RESEARCH PROGRAM ON Forests, Trees and Agroforestry

CGIAR

Food and Agriculture Organization of the United Nations

Asia-Pacific Forest Sector Outlook: Roadmap on innovative technologies for sustainable forestry and sustainable forest management

Report of the online expert workshop
November 30th, December 1st, and December 3rd, 2020

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Disclaimer

FAO and CIFOR, lead center of the CGIAR research programme on Forests, Trees and Agroforestry (FTA), are developing a roadmap on innovative technologies for sustainable forestry and sustainable forest management in Asia and the Pacific. This roadmap is developed through an inclusive and participative process associating a wide range of key regional forest experts and decision-makers.

An online expert workshop on innovative forest technologies was organized on 30th November, 1st and 3rd December 2020: to exchange experience and views on the application of innovative technologies in the forest sector and to identify: the most promising innovative technologies in the region in the next decade; their positive and negative impacts; as well as the technical, social, economic and institutional bottlenecks preventing technology access, uptake and upscaling. Participants during this workshop also drafted recommendations, directed to different stakeholder groups, for the use of innovative technologies to advance sustainable forestry in the region

This non-edited document reflects the views expressed during this workshop. It should thus be considered as work in progress. It does not necessarily reflect the views or policies of FAO or CIFOR.

In the coming months, FAO and CIFOR will prepare and co-publish a technical paper and a policy brief for decision-makers, gathering the main findings and concrete recommendations emerging from this work.

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Asia-Pacific Forest Sector Outlook:
Innovative technologies for sustainable forestry and sustainable forest management in Asia and the Pacific
Online expert workshop
November 30th, December 1st, and December 3rd, 2020

Summary

Following the recommendations of the 'Third Asia-Pacific Forest Sector Outlook Study' (FAO, 2019)[1], FAO and CIFOR, lead center of the CGIAR research programme on Forests, Trees and Agroforestry (FTA), are developing a roadmap on *innovative technologies for sustainable forestry and sustainable forest management in Asia and the Pacific*. This roadmap is developed through an inclusive and participative process associating a wide range of key regional forest experts and decision-makers.

An online expert workshop on innovative forest technologies was organized on 30th November, 1st and 3rd December 2020 to take stock of the progress made in the development of the roadmap and prepare the next steps. The workshop was on invitation. Overall, 52 experts attended, coming from 19 different countries, mainly from the Asia-Pacific region.

Building upon the annotated outline circulated ahead of the workshop (see **Appendix 3**), participants were invited to: (i) exchange their views on the different categories of promising innovative technologies for the forest sector in the region (**Session 1**); (ii) explore the different functions they can perform along forest value chains (**Session 2**); (iii) assess their associated challenges and opportunities in different contexts (**Session 3**); (iv) identify the main technical, socio-economic and institutional barriers to technology transfer, uptake and upscale, as well as the transformations needed to overcome these barriers and create an enabling environment (**Session 4**). On the last day of the workshop, participants discussed possible recommendations, directed to different stakeholder groups, for the use of innovative technologies to advance sustainable forestry in the region (**Session 5**).

Each session was introduced by presentations on specific case studies (i.e., one innovative technology applied in a specific context) or specific issues of interest for the workshop to stimulate the discussions among participants. Making the most of online technology, participants have been then split in breakout groups of about 10 people each, including a chair and a rapporteur, to allow more inclusive and interactive discussions. Discussions in breakout groups were structured around guiding questions and expected outcomes. Breakout group chairs reported on the breakout group discussions to Plenary.

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Thomas Hofer, Senior Forestry Officer in FAO Regional office for Asia and the Pacific (FAO-RAP, Bangkok), Natural Resources Management (NRM) Group Leader and Secretary of the Asia Pacific Forest Commission (APFC), welcomed all participants, inviting them to adopt, during this workshop a forward-looking perspective. He also praised the substantial participation of young people, able to bring in the debate out-of-the-box thinking, as well as new and original perspectives on innovative technologies.

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1 FAO. 2019. Forest futures – Sustainable pathways for forests, landscapes and people in the Asia Pacific region. Asia-Pacific Forest Sector Outlook Study III. Bangkok. 352 pp. http://www.fao.org/3/ca4627en/ca4627en.pdf

Vincent Gitz, Director of the CGIAR research programme on Forests, Trees and Agroforestry (CIFOR/FTA) then presented the process of development of the roadmap on innovative technologies, the purpose and expected outcomes of the workshop and the organization of the discussions. Overall, he said, the purpose of the workshop is to go beyond general considerations on innovative technologies; to identify a set of illustrative uses of these technologies in context, their potential positive and negative impacts, as well as the conditions that constrain or support their use; and, to have a first draft of what could be recommendations to governments and other actors.

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During **Session 1**, James Roshetko (ICRAF/FTA) clarified that, for the purpose of this roadmap, the term "innovative technologies" embraces not only new technologies that could mature in the next 10 years, but also recent technologies emerging for new purposes or in new contexts". He presented a possible typology of innovative technologies organized in four main clusters: (i) digital technologies; (ii) biological technologies; (iii) technical innovations (processes and products); and, (iv) innovative finance and social innovations.

Four experts were invited to illustrate these different clusters by specific examples of innovative technologies developed along the value chain. Junqi Wu (INBAR, China) explained how harmonized system (HS) coding can improve the monitoring of bamboo and rattan international trade. Tony Page (University of the Sunshine Coast, Australia) showed how participatory domestication of teak in Papua New Guinea can offer an example of innovative solution to address localized timber shortages, diversify income and reduce dependence on natural forests. Jalaluddin Harun (Academy of Science, Malaysia) presented the efforts realized in Malaysia to develop rubber production and adapt it to the market requirements, moving away from a sharp focus on latex production to a wider approach embracing also timber production. Bas Louman (Tropenbos, the Netherlands) highlighted the potential of innovative finance mechanisms, such as blended finance, green bonds, climate bonds or crowdfunding, to bridge the investment gap in the forestry sector.

