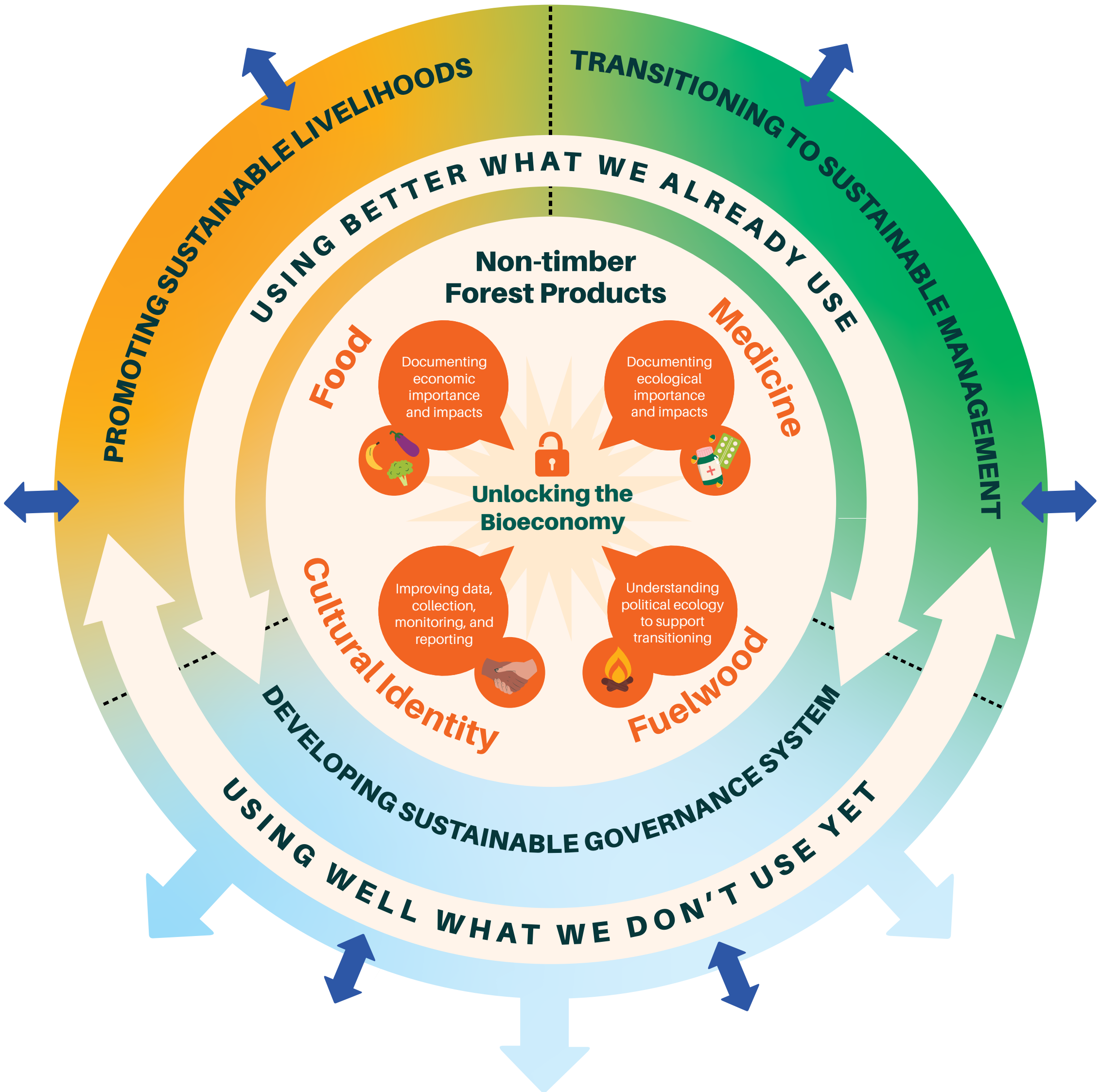


**Figure 1. Sustainability of rubberwood and latex NTFP value chains in the bioeconomy (IUFRO NTFP Task Force 2019).**

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# FLEGT and other mechanisms to promote wood trade legality and avoided deforestation

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## Extended abstract

Concern about the environmental impacts of illegal logging has grown considerably over the past two decades and brought the issue to global attention, with international environmental NGOs at the forefront in raising awareness about the issue. Reported to account for more than 50% of annual harvest in several countries, illegal logging has been seen as undermining the efforts by the private sector and donor agencies to support sustainable forest management. These concerns have led to the development of regional and global initiatives to combat illegal logging, including the 2003 Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT) of the European Union.