Participants in the breakout groups were invited to identify the 3 to 5 most promising innovative technologies in the 10 next years for the forest sector in the region. Group 1 focused on digital technologies and highlighted in particular the potential of: (i) drones (whether aerial or terrestrial); (ii) remote-sensing and spatial analysis; and, (iii) sensor networks, combined with big data analysis, artificial intelligence and machine learning. Group 2 focused on biological technologies and discussed the importance of high-quality genetic material, as well as the potential of genetic profiling for DNA timber tracking and other uses. Group 3 focused on technical innovations (processes and products) and discussed the potential of improved varieties of priority species, including clones, and the need of further work on under-utilized species. Groups 2 and 3 also highlighted the diversity of situations across countries and the need to adapt innovative technologies to the local context, and especially to the specific needs of smallholders and small-scale enterprises. Group 4 focused on innovative finance and social innovations and identified three key technologies, each having multiple uses: (i) the use of drone, remote sensing and satellite imageries; (ii) information technology with mobile apps; and (iii) artificial intelligence. Group 4 also discussed two key financing innovations: (i) payment for ecosystem services (PES); and (ii) carbon financing.

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Session 2, on functions, was introduced by James Roshetko (ICRAF/FTA) who enumerated the different functions that innovative technologies can perform along the forest value chains, including for instance: tree improvement, forest monitoring, wood harvesting, wood processing, quality control and traceability, etc. Three experts were then invited to present specific applications of innovative technologies within forest value chains. Vu Tan Phuong (Academy of Forest Sciences, Vietnam) drew a broad overview of the application of innovative technologies in forestry and forest management in Vietnam, highlighting in particular gene technologies, remote sensing and automation as key areas of innovation in the country. Shengfu Wu (National Forest Products Industry Association, China) highlighted the hard work done and presented some of the innovative solutions developed by the woodworking industry in China. Oliver Coroza (Center for Conservation Innovations Ph, the

Philippines) showed how geospatial solutions can contribute to conservation by addressing current information gaps on forest cover and other spatial features.

Participants in the breakout groups were invited to identify the main contributions of different innovative technologies to sustainable development in different contexts. Innovative technologies have a huge potential but can also be conducive to social, economic or environmental changes that can be damaging. Affordability is an important issue but improving access to technologies also requires appropriate capacity building and technical training of local actors. Technology dissemination and adoption also require appropriate policies and regulations (e.g., legal and privacy issues linked to drone operation). Participants highlighted the need to think “small”, i.e., to make sure that technological advances do not further marginalize smallholders and local communities. Beyond technology, finance options, as well as social and institutional innovations are critical to bridge the gap between technology developers and end-users and to facilitate local stakeholder engagement, which is a key condition for successful technology adoption.

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Session 3 focused on the opportunities but also the challenges that technologies could create, so looking at both positive and negative impacts. Three experts, from the different stakeholder groups, were invited to present specific case studies, covering not only technical but also social innovations. Lok Mani Sapkota (RECOFTC, Nepal) demonstrated how community forestry, introduced in Nepal in the 1970s, empowered local communities, enabling them to sustainably manage their own forest resources. Andrew Lowe (University of Adelaide, Australia) explained how DNA fingerprinting and genetic profiling can be used to support law enforcement and fight illegal logging. Finally, Lobzang Dorji (Department of Forest and Park Services, Bhutan) illustrated how the use of innovative technologies contribute to advance sustainable forest management in Bhutan.

Participants in the breakout groups were invited to identify and discuss for a few case studies (one technology applied in a specific context) the main positive and negative impacts of the considered innovative technology in the given context. Group A highlighted the positive contributions of innovative technologies, including to: increase resource efficiency; develop new uses for more diverse species, especially low-value species or smaller trees; encourage wood substitution of fossil fuel-based products; open new production potentials in areas previously inaccessible. It also discussed the trade-offs: (i) between new production potentials and conservation challenges; and (ii) between employment on the one hand, productivity and automation on the other hand. Group B reviewed the four technology clusters to identify their positive and negative impacts. It recalled the multiple functions performed by digital technologies but also the legal issues they raise. It discussed the great untapped potential of indigenous and/or under-utilized species and the investments required to harness this potential. It considered that, in theory, innovative finance mechanisms are a powerful tool to mobilize additional resources but that, in practice, viable examples of such mechanisms seem to be limited on the ground. It also discussed the dynamic of “capture by elites” occurring when, as prices increase, payment for ecosystem services (PES) and carbon credit schemes become more profitable.

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Session 4 focused on the barriers and enabling conditions associated with technology generation, deployment, dissemination and adoption. Participants in the breakout groups were invited to identify 3 to 5 priority transformations needed to support innovation. Group A considered that, to facilitate adoption of innovative technologies, three critical aspects should be considered: (i) the technology per se, its characteristics and how it can be adapted to the local context; (ii) the larger socio-economic context; (iii) the specific context (farm, enterprise) where the technology will be implemented. Many technologies are not scale-neutral. The demonstration effect is key for dissemination. Cross-sectoral collaboration (including with agriculture, water [and energy] sectors) can stimulate innovation in the forest sector. A lot of innovations have been driven by profitability. Corporate social responsibility (CSR) could drive the next wave of innovations for a sustainability agenda. Group B discussed the technical, socio-economic and institutional barriers preventing technology adoption and identified priority areas of work to overcome these barriers, including: (i) address information asymmetries, facilitate training and capacity building; (ii) encourage multi-stakeholder partnerships and collaboration; (iii) enhance transparency and participation; and, (iv) adapt innovations to the local context.

At the end of Day 2, Ravi Prabhu (ICRAF/FTA) gave an inspiring keynote address. He made a strong call for grasping the opportunities offered by innovative technologies to address the multiple challenges that we are facing, including: climate change, carbon, forest fires, biodiversity, land degradation, water scarcity and quality, and above all creation of decent jobs and green economy. He recalled that a narrow focus on economic development and timber production will make the forest sector move towards more robotization and automation. To create the decent jobs we need in agriculture and forestry, we have to enlarge our focus, explore new frontiers and consider also nutrition, fiber, energy, bioproducts and ecosystem services. Research must be positioned at the heart of a larger innovation system. Much stronger efforts and investments are needed. For now, we have only started to scratch the surface regarding the possible contributions of forests and trees to sustainable development.