FLEGT is a pragmatic public policy response to a complex problem, dealing with both production and consumption. On the production side, producing countries can engage the EU in the negotiation of voluntary partnership agreements (VPA), trade agreements in which producer countries engage to produce and export – and the EU engages in importing and trading – only timber of 'legal' origin (FLEGT-licenced timber). On the EU side, the EU Timber Regulation (effective as of 2013) forbids the placing of 'illegal' timber on the market, guarantees a 'green lane' for timber imported with a FLEGT-licence delivered in VPA countries, and mandates due-diligence to companies importing non-licenced timber.

Over the years, several more efforts to tackle illegal logging and trade have been adopted, including responses in the US, in Australia, Japan, South Korea, and more recently, China. Although FLEGT remains unique in its dual engagement (VPA + EUTR), all other engagements indicate that concern for illegal logging has broadened over the years.

As of 2020, while about 15 producing countries are engaged in the VPA process, only Indonesia is exporting FLEGT-licenced timber. Data indicate that the licence may have contributed to an increase in Indonesian exports to the EU market, while upstream impacts in the country of origin (social, environmental and economic) remain mixed and in need of better data and assessments.

Today, it seems that the expansion of rubber plantations in Central Africa is driving a FLEGT-like response from environmental organizations, similar to the one they had to illegal logging in the 1990s. Yet a FLEGT-like instrument may not necessarily be the most adapted to the current rubber production and trade trends.

**Key words:** FLEGT, Illegal logging, VPA

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# Jurisdictional approaches to reducing deforestation and promoting sustainable livelihoods

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## Extended abstract

Jurisdictional approaches to REDD+ and low-emissions development can be understood as government-led, comprehensive approaches to forest and land use across one or more legally defined territories (Boyd et al. 2018; Stickler et al. 2018). They offer important opportunities to link REDD+ incentives, sustainable supply chain initiatives, and domestic policy and finance in more integrated ways (Nepstad et al. 2013). In Brazil, Acre's State System of Incentives for Environmental Services (SISA) is known as the world's first subnational jurisdictional REDD+ program. It was created through State Law 2.308 (Government of Acre 2010), which was passed in October of 2010. SISA, and specifically ISA-Carbono, is a state policy designed to reduce emissions from deforestation and forest degradation, while promoting conservation and sustainable forest management. It was a culmination of decades of pioneer initiatives for sustainable development in the state.

Acre's state government, known from 1999–2010 as the 'Forest Government,' is credited with the creation of an innovative, forest-based development model in the state. This model combines market-oriented strategies with local participation and social development. It was largely inspired by the success of the rubber tapper social movement, in which Chico Mendes was an important leader. That movement resulted in the creation of extractive reserves and recognition of some traditional land rights (Allegretti 1990). As part of this development model, the government undertook ecological–economic zoning; worked to restimulate the rubber economy, which had declined after federal price supports were removed; created new agencies responsible for timber management and smallholder production systems; experimented with payments for environmental services; and pursued sustainable forest management initiatives at both the industrial and community scales (Schmink et al. 2014).

SISA's jurisdictional REDD+ approach is based on three overall strategies: (i) command-and-control – promotion of environmental compliance, including application of the Rural Environmental Registry (CAR) required by the Brazilian Forest Code; (ii) monitoring – improved monitoring of small-scale deforestation and forest degradation through technological advancements; and (iii) sustainable production – promotion of sustainable activities in both the agriculture and forestry sectors, including beef and milk production, family agriculture, reforestation, and bolstering sustainably-managed timber and non-timber forest products (NTFPs), such as natural rubber (Duchelle et al. 2014). It has become a model for partnership between government agencies and indigenous peoples in jurisdictional REDD+ strategies towards promoting effective and equitable outcomes (DiGiano et al. 2020). It also reshapes the idea of payments for environmental services by emphasizing that forest use, including through the production of natural rubber, can facilitate protection (Greenleaf 2020).

In the period from 2010–2019, Acre received approximately USD 192 million to support SISA, including results-based finance from

the REDD+ Early Movers Programme, which is funded by the German and UK governments. Yet, it has made less progress than other tropical jurisdictions towards meeting its deforestation reduction targets, given recent road paving and the importance of cattle production in the state (Stickler et al. 2020). Balancing forest conservation and development goals remains a challenge, but Acre has served as a laboratory for innovative, forest-based development policies that require continued support.

**Key words:** REDD+, jurisdictional approach, non-timber forest products (NTFPs)

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## Conclusions of the chair

This session allowed the opportunities for better integrating natural rubber in broad climate change and sustainability policies to be considered, including economic and social dimensions. Natural rubber, as a renewable material, and because of its contribution to the livelihoods of millions of small holders has a considerable potential to contribute to sustainable development in its three dimensions: economic, social and environmental.

Rubber offers a good opportunity to be part of future economic development trends towards a circular, forest-products-based bioeconomy. It is a natural product with many positive characteristics which make it an essential part of plastic substitution and future uses in industry, textiles/footwear, and construction. The Sustainable Wood for a Sustainable World (SW4SW) initiative aims to strengthen sustainable wood value chains by enhancing and promoting their social, economic and environmental benefits from production through to consumption. The development of FLEGT and other mechanisms to promote wood trade legality and avoided deforestation show the growing interest of importing and exporting countries to promote mechanisms that can guarantee sustainable sourcing to consumers. There is growing interest in jurisdictional approaches to reducing deforestation and promoting sustainable livelihoods. Such approaches can support the coordination of initiatives and actors in a landscape.

The discussion highlighted the importance of balancing the three Ps: people, planet and profit. There is a risk of smallholders exiting rubber production if it is not profitable anymore. Need to be careful not to create additional constraints and costs for smallholders. They need to be supported and to have a voice in discussions on sustainability. The social dimension is too often ignored. There is in fact a lack of data on social issues in many countries. Certification might not be the best way to promote sustainability for tyres as consumers do not directly buy their tyres and tyres are not the main environmental concern when thinking about cars. It would also be very difficult to implement traceability for sustainability schemes, particularly for smallholders if there is no additional benefit.

It is particularly important for all actors to work together to improve the sustainability of the rubber sector. It would for instance be good to have the private sector supporting efforts for conservation of genetic resources and breeding research conducted in producing countries and that ultimately benefit the whole sector. There is a considerable potential for new uses of rubber and modified rubber, including to replace plastic. There is a need to strengthen research capabilities and there are opportunities for the private sector to get engaged.

Photo by Mokhamad Edliadi/CIFOR

4

# Session 4
# Rubber and climate change in the international fora

*Chairman*: Salvatore Pinizzotto
Secretary General, IRSG

Session 4, chaired by Salvatore Pinizzotto, Secretary General, IRSG, considered how natural rubber could be better integrated in international discussions on climate change.

# Opportunities for natural rubber in international climate change negotiations and mechanisms

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## Extended abstract

There is growing agreement that meeting the global temperature targets of +2°C or even +1.5°C will not be possible without the land use sectors (IPCC 2018, 2019; Roe et al. 2019). Natural rubber has a key role to play for both adaptation and mitigation of climate change. However, this role is not properly accounted for. Neither the IPCC Fifth Assessment Report nor its Special Report on Land Use mention rubber. Nor is rubber mentioned in international discussions on climate change.

Reflections and discussions about trees in climate international negotiations have been very much focused on REDD+, but REDD+ is a tool that was designed to reduce deforestation and forest degradation to mitigate climate change. It was not adapted to the needs and specificities of rubber. In fact, in this context rubber was rather felt, along with other plantations, as contributing to deforestation, even though rubber plantations are considered as forests. We need to take the full dimension of what has changed with the Paris Agreement: it is a bottom-up approach involving all countries, and increasingly other actors; it is grounded on a much more holistic approach to the land use sectors, particularly for developing countries; and it gives more consideration for synergies, both between adaptation and mitigation and with sustainable development. All of this creates considerable opportunities to increase the visibility and integration of rubber in international negotiations and mechanisms. But to size these opportunities the sector needs to understand and engage with the negotiation process. The purpose of this intervention is to highlight what creates new opportunities for natural rubber in the international negotiations on climate change, identify some of these opportunities, entry points in the negotiations, in terms of institutions and issues, and propose a way forward.

### The Paris Agreement creates new opportunities for natural rubber

Natural rubber production has a considerable potential for both climate action and sustainable development (Gitz et al. 2020) and for enhanced synergies between climate action and sustainable development. This potential has not been yet recognized in international discussions on climate change. The changes brought by the Paris Agreement create new opportunities.

The aim of the Paris Agreement is, as described in its Article 2, to enhance the implementation of the United Nations Framework Convention on Climate Change (UNFCCC) by:

b. Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
c. Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;

d. Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The Paris Agreement recognizes the importance of land use for the achievement of its goals. Moreover, under the Kyoto Protocol, there were two very different categories of countries: Annex I (developed countries) and non-Annex I. This had very important consequences on the way land use activities were considered, with REDD+ activities in non-Annex I countries to reduce deforestation and forest degradation, to be financed by Annex 1 developed countries; and for Annex I countries, a much broader coverage of land use activities including agriculture and land use, land use change and forestry (LULUCF). All land use activities are now covered in all countries.

With the Paris Agreement and the nationally determined contributions (NDCs) there is also a better recognition of synergies and trade-offs between mitigation and adaptation as well as of synergies with sustainable development, opening up additional ways to better integrate land use, and in particular rubber production.

The PA has also profoundly changed the way climate action is determined, putting the focus on the NDCs, on national action, priorities and specificities. This gives additional opportunities for sectors that are important nationally to have a broader influence in the determination, implementation and revision of the NDCs. In addition, recent years have seen a growing emphasis on the role of the private sector in climate action, with more importance given to initiatives of actors other than governments.