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Session 5, on the last day of the workshop, aimed at elaborating possible recommendations for decision-makers on how to best enhance the adoption of innovative technologies in the forest sector in the Asia-Pacific region. Key points and main insights emerging from the discussions during the first two days, were compiled by the CIFOR/ICRAF organization team in the form of a set of draft recommendations for decision-makers that were reviewed, further inputted and discussed by two breakout groups and in Plenary. The recommendations were directed to the four following categories of actors: (i) public actors; (ii) private sector actors; (iii) civil society and local communities; (iv) research and academic institutions. They considered as appropriate different scales (from local to global).

During the discussion, participants highlighted the need for collaboration and coordination across stakeholder groups and across scales. The recommendations cannot be considered in isolation but as a whole. They called for operational recommendations, covering not only the “why” but also the “how” in specific situations, so that they can be used and implemented by decision-makers on the ground. However, given the diversity of situations encountered in the region, it seems impossible to craft a short set of actionable recommendations adapted to all situations. More generic overarching recommendations might be also needed to offer a general framework and open the way for sustainable forest management in the region. Hence, the roadmap could have different levels of reading: each recommendation could be illustrated by a specific successful case-study that could inspire other actors, showing them practical and solution-oriented pathways that could be adapted to and implemented in their own context. Such case studies could facilitate fruitful exchanges of experience among countries in the region.

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Vincent Gitz (CIFOR/FTA) and James Roshetko (ICRAF/FTA) reminded the participants that this interesting and very rich discussion on recommendations marked the end of this workshop but is only a starting point in the overall process of elaboration of the roadmap. An immediate next step will be to dig further, with dedicated experts, particular aspects of technologies by means of bilateral interviews. An important milestone in this process will be the World Forestry Congress 2021 that will provide key opportunity to further discuss the main findings and key recommendations emerging from the roadmap.

Closing the workshop, Thomas Hofer (FAO) wanted to remind the participants about the big picture. He praised all the participants for their excellent presentations and active participation during this three-day workshop. This workshop, he said, is an important step in the process of development of the roadmap that started last year with the launch of the third Asia-Pacific Forest Sector Outlook Study. He encouraged the participants to remain mobilized in the coming weeks and months, including through the open consultation, bilateral interviews and the call for abstracts for youth.

Introduction

Following-up on the 'Third Asia-Pacific Forest Sector Outlook Study' (FAO, 2019)[2], launched in June 2019 at the Asia-Pacific Forestry Week in South Korea, FAO and CIFOR, lead center of the CGIAR research programme on Forests, Trees and Agroforestry (FTA), collaborate to develop *two inter-related roadmaps for the Asia-Pacific region on: (i) primary forest conservation* and *(ii) innovative forest technologies*, including key recommendations (policy and concrete actions) informed by science.

These roadmaps are being developed through an inclusive and participative process involving key regional stakeholders and technical experts from governments and intergovernmental organizations, private sector, civil society organizations, academia and research institutions. An online regional inception workshop was organized on 30th July 2020 to launch the development of the two roadmaps and start building a strong and diverse community around this project. Since July, further contributions have been collected through different channels: direct interviews of selected key regional stakeholders; an open online consultation; and a call for abstracts directed to students and young people engaged in formal or informal activities linked to the forest sector in the Asia-Pacific region.

A technical workshop, focusing specifically on *innovative technologies for sustainable forestry and sustainable forest management in Asia and the Pacific*, was organized online on 30th November, 1st and 3rd December 2020 (the detailed agenda of this workshop is reproduced in **Appendix 1**). This workshop targeted an audience of regional experts, from academia and research organizations, national governments and intergovernmental organizations, private companies and civil society organizations (see **Appendix 2** for the list of participants). This workshop also included a substantial participation of students and young people engaged in activities related to the forest sector in the Asia-Pacific region.

The purpose of this workshop was to take stock of the progress made in the development of the roadmap and prepare the next steps. Building upon the annotated outline circulated ahead of the workshop (see **Appendix 4**), participants were invited to: (i) exchange their views on the different categories of promising innovative technologies for the forest sector in the region (Session 1); (ii) explore the different functions they can perform along forest value chains (Session 2); (iii) assess their associated challenges and opportunities in different contexts (Session 3); (iv) identify the main technical, socio-economic and institutional barriers to technology transfer, uptake and upscale, as well as the transformations needed to overcome these barriers and create an enabling environment (Session 4). On the last day of the workshop, participants discussed possible recommendations, directed to different stakeholder groups, for the use of innovative technologies to advance sustainable forestry in the region (Session 5).

This report presents the information and ideas collected during this workshop and the next steps of the process.

[2] FAO. 2019. Forest futures – Sustainable pathways for forests, landscapes and people in the Asia Pacific region. Asia-Pacific Forest Sector Outlook Study III. Bangkok. 352 pp. http://www.fao.org/3/ca4627en/ca4627en.pdf

1 Targeted audience of experts

The workshop was on invitation. The 52 experts registered (full list in **Appendix 2**, among which 10 women, were coming from 19 different countries, mainly from the Asia-Pacific region. They represented all the key regional stakeholder groups, including: 30 experts from research and academic institutions; 9 representatives of international or intergovernmental organizations and international donors; 3 officials from national governments; 6 experts, either independent or working for private sector organizations; and 4 people from civil society organizations.

Among the workshop participants were 9 students or young people engaged in the forest sector in the Asia-Pacific region. Selected from those who participated to the call for abstracts, they participated actively to the workshop providing valuable technical inputs as well as their own forward-looking perspectives.

2 Opening remarks and overall organization of the workshop

2.1 Welcome remarks, by Thomas Hofer (FAO)

Distinguished Participants and Colleagues,

It is my pleasure to welcome you all to this 3-day online workshop on *Innovative technologies for sustainable forestry and sustainable forest management in Asia and the Pacific*. I am Senior Forestry Officer in FAO Regional Office for Asia and the Pacific in Bangkok, leader of the Natural Resources Management Group and Secretary of the Asia-Pacific Forest Commission.