**International discussions on climate change offer multiple entry points for rubber related issues**

The Conference of the Parties (COP) is the highest governing body for the UNFCCC. The Kyoto Protocol (KP) has its own governing body: the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), constituted of the parties that have ratified the KP. The COP serves as the meeting of the Parties to the Paris Agreement (CMA), constituted of the parties that have ratified the agreement is the governing body of the Paris agreement. The Subsidiary Body for Scientific and Technological Advice (SBSTA) assists the governing bodies (COP, CMP, CMA) through the provision of timely information and advice on scientific and technological matters. The Subsidiary Body for Implementation (SBI) assists the governing bodies in the assessment and review of the implementation of the Convention, the Kyoto Protocol and the Paris Agreement.

In addition, the Convention has a range of constituted bodies with specialized functions. They include, among others:
- The Adaptation Committee (AC)
- The Least Developed Countries Expert Group (LEG)
- The Technology Executive Committee (TEC)
- The Climate Technology Centre & Network (CTCN)

There is also a range of funds and financial entities linked to the Convention:
- The Green Climate Fund
- The Adaptation Fund
- The Global Environment Facility (GEF)
- The Least Developed Countries Fund (LEG)
- The Special Climate Change Fund

The GCF is the largest international climate fund. It aims at allocating resources evenly between mitigation and adaptation. It has two results areas particularly relevant for forests: forest and land use (under mitigation), and ecosystems (under adaptation), and aims at looking at them together under cross-cutting mitigation and adaptation projects. The GCF is preparing sectoral guidance for forestry and agriculture. It would be important to ensure that this guidance can cover rubber.

The nationally determined contributions are submitted by countries. They have no predetermined format, have to cover mitigation and can include adaptation. The first set was submitted in 2015 for actions post-2020. They are to be reviewed every five years, being gradually more ambitious. There will be a global stock taking in 2023 and then every five years.

Article 6 of the PA, on market and non-market financial mechanisms, is still under discussion. Three mechanisms are being discussed:

- **Cooperative approaches** involve countries working with one another using internationally transferred mitigation outcomes (ITMOs) in the achievement of their NDCs.
- The Paris Agreement established a **sustainable development mechanism** commonly referred to as the 6.4 mechanism. It is to mitigate greenhouse gas emissions and support sustainable development.
- **Non-market approaches** are considered to be actions and activities that address mitigation and adaptation but do not result in tradable units.

In addition, the International Civil Aviation Organization (ICAO) agreed in 2016 to set up a new offsetting mechanism to compensate the growth in aviation emissions post-2020. To meet requirements under this new mechanism, called the **Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)**, airlines will purchase offsets from international schemes.

There is a wide range of issues where rubber could be introduced. For instance, there are discussions in the Koronivia Joint Work Program on Agriculture (KJWA) on the need to properly prevent and manage risks. It could be highlighted that such systems of risk monitoring for weather, pests and diseases shall also cover plantations, including rubber. Carbon stocked in **harvested wood products** can be accounted for as sinks. Currently it does not take into account rubber, nor bamboo and rattan. There could be value in proposing to integrate rubber, bamboo and rattan. Such a proposal would have more weight if it is supported by strong evidence with numbers; it relates to both rubber, bamboo and rattan; or it is supported by a consortium.

### How to bring rubber into the international discussions?

There are various ways to bring rubber into the discussions: give visibility to research findings on rubber and climate change, particularly in IPCC reports and in the research dialogues of SBSTA; bring rubber directly into the negotiations, linking it to a topic under discussion, for instance a topic linked to land use, or Harvested Wood Products (HWP) or the KJWA; more broadly give visibility to rubber in the discussions around the negotiations including with civil society and the private sector.

These are not exclusive but on the contrary very complementary, supporting each other. This event is a good start for an organized plan of action mobilizing various channels: scientific papers, official negotiations channels, mobilization of the private sector; including action at national level as will be presented in the next intervention.

**Key words:** Rubber, climate change negotiations, Paris agreement, Harvested wood products, Koronivia Joint Work program

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# Opportunities for natural rubber in NDCs and NAPs

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## Extended abstract

Nationally determined Contributions (NDCs) and national adaptation plans (NAPs) are national policy documents that are meant to orient national policies and planning related to climate change. They have both been established under the United Nations Framework on Climate Change (UNFCCC). They are increasingly used by international funds like the Green Climate Fund (GCF) and others as well as by international cooperation to orient their funding decisions. These common characteristics make them particularly important to orient action and investment related to climate change in countries. Both NDCs and NAPs are to be periodically reviewed and updated, creating opportunities for natural rubber to be more visibly covered. NDCs and NAPs are however very different in nature and scope.