Today, you are about 50 participants joining us in this workshop and without exception you are some of the leading forestry experts and practioners in the field in the region. I am indeed delighted to see that all of you are able to participate in this virtual workshop despite several restrictions and challenges posed by the COVID crisis. So let me, on behalf of FAO, and also on behalf of CIFOR, our partner for this initiative, extend a warm welcome to you.

As some of you are aware, as a follow up to the recommendations of the Asia Pacific Forestry Commission and of the 3rd Asia Pacific Forest Sector Outlook Study, FAO and CIFOR are engaged in a collaboration to address two major areas of concern for the region. These are conservation of primary forests and promotion of innovative technologies in forestry. A workshop was held on 30th July 2020 to launch the work on these two areas.

This 3-day workshop is a follow up to this launch and will exclusively focus on innovative technologies.

This forward-looking gathering of experts provides an excellent opportunity for various experts coming from different specializations and areas, to share their experiences and views on the prospects of innovative technologies in forestry. This workshop will include a substantial participation of young people, able to bring in out-of-the-box thinking and new perspectives on innovative technologies.

This workshop will also examine the technical, social, economic and institutional bottlenecks preventing technology access, uptake and upscaling.

For each category of technologies, it will discuss positive and negative impacts, especially in terms of livelihoods and employment for local communities.

Based on these discussions, experts will also be invited to formulate key recommendations for decision-makers, on the use of innovative forest technologies for sustainable forestry and sustainable forest management in the Asia-Pacific region.

I trust that our deliberations over the next three days will help shed light on important issues related to innovative technologies and contribute to strengthen our efforts to advancing sustainable forest management in the region. I am particularly pleased to note the enthusiasm received to participate and I am confident that our efforts will focus on what is really needed on the ground.

Last but not least, let me also take the opportunity to thank all the colleagues for their efforts in organizing this virtual workshop- which by itself is a great effort.

I wish all of us the best of luck for this workshop and I look forward to your active participation during all the three days.

2.2 Introduction, by Vincent Gitz (CIFOR/FTA)

Presentation of the roadmap

Following-up on the 3rd Asia Pacific Forest Sector Outlook Study (APFSOS III), FAO and CIFOR, lead center of the CGIAR research programme on Forests, Trees and Agroforestry (FTA), are developing a roadmap on innovative forest technologies. In particular, FAO and FTA will prepare and co-publish a technical paper, with key recommendations (for policy and concrete actions) informed by science, on the use of innovative technologies to advance sustainable management in the forest sector in the Asia-Pacific region. A policy brief, directed to key decision-makers, will gather the main findings and concrete recommendations emerging from this work.

The roadmap is developed through a participative process, launched with an online inception workshop co-organized by FAO and FTA on July 30th, 2020, involving key regional stakeholders and technical experts from governments and intergovernmental organizations, from the private sector and civil society organizations, as well as from academia and research institutions. Technical information on the application of innovative technologies in forestry and forest management, is also gathered through online interviews with key stakeholders and through an online open consultation. This workshop is a key moment in the process. A final validation workshop will be organized at the end of the process to discuss and validate the main findings and key recommendations of the study. It could be organized back-to-back to the XV World Forestry Congress, to be held on 24-28 May 2021 in Seoul. The final draft of the technical paper will be submitted in parallel to an independent scientific peer-review. The objective is to publish the technical paper and the corresponding policy brief by end November 2021.

Very importantly, this whole process gives special attention to the contribution of students and young professionals of the forest sector in the Asia-Pacific region. Specifically, a call for abstracts was launched to gather their ideas and suggestions. I welcome the 10 young people invited for this workshop: they were selected from those having responded to this call. The best abstracts will be developed in short papers that will published on our website. The authors of the best papers will be invited to present them during or around the World Forestry Congress.

Expected outcomes of the workshop

This workshop is organized in 5 sessions along 3 days. For each session, there will be an introduction on the purpose and expected outcome of the session, short expert presentations of case studies giving food for thought, followed by breakout groups for discussion on specific items. Breakout groups allow to enrich discussions, making them more lively. The distribution by breakout groups has been prepared in advance for each day, by groups of technologies for the first day, to ensure diversity for the two following days.

The first day is focused on technologies, with: session 1 on innovative technologies and session 2 on their applications to specific functions. Day 2 broadens perspectives to the environment of technologies: session 3 looks at innovative technologies in relation to challenges and opportunities for the forest sector and session 4 considers barriers to and enabling conditions for technology uptake and upscaling. The last day is focused on recommendations.

Overall, the purpose of the workshop is to go beyond general considerations on innovative technologies; to identify a set of illustrative uses of these technologies in context, their potential positive and negative impacts, as well as the conditions that constrains or support their use; and, to have a first draft of what could be recommendations to governments and other actors.

Presentation of the outline of the technical paper

The technical paper, to be co-published by FAO and CIFOR/FTA, will examine how the application of innovative technologies affect different functions throughout the value chain and the extent to which this contributes to sustainable management in the forest sector. Among these functions are: germplasm selection, production and breeding; forest monitoring; forest management (tree planting, tree growing, forest protection); wood harvesting; wood processing (first and second transformation); quality control; traceability; transport; distribution; and, when we go down the value chain, final use of wood-based or non-wood forest products; reuse and recycling; waste management; marketing; etc.

Assessing the strengths and weaknesses of each innovative technology in performing these different functions will ground an analysis of their advantages and disadvantages in different contexts. Such an assessment can offer a framework to compare very different innovative technologies, whether "modern" or "traditional", and help identify and categorize the most promising innovative technologies for the forest sector in the coming decade, on which to focus our investments and efforts. The way one technology performs one function, as well as its positive or negative impacts for people and the planet, may vary significantly across contexts and the region as you know is very big and diverse. Even in the same context, impacts may be perceived differently by different stakeholder groups. In addition, the social, economic and technical contexts are also evolving quite rapidly.

The study will also consider the potential negative impacts of new technologies on local communities (access to natural resources, food security and livelihoods), natural ecosystems and biodiversity. Innovative technologies can provide new products and services, reduce operational costs and improve productivity, thus generating further income and employment opportunities in the forest sector. The adoption and dissemination of innovative technologies will likely generate major shifts in forest value chains, modifying wood demand, including increased needs for high quality and diverse planting material, and the labor market. Innovative technologies have the potential to generate new skilled jobs (e.g.: drone operators, ICT developers and operators, etc.). Innovative, safer and greener jobs can, in turn, help make the forest sector more attractive, in particular to young professionals. However, innovative technologies, including automation, might also lead to the loss of many unskilled jobs. Innovative technologies can also reduce waste and improve energy- and resource-use efficiency, thus increasing profitability of the forest sector and contributing to the sustainable management of natural forest resources. They can limit or avoid collateral environmental damages to ecosystems (e.g.: pollutions, destruction of untargeted organisms or species). On the other hand, they can accelerate deforestation and forest degradation, habitat destruction and species extinction.

The study will analyze the process of dissemination of innovative technologies and the actors involved. The rate of uptake of innovative technologies varies across countries and sub-regions. It will analyze the technical, economic and social barriers preventing the uptake and upscale of innovative technologies in the forest sector. It will also consider the institutional changes needed in forest sector governance (land planning, land tenure and other relevant development policies), to overcome these barriers, to support the uptake and upscaling of innovative technologies in the region, to ensure that these technologies will effectively contribute to sustainable forestry and sustainable forest management.

Finally, the idea of this roadmap is to lead to recommendations to policy-makers and other actors.

During these three days, we will discuss very rich and important topics for forestry in the region. I'm looking forward a lively, direct and participative workshop. I will now pass the floor to James Roshetko (ICRAF/FTA) lead person to support and guide our work on this study. He will present the workshop and particularly session 1.

3 Session 1: Typology of innovative technologies

James Roshetko (ICRAF/FTA) introduced the workshop through a brief presentation of the roadmap on innovative technologies. The purpose of this roadmap is to evaluate how the application of innovative technologies in the forest sector can contribute to sustainable forestry and sustainable forest management in the Asia-Pacific region, including by: (i) improving productivity and resource-efficiency; (ii) contributing to the conservation of ecosystems and natural resources; (iii) enhancing socio-economic and political conditions and livelihoods.

In the roadmap, the term “innovative technologies” embraces: (i) new technologies either in the generation phase, or in the pre-pilot or pilot phase, that could become mainstream or mature in the next 10 years, as well as (ii) recent technologies emerging for new purposes or in new contexts. Innovative technologies have the potential to outperform currently utilized technologies, or provide new functions/applications. The roadmap covers technologies initially developed both outside or within the forestry sector.

For the purpose of the roadmap, innovative technologies are grouped into four main clusters that will structure our discussions during this workshop: (i) digital technologies; (ii) biological technologies; (iii) technical innovations (processes and products); and, (iv) innovative finance and social innovations.

3.1 Expert presentations

Rao Matta (FAO) invited four experts to illustrate these four technology clusters by specific examples of recent developments for specific technologies along the value chain, from planting (with the example of teak), processing and value addition (rubber wood), to international trade (bamboo and rattan). The last presentation focused on investment, which is a critical challenge.

Harmonized system code for monitoring international trade of bamboo and rattan

Dr. Junqi Wu, Director of Communications, International Bamboo and Rattan Organisation (INBAR), China

This presentation focuses on the significance of Harmonized System (HS) coding for bamboo and rattan commodities and the development of the sector. The classification of bamboo and rattan products by HS codes makes it possible to review and monitor the international market value and status of bamboo and rattan commodities, including market size, trends and flows by trade actors. The presentation concludes that international cooperation and dialogue on the development of HS codes for bamboo and rattan can help develop market access for bamboo and rattan commodities and push forward the sustainable development of the sector.

Bamboo and rattan are important natural resources which make great contributions to sustainable development across the areas where they are distributed.

Bamboo and rattan are two of the most important non-timber forest resources. According to the *World Checklist of Bamboo and Rattan* (Vorontsova *et al.,* 2016), there are 1642 known bamboo species and 631 rattan species. Bamboos occupy a broad range of environments across the world, largely in tropical to warm temperate ecosystems across Africa, Asia and Central and South America. In 2018, INBAR estimated that bamboos covered more than 37 million hectares of land across the world.

Bamboo and rattan are astounding resources with unique potential to combat poverty and natural resource challenges. They grow locally, close to some of the world's poorest communities in the tropics and subtropics, and have many uses, providing a vast range of sustainable products, livelihood options and ecosystem services. Bamboo and rattan are very versatile: these plants have thousands of documented uses, and can replace materials with high carbon emissions, such as PVC, steel and concrete. They can also reduce pressure on forest timber resources. Increasingly, bamboo and rattan are being used to create products which are very useful in public infrastructure, including pipes, housing and storage facilities. Bamboo in particular is an excellent renewable resource and is often used as a fast-growing alternative to timber.

HS codes development can help to monitor and assess the international market for bamboo and rattan commodities.

Prior to 2007, most bamboo and rattan products were mixed with other products of similar materials. With the efforts and cooperation of INBAR, Food and Agriculture Organization of the UN (FAO) and China Customs Authority, 24 individual HS subheadings were approved by the World Customs Organization in 2007 and made effective from 2017. The newly produced HS codes identify the majority of bamboo and rattan products, including raw materials, bamboo shoots, bamboo and rattan baskets, curtains and furniture, as well as products such as bamboo panels, charcoal, pulp and paper articles, construction materials, etc.

The 24 new HS codes make it possible to form a comprehensive and clear picture of bamboo and rattan international trade and significantly enhance the quality of global trade data for bamboo and rattan, as well as more accurately reflect the overall status of bamboo and rattan trade. More importantly, they enhance recognition of bamboo and rattan products in the international market, which will allow developing countries to monitor, assess and stimulate their evolving trade and developing markets for bamboo and rattan.

Based on available data from INBAR Member States, it is estimated that the global bamboo and rattan sector has a trade value of around USD 70 billion. The majority of this trade is domestic. According to the UN Comtrade database, the world export of bamboo and rattan commodities in 2018 reached USD 3.25 billion. China is the largest producer, consumer and exporter of bamboo and rattan products in the world with a market share of more than 70 percent. Most Asian countries, including Indonesia, Viet Nam, Malaysia, and the Philippines, are important traditional bamboo and rattan countries for both domestic and international markets. The EU, the USA, Japan and Canada are key importers of bamboo and rattan products in the world. Meanwhile, the EU and the USA also export a number of 'further processed' bamboo products with the materials imported from other countries.