### Land use, forests and rubber in the NDCs

The NDCs (initially INDCs) have been prepared by countries to state their commitments as part of the process towards the Paris Agreement (PA), in the context of the international negotiations. Their original purpose is to convey national commitments and relative orientations to the international discussions, not to constitute an internal plan of action, even if they provide the orientations for such a plan. They are thus generally short and synthetic documents, with varying degrees of precision regarding the activities covered, implementation and means of implementation. They always include mitigation commitments. They may include adaptation commitments, in fact present in all NDCs of developing countries. NAP is often mentioned in the NDCs as the vehicle for implementation of their adaptation commitments. Commitments are often distinguished in non-conditional commitments, to be achieved with national resources, and conditional commitments that depend on additional international resources. The first set of NDCs (the INDCs) were prepared in 2015, often quite quickly to meet the UNFCCC deadline before COP25. There was an opportunity for countries to review their NDCs before ratifying the PA. NDCs are now entering implementation. It is the moment to look for opportunities to propose rubber-related measures that contribute to the realization of the commitments of the NDCs. The monitoring of their implementation as well as the preparation of the next round of NDCs, that, by construction, need to be more ambitious, will provide additional opportunities.

Most NDCs distinguish, in their mitigation part, agriculture emissions and the land use, land use change and Forestry (LULUCF) sector that accounts for emissions and captures from carbon sinks. LULUCF is referenced in 77 percent of all countries' INDCs, and as such is second only to energy. Agriculture is mentioned in 73 percent of the countries' mitigation contributions. 86 percent of countries refer to agriculture and/or LULUCF. In addition, land use is the sector the most frequently mentioned for synergies between adaptation and mitigation as well as for co-benefits with SDGs. This gives a strong basis for integration of rubber related measures even if rubber is rarely explicitly mentioned. This absence is not really surprising considering that NDCs cover all economic sectors and are often very short. For instance, the NDC of Malaysia is six pages long. However, the NDC of Indonesia mentions the objective of making more use of rubber wood for energy. Most NDCs of rubber-producing countries contain broad orientations on forests or plantations (afforestation, plantations, sustainable forest management) aimed at increasing carbon sinks, reducing deforestation, and strengthening adaptation to which policies and measures for implementation in the rubber sector could be linked. There might also be opportunities in consuming countries, either to support actions in producing countries, or for actions based on

broader commitments on biomaterials to promote use of natural rubber to substitute non-renewable products, or to increase the lifespan of carbon stocked in rubber products, for instance blending ground tyre rubber with asphalt to produce longer lasting road surface.

At this stage, either for the implementation of the NDCs or to increase commitments in the next period, many governments would welcome proposals that show contributions to the national commitments, based on solid evidence, including quantitative impacts in terms of mitigation, adaptation and co-benefits. Because of its potential contribution to both climate action and sustainable development, the rubber sector could attract interest of both national governments and international donors for the implementation of the NDCs, provided it builds a strong case for it.

### Forests trees and rubber in the NAPs

The NAP process was established by the UNFCCC in 2010 in Cancun (COP16) with the objectives to a) reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience; b) facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate. The process shall be “guided by best available science” (UNFCCC, decision 5/CP.17). To date 20 countries have published their NAPs.

The NAP covers all sectors but it focuses, by definition, on the most vulnerable sectors and populations and on the issues that are the most important for the adaptation of the whole country. It is most often organized by chapters/sections by sectors. Two NAPs, Sudan and Palestine, are organized by regions, with in both cases a strong focus on agriculture. The Ethiopian NAP is organized by broad options. Some NAPs (Cameroon, Chile, Colombia, Kenya) explicitly mention forms of coordination and organization at subnational level. Forests are in the majority of cases integrated in the ecosystems and biodiversity section. There are some exceptions where forestry is a specific section (Cameroon) or a subsection of a broader agriculture and forestry part (Togo). For Chile, forests are included in the biodiversity plan, but planted forests are part of the silvo-agro-pastoral plan. For Ethiopia, one “option” is sustainable forest management, explicitly linked to other sectors. By contrast, in most adaptation plans of developed countries there is a specific section on forestry, covering all types and functions of forests.

Main measures for adaptation of natural forests in the NAPs relate to: monitoring and risk management systems of risks (forest fires, pests and diseases) and more broadly of changes; research, especially on species of interest (commercial, threatened, invasive), restoration, biological indicators of stress, modelling effects on ecosystems; and ecosystem-based adaptation. Main measures for adaptation of planted forests in the NAPs include monitoring and risk management systems, with for instance an integrated monitoring system for pests and diseases for agriculture and planted forests in Chile; changes of planted species and varieties; conservation and sustainable management of genetic resources; anticipation of future changes, for instance use seeds coming from areas that are hotter or drier in order to have adult trees that will be adapted to the future climate.