As the world leader of the bamboo and rattan industry, China has developed a very good national custom codes list for bamboo and rattan products, which can provide a clear overview of the international trade situation of the sector. Compared with the suggested downtrend in international bamboo and rattan trade provided by UN Comtrade data, China's custom codes tell a different story: China's bamboo and rattan trade keeps growing, especially through increased exports of further processed bamboo products.

International cooperation needs to be strengthened to develop the HS coding system for bamboo and rattan commodities.

The bamboo and rattan sector employs millions of people around the world and has created an industry valued at more than USD 700 billion annually. Monitoring trade of bamboo and rattan products is an essential part of supporting and developing the industry. The development of HS codes for bamboo and rattan commodities is a long-term process, fundamental to the development of the sector and trade. Along with technical innovation in the bamboo and rattan industry and in the development of products, the classification of bamboo and rattan commodities shall be developed further.

As the only international intergovernmental organization focusing on bamboo and rattan, with 47 Member States, INBAR will continue to focus on this issue, in cooperation with government agencies, research institutes, and private sector actors including producers, exporters and importers from all over the world who have a stake in the bamboo and rattan industry, and will push forward trade facilitation, with actions to improve market access for bamboo and rattan commodities.

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Development and deployment of teak germplasm in Papua New Guinea

Dr. Tony Page, University of the Sunshine Coast, Australia

Introduction

Plant domestication is one of the oldest of human innovations to bring about improvements in agricultural productivity (Harlan, 1971; Sauer, 1952). While the techniques and tools for domestication have changed over the centuries it remains a relevant technology for existing as well as new crops. The systematic domestication of timber tree species has been occurring over the last 70 years with a focus on key genera such as *Eucalyptus*, *Pinus* and *Acacia* (Simons and Leakey, 2004). The domestication of tree species for smallholder production in woodlot and agroforestry systems can be an effective means for addressing shortage of locally available products, import replacement or export markets supply (Nichols and Vanclay, 2012). A participatory approach to domestication that involves farmers in the improvement process, can empower local innovation and ownership (Ceccarelli and Grando, 2007; Leakey *et al.*, 2012). In this short communication, the process of participatory domestication of teak in Papua New Guinea (PNG) is used to illustrate the potential of innovative technologies to address localized timber shortages, diversify income and reduce dependence on natural forests.

Shortage of timber in a forested nation

Despite an abundance of forest resources in PNG, access to durable timber has become limited in some areas through the combined effects of forest conversion to agriculture and logging or mining in adjacent accessible forest. Landowner tree planting and agroforestry is promoted by the PNG government particularly in regions that experience shortages of wood and wood products for domestic use (PNGFA, 2020). Timber shortages have become particularly acute in areas with high population pressures such as the northeast Gazelle Peninsula in East New Britain Province (ENBP). A shortening of fallow periods in this region has resulted in natural transition away from regrowth comprised of mixed tree species towards dominance by the introduced tree *Spathodea campanulata* and grass *Sorghum propinquum* (Bourke *et al.*, 2002). The reduction in available timber at the local level has led to greater timber extraction in adjacent forests, which, combined with both logging concessions and forest conversion to oil palm, has led to a regional shortage of timber. Consequently, households are compelled to purchase timber from town (at high cost), contract a portable sawmill to harvest from distant forests (also at high cost), or rely on locally-sourced pioneer trees that recruit naturally within the shortened fallows (Rivan pers. comm., 2020). Fallow trees are typically characterized by their rapid growth and non-durable timber, and their use in construction leads to a decline in house longevity and associated reduction in livelihoods.

Smallholder aspirations

Landholders on the northeast Gazelle Peninsula have aspirations to establish woodlots using trees that produce durable timber for house construction and sale (Jenkin, 2019a; Page *et al.*, 2016a). While subsistence woodlots of various sizes and configurations can be accommodated on smallholder blocks (Jenkin, 2019b), land scarcity remains a prominent constraint to woodlot plantation(Page *et al.*, 2020). There is potential for development of a more substantial commercial smallholder resource in less populated areas on the margin of the main agricultural districts where landholdings are larger (Rabbie pers. comm., 2019). Such areas are close to local and domestic markets and within 2-3 hours by road to the closest shipping port in Rabaul. Despite this potential, a major constraint to developing a more substantial smallholder teak estate has been the availability of good quality seed. Germplasm supply is a common constraint to development and expansion of smallholder forestry systems (Nyoka *et al.*, 2011).

Teak as a focal species

A strong local demand for teak seedlings has been demonstrated on the Gazelle Peninsula (Page *et al.*, 2016a). Local demand for teak is based on its high growth rates, people's familiarity with its durable properties and value (based on harvesting of colonial plantations) and wide range of markets (local, domestic and export). Teak was introduced into PNG first by the German and then Australian colonial administrations during the early- and mid- 20th Century. The Australians established plantations and commenced a breeding program in the 1960s (Cameron, 1966). Despite this early development, the original plantings and all but one seed stand (Mt. Lawes clonal seed orchard) had been commercially harvested by the mid-2000s (Howcroft, 2005). Therefore, contemporary development of planted teak in PNG has been constrained by the availability of high-quality seed. To address this constraint, 26 different international and local sources were introduced to form the basis of a teak improvement program. Harwood (2011) described that introductions comprised of narrow genetics often result in the development of an inferior land race, therefore a wide range of teak sources were introduced for evaluation. To satisfy local demand the seed introductions were also deployed for establishment of smallholder woodlots. These early woodlots served as the foundation for developing locally-relevant management systems and for participatory domestication and source of *circa situ* genetic variation.

Teak domestication

A teak improvement program in PNG involved the participation of three sectors including government (FRI) University (UNRE) and non-government (OISCA and PIP) organizations. This approach was taken to spread risk associated with funding or policy changes within an organization. It was also undertaken to promote scientific rigor among institutions and maximize the potential for landholder engagement and distribution of germplasm. Lillesø *et al.* (2017) proposed that seed distribution mechanisms for agroforestry trees are central to capitalizing on the benefits gained through domestication.

Teak improvement in PNG was based on provenance introductions, phenotypic selection and vegetative propagation. Activities included: (a) the establishment of provenance trials (UNRE, FRI) and provenance plots (OISCA and local farmers); (b) the clonal capture of candidate plus[3] trees from the only remaining seed stand prior to its harvest (29 selections Mt Lawes CSO); (c) identification and clonal capture of phenotypic selections made in three mature stands (18 selections); and (d) early selection and clonal capture of candidate individuals from within the UNRE provenance trial (21 selections). Two clonal archives, comprised of clonal hedges, were established to preserve and replicate the selected individuals. From these archives, a new clonal seed orchard was established on secure government leasehold (PNG Forest Authority) and two clonal test trials were established (UNRE & OISCA) to determine the clonal performance of 21 phenotype selections. The use of clonal propagation of selected trees was based on the potential to capture non-additive genetic variation[4], but also avoids the limitations of the species breeding system, i.e., a slow reproductive maturity combined with a low seed production and viability (Kjaer *et al.*, 2000). Mean annual stem growth of selected trees has been at least 12.5 percent greater than unselected stock.

The engagement of farmers in the process of domestication permits greater stakeholder ownership (Ceccarelli and Grando, 2007) with potential long-term sustainability in the absence of institutional funding for tree breeding. A participatory approach to teak domestication in PNG has been undertaken, where growers were provided seed/seedlings of known provenance, as well as engagement on woodlot management and identifying attributes of a good timber/seed tree. This enabled the deployment of seed to growers at the same time as the more formal improvement activities described above. This was important to satisfy household demands for seed, develop capacity to manage nurseries and woodlots and also establish local distribution networks for improved seed/clones. Engagement of lead farmers was undertaken with the view to building their skills in assessing the quality of woodlots (Page *et al.*, 2016b). Extension materials were developed in collaboration with smallholders and project partners and provided through Pacific Island Projects and information hubs linked to church and community groups.

Contribution of the technology to sustainable forest management.

Teak is a major international plantation species and is also widely produced under smallholder systems (Midgley *et al.*, 2015), providing much needed income for smallholders (Newby *et al.*, 2011; Rohadi *et al.*, 2012). However smallholders rarely utilize improved germplasm to establish their woodlots, thus limiting their commercial potential (Roshetko *et al.*, 2013). In PNG, smallholder teak woodlots of known provenances were established through low cost bare-root seedling production on family-owned land. Landowners considered this technology accessible, and it was adopted widely, with 38 community nurseries distributing seedlings to

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[3] A phenotypically superior but untested tree.

[4] Non-additive genetic variation results from interactions between genes.

smallholders within their communities. Through this process 280 farmers planted 22,000 seedlings where the source provenance was recorded, while an additional 8,000 seedlings were planted without associated records. The nurseries and woodlots were established using seed and technical advice provided by the project, with growers providing land and labor. While the rate of adoption may be considered modest, the independence of the growers in establishing these woodlots without cash or other incentives offers a sustainable model for scaling out as local germplasm supply increases.

Many woodlots are now approaching 5-6 years and tree owners are being approached by village-based portable sawmill owners to cut the trees for sale, since some trees are already around 20cm diameter at breast height (DBH) (Vinarut pers. comm., 2020). Demand for teak thinnings was significant with posts sold down to an over-bark small-end diameter (SED) of 9.0 cm (mean SED of 15 cm). The posts were sold on a linear meter basis for USD 1.42 per linear m which equated to USD 123 (PNG Kina 493) per m^3 (Jenkin, 2019c). This shows the very high demand for timber in the region and also demonstrates an avenue for commercial thinning. For final harvest most landholders are willing to wait until the trees attain a commercial size of around 40cm (~12-15 years) as trees of such size will meet their requirements for permanent house construction (Vinarut pers. comm., 2020). A smallholders' teak estate of 174 ha would satisfy timber demand for local house construction in the Gazelle peninsula in 20 years (Jenkin 2019d). This would indeed reduce pressure on already logged over forests as a source for timber used in local construction. A teak estate that exceeds this area would require the development of domestic and export markets. This commercialization of smallholder teak timber will however, require further reform of existing legislation and policy to enable smallholders to legally market timber derived from their woodlots (Jenkin, 2019e). It has been shown in Lao PDR that while the technical aspects of teak production are well known (Pachas *et al.*, 2019), the full potential of smallholder participation in commercial supply chains can be constrained by the policy and regulatory environment (Smith *et al.*, 2017).

Smallholder tree production systems are being increasingly recognized as sustainable sources of timber for domestic and international markets (Midgley *et al.,* 2017). The primary motivation for smallholder participation in this sector is to generate a financial return. Tree domestication is an important innovation for generation of quality tree germplasm for smallholder forestry to optimize returns and reduce risk (Leakey, 2014; Roshetko *et al.,* 2007). Quality tree germplasm is of particular importance when scaling up commercially focused and/or export oriented smallholder systems to ensure the products can meet the quality standards of agents and end-consumers (Lillesø et al. 2017). For tree domestication to improve smallholder income generation, effective modes of germplasm dissemination are required. Widespread smallholder adoption of quality germplasm can be achieved through their participation in the germplasm supply chain (Roshetko *et al.,* 2007) and/or through participatory domestication mechanisms where improved germplasm is developed by and exchanged among farmers (Cornelius *et al.*, 2010; Leakey *et al.*, 2012; Tchoundjeu *et al.*, 2010).

The application of tree improvement and equitable distribution of quality germplasm is a simple but effective innovation. In PNG, a base population of teak comprising genetically diverse germplasm has been established with institutions and smallholder growers. This forms the foundation for selection and improvement of teak germplasm, with local networks in place for distribution of germplasm to smallholder growers. Smallholder teak plantings using diverse germplasm are already producing durable posts from thinnings. These are being used in the construction of local outbuildings, which reduces landholder dependence on low quality species in the agricultural landscape. The timber produced at final harvest will enable construction of permanent structures through direct use of sawn timber and sales of surplus trees to purchase non-timber elements. This will improve livelihood outcomes for families that currently have limited access to timber. The wider adoption of teak planting can also reduce regional dependence on timber extracted from natural forests and create opportunities for sustainable commercial timber supply in the province.