Most NAPs promote the plantation of trees for numerous adaptation purposes. A first group is for natural resources management, including to: restore degraded land, reduce soil erosion, restore water catchments, protect water tanks and rivers (against erosion and evaporation), reduce coastal erosion and protect against storms. A second one relates to agriculture with wind breaks, shade trees, agroforestry in general. A third one is for the protection and greening of cities to reduce the urban heat island effect, while managing increased fire risks.

In most cases agroforestry is covered in the agriculture section of NAPs. The word “agroforestry” is mentioned in about two-thirds of the NAPs; three countries mention it more than twice. There are only few mentions of the need to adapt agroforestry systems or planted trees (Sri Lanka, Cameroon and Chile). In some cases, agroforestry is mentioned (Togo) or broad measures like increase the proportion of perennial plants and forest farming or planting 10% of agricultural land with forest trees (Sudan). In some countries broad measures or orientations implicitly include agroforestry like: design farming systems to reduce thermal stress, plant shade trees (Chile), identify and manage ecosystems that provide ecosystem services that sustain agriculture systems, to prevent soil erosion, regulate nutrient cycles, pollinate plants, control pests and regulate water in quantity and quality (Colombia).

NAPs already published give good examples for integration of rubber. In Sri Lanka's NAP rubber is part of the agriculture export sector along with other commodities for which the following adaptation options have been identified: germplasm improvement, improvement of farm and nursery management practices, initiate research studies to assess climate impacts, monitoring and surveillance of pests and diseases, sectoral capacity development. Importantly the Rubber Research and Development Institute was associated to the preparation of the NAP. Cameroon's NAP contains a measure (6.15): strengthening of rubber production capacity in a context of climate change, classified in the Industry section. In Chile's NAP there is a specific adaptation plan for plantations, with some measures common to agriculture (monitoring of pests and diseases). Some countries (Urugay, Uganda) have conducted multistakeholder dialogues that can inspire a similar national process for rubber.

These experiences also show some of the elements that can facilitate the integration of a sector in the NAP process:

- Evidence of the contribution of the sector to economy, employment and to improve resilience of the most vulnerable populations
- a sector-focused adaptation reflection, to identify vulnerabilities and means for adaptation
- a dialogue between the sector and the sectors that can benefit from it for adaptation (allies)
- engagement of the scientific community

**Keywords:** Rubber, NDC, NAP, adaptation

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# Climate risks: What 1.5°C pathway for rubber fora?

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**Extended abstract**

The climate crisis is becoming increasingly evident with more frequent, more intense natural disasters. These phenomena are clearly felt in the areas where natural rubber is planted and grown. Asia-Pacific contributes 91% of natural rubber production, a strategic raw material essential to guarantee mobility and improve healthy living (IRSG 2020a). Limiting warming to 1.5°C would reduce the odds of initiating the most dangerous and irreversible effects of climate change and such a pathway would require dramatic emissions reductions over the next 10 years. Keeping to 1.5°C would require limiting all future net emissions of carbon dioxide from 2018 onward to 570 gigatons and reaching net-zero emissions by 2050 (McKinsey 2020). Natural rubber has a key role to play for both adaptation and mitigation of climate change as an important land user, a producer of renewable materials, and as a major economic activity. Adoption of sustainable practices in production and consumption with efficient traceability check from product origin will boost a sustainable rubber economy. Business model shift towards sustainable production and consumption, embracing the circular economy and boosting efficiency in raw material to reduce carbon emissions, would underlie the transition to a 1.5°C pathway.

Sustainable production implies the adoption of land use changes and farming practices together with the implementation of an efficient traceability system from land of origin, deforestation free supply chains embracing circular economy to reduce overall carbon footprint. The development of bio-based products and the enhancement of material recycling in the tyre and non-tyre segments are all important factors that could improve the carbon footprint of rubber and rubber products (IRSG 2020b). New mobility solutions are aiming for energy-efficient transition towards decarbonization and various regulations are in place to achieve this goal.

Reducing carbon emissions is no longer enough to halt the impacts of climate change. There is an urgent need to address ecosystem-based adaptation plans for renewal of plantations well aligned with the nationally determined contributions (NDCs). Around 14 million hectares of rubber plantation is a strong carbon sink (IRSG 2020a). Climate finance is critical to significantly reduce emissions and to encourage climate adaptation ensuring livelihood improvement for small farmers. It is important to bring forward projects on mitigation and adaptation and increase awareness among farmers for adopting them. A strong partnership among stakeholders in the natural rubber value chain can bring discussion on integration of rubber in mitigation policies, measures, and adaptation policies in the wider climate dialogues.

**Keywords:** Sustainable production, Natural rubber, Circular economy, NDC

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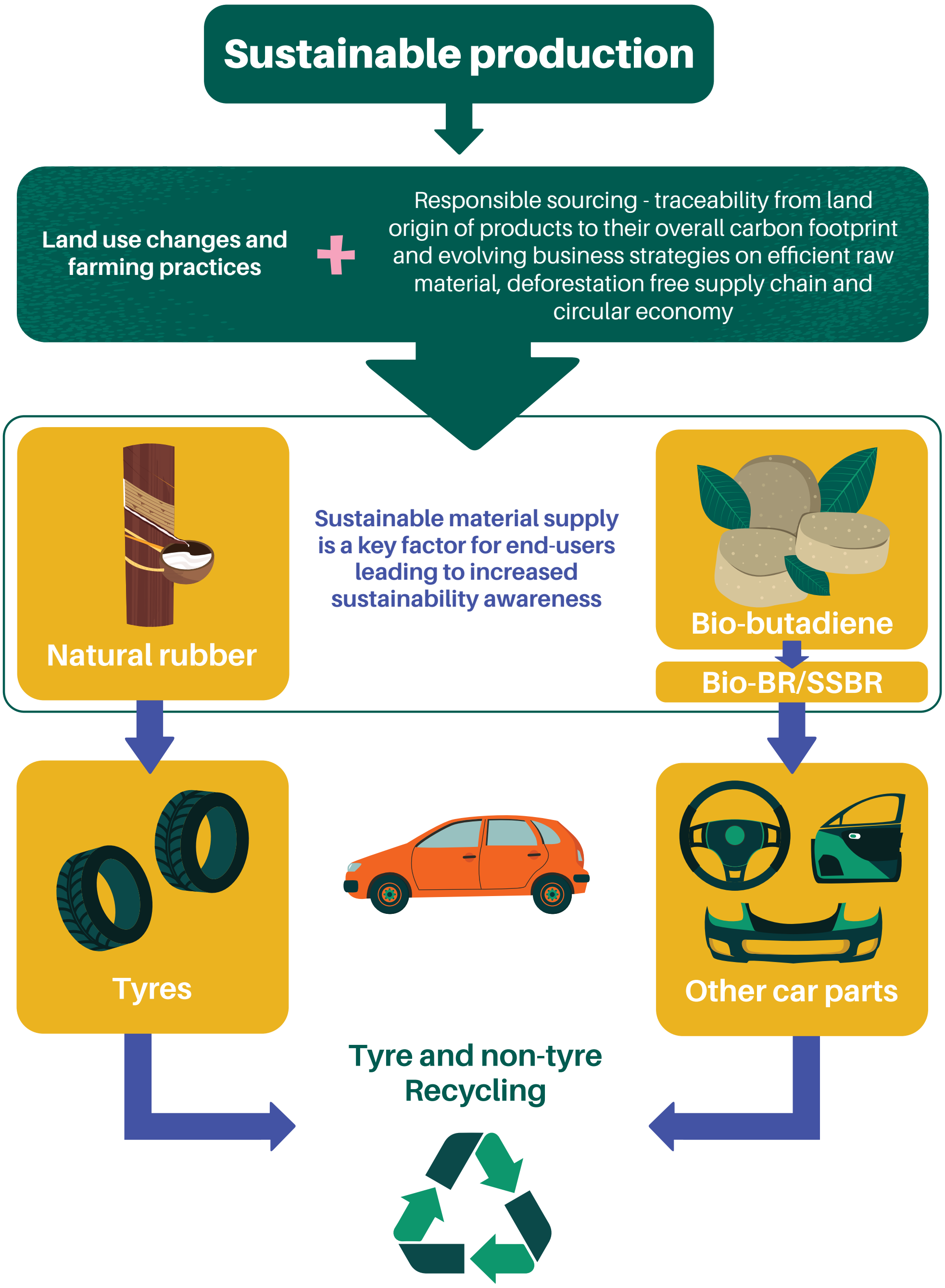


**Figure 1. Transition to a 1.5°C pathway for rubber fora**


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## Conclusions of the chair

The importance of bringing rubber at the centre of the climate change debate has been acknowledged by the speakers of this session. To effectively reach this goal it is essential to abandon a silos approach and adopt coordinated actions both horizontally (among the various stakeholders) and vertically inside the institutions overlooking the natural rubber economy. Rubber is not mentioned very often in national and international fora as the main entry point in the climate change discussions is food security and it has been easier to consider other commodities such as cocoa or coffee. But rubber has a powerful narrative: a renewable material, 90% of production coming from smallholders and a strategic economic and social raw material for many countries in the world. We need to start to introduce rubber in the public debate on climate change highlighting rubber's role at national and international levels, the important role played by the private sector and its contribution to food security and a more stable economy.


Photo by Deanna Ramsay/CIFOR

5

# Session 5
## The way forward: Short term actions and long term plans

Chairman: **Lekshmi Nair**
*Head of Economics & Statistics, IRSG*

The Session 5 panel discussion titled "The way forward: Short-term actions and long-term plans" was chaired by Dr Lekshmi Nair (Head of Economic & Statistics, IRSG). Four panellists joined this session: Dr Jérôme Sainte-Beuve (Rubber Value Chain Correspondent, CIRAD), Datuk Dr Abdul Aziz Kadir (Secretary General, IRRDB), Dr Vincent Gitz (Director, CGIAR Research Program on Forests, Trees and Agroforestry (FTA)), Mr Salvatore Pinizzotto (Secretary General, IRSG).

The chairperson started the panel discussion by re-emphasizing that there is a great opportunity for the rubber industry to open the dialogue on mitigation and adaptation to climate change. Dr Nair gave the floor to the panellists by asking them their takeaways from the workshop. The four panellists shared their opinions accordingly.

According to Dr Gitz from the perspective of a person with a climate change background, it is striking to know how collaborative research in the past has helped the natural rubber industry.

He also emphasized the importance of a systematic approach in understanding how the bio-physical conditions could combine with possible technological itineraries in the rubber industry and how that could interact with the labour component in the rubber value chain. Thus, reliable and accurate data is critical to the future work in this aspect. Dr Gitz concluded that climate change actions are going to be people-centric in the future as has been already recognized by the SGDs.

Dr Aziz, IRRDB, stated that natural rubber is considered as a capital-intensive crop for many smallholders. The smallholders do not have the necessary financial means to carry out replanting under the current circumstances having rubber prices been persistently low. Furthermore, the industry is becoming less attractive to younger generations. Dr Aziz also pointed out that natural rubber is often wrongly categorized as an industry crop among the climate change discussions. He urged the industry to consider not only the *Hevea brasiliensis* but to bring all other NR species to discussion.

Mr Sainte-Beuve, CIRAD, pointed out that there is a lack of scientific knowledge regarding the relation between natural rubber and climate change and the industry needs to address that urgently. The industry needs actual and real-time data about the welfare of smallholders so that the social-economic aspect could be reinforced in the framework of discussion and meaningful projects could be initiated.

Mr Pinizzotto, IRSG, mentioned that there is a significant data gap in relation to the socioeconomic aspects of the natural rubber industry. He suggested the rubber industry to set priority to research and development and pointed out that the international organizations in the rubber industry should also take responsibility on the slow progress in climate change discussion.

When asked by the chairperson on how to address the issues raised during the workshop, the panellists shared their ideas and opinions as follows.

Mr Pinizzotto emphasized that the participating organizations in this workshop need to build on from the proceedings of the discussion and to agree on a follow-up agenda and an action plan to bring this agenda forward. The rubber industry needs to identify areas to initiate actions immediately.

Dr Sainte Beuve added on by saying participating organizations need to identify shared priorities and search for organizations to fund priority research projects. There is also a need to leverage on the private sector in the climate change discussion for the rubber industry.

Dr Aziz urged the industry to bring rubber as a discussion topic to the UNFCCC Conference of the Parties (COP). Dr Aziz also emphasized the importance of value addition for smallholders and involving the cooperatives in the climate change discussion.

Lastly, Dr Gitz stressed the need to increase the visibility of the rubber sector at the international level, in an evidence based and organized way. The participating organizations should fully utilize the outcomes of this workshop and seize the opportunities in various climate change events in 2021 such as COP26. The industry needs to explore new ways of communication in the new normal in order to attract attention from the public and the rubber community.

The chairperson, Dr Nair, concluded the panel discussion by mentioning the opportunity to take the rubber sector into the international level of climate change discussion with collaboration between IOs in rubber industry.

Finally, Mr Pinizzotto ended the workshop by stating the urgent need for an action plan and the importance of communication and collaboration between different parties in the rubber industry.

Photo by Ryan Woo/CIFOR

# FTA WORKING PAPER

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The International Rubber Study Group (IRSG), with the International Rubber Research and Development Board (IRRDB), the CGIAR research program on Forests, Trees and Agroforestry (FTA) led by CIFOR, and the French Agricultural Research Centre for International Development (CIRAD), ran an open digital workshop on natural rubber systems and climate change on 23–25 June 2020, attended by more than 500 scientists and stakeholders.

The purpose of the workshop was to review recent research results on impacts of climate change on rubber production, potential means of adaptation and contribution to mitigation of climate change, and to identify knowledge and research gaps as well as recommendation for action.

This document brings together the extended abstracts of the presentations and summaries of the discussions held during the workshop.

The CGIAR Research Program on Forests, Trees and Agroforestry (FTA) is the world's largest research for development program to enhance the role of forests, trees and agroforestry in sustainable development and food security and to address climate change. CIFOR leads FTA in partnership with ICRAF, the Alliance of Bioversity International and CIAT, CATIE, CIRAD, INBAR and TBI.

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