Abbreviations

- FA: PNG Forest Authority
- FRI: PNG Forest Research Institute
- OISCA: Organisation for Industrial, Spiritual and Cultural Advancement
- PIP: Pacific Island Projects
- UNRE: PNG University of Natural Resources & Environment

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Rubberwood: Valuable source of plantation grown timber for high value-added products in Malaysia

Dr. Jalaluddin Harun, Fellow, Academy of Science, Malaysia

The rubber tree (*Hevea brasiliensis*) originated from Brazil was first cultivated in Malaysia more than 130 years ago. The rubber industry in Malaysia which primarily focused on latex production had grown extensively with cultivation reaching 1.2 million hectares, predominantly owned by smallholders with less than 2.5 ha per person.

The Rubber Research Institute of Malaysia (RRIM) was established in 1925. It is the second oldest RRI established after RRI Sri Lanka in 1909. RRIM conducted extensive research in rubber trees including clonal breeding to produce greater amount and better-quality latex from *Hevea brasiliensis*. RRIM managed to produce rubber tree clones such as RRIM 600 and RRIM 900 Series. Successful tree breeding research in producing RRIM 600 clones benefitted not only Malaysia but also other rubber producing countries such as Thailand, Africa and Latin America. In Thailand, 60 percent of rubber cultivation are using RRIM 600 Series due to high quantity and quality of latex produced. Thailand currently is the largest producer of rubber in the world.

The RRIM, reorganized into the Malaysian Rubber Board (MRB), then expanded its breeding program from a sharp focus on latex production to include further development of rubberwood. These new clones produce simultaneously higher quantity of latex and larger diameter tree bole than earlier clones. MRB defined these clones as LTC (Latex Timber Clones) such as RRIM 2000 and RRIM 3000 Series.

Though rubber trees had been cultivated in small holdings and large plantations, with the new development of LTC new cultivation concepts and strategies of rubber trees were developed. A new forest plantation venture was initiated by the Malaysian Government through the Malaysian Timber Industry Board (MTIB), Ministry of Plantation Industries and Commodity (MPIC). The program called Forest Plantation Development (FPD) was launched in 2007, with an initial funding from Ministry of Finance Malaysia managed by the MTIB, amounting to Malaysian Ringgit (RM) 1.04 billion over a 15 year-period. A total of 9 fast growing timber and bamboo species[5] were offered as species for selection by the borrowers for cultivation. This initiative is a Public – Private Partnership Forest Plantation Program based on loans at a low interest rate of 3 percent and on a 15-year tree harvesting cycle. The loan taken is payable only after harvesting cultivated trees. The government provides soft loans while the private sector undertakes cultivation and management of the forest plantation. As a result of the FPD Program, a total of 126,000 ha of new plantation areas have been cultivated. Among the 9 species offered, almost 70 percent of borrowers selected Rubber tree, followed by *Acacia mangium* (25 percent). Only 5 percent of the borrowers selected other species for cultivation. This reflects the importance of rubber trees in this program due to its dual revenue generations i.e., latex and timber. The first tree harvesting shall commence in 2021.

Once latex's economic yield decreases, normally after 25 years, rubber trees are harvested for replanting. Initially, Malaysia used to burn harvested rubber trees for energy. However, intensive R&D efforts, focusing on fundamental rubberwood properties (whether anatomical, physical, mechanical or chemical) as well as on its workability in product manufacturing, were conducted in the 1980s' and 1990s'. These concerted R&D efforts enabled innovative uses of rubberwood in furniture manufacturing, uses now considered as suitable due to rubberwood good quality and viable due to rubberwood abundant availability. Rubberwood furniture industry, initiated in the 1990s', developed at an accelerated pace until today, catapulting Malaysia in the Top 10 exporters of furniture in the world. Rubberwood furniture constitutes 80 percent of Malaysia total furniture export annually, for a value of RM[6] 9.1 billion in 2019, ranging consistently from RM 7 to 10 billion over the past 5 years. Domestic furniture consumption is estimated to reach about RM 5 to 7 billion annually over the same period. Major export markets for Malaysian Rubberwood furniture include USA, Japan, European Union, Middle East, China and Australia. Currently, the major part of wooden furniture is manufactured based on

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[5] viz. *Acacia mangium*, Rubber tree (*Hevea brasiliensis*), African Mahogany (*Khaya sp.*), Binuang (*Octomeles sp.*), Kelampayan (*Neolamakia cadamba*), Teak (*Tectona grandis*), Sentang (*Azadiracta excelsa*), Batai (*Paraseriantes falcataria*) and Bamboo.

[6] Malaysian Ringgit: RM 1 = USD 0.25 [as of 21 December 2020].

original equipment manufacturing[7] (OEM) or reproductions. More furniture companies are moving towards ODM (own design manufacturing) and eventually OBM (own brand manufacturing). Both ODM and OBM normally command better selling price than OEM furniture.

Besides furniture manufacturing, rubberwood, along with other forest timber species, can also be converted into building components or BJC (builder, joinery and carpentry) such as floors, moldings, window and door frames. Current trends are gearing towards the use of timber as a load-bearing structure in multi-storey buildings. At present, the tallest multi-building structure made almost exclusively of timber is the Brock Commons, University of British Columbia, Vancouver, Canada. It is an 18-storey building, using Spruce, a softwood species (with density ranging from 370 to 571 kg per m^3) using glulam and cross laminated timber (CLT) technology. Rubberwood with density between 500-640 kg per m^3 with light color and good workability can be effectively used for building components and for multi-storey load-bearing structures in building constructions. R&D effort are now being carried out towards using rubberwood in load-bearing construction and using IBS (Industrialized Building System) technology. In Malaysia, manufacturing of BJC and wood moldings are established with export of these products amounted to RM 1.9 billion in 2019.

Bio-composite products, viz. medium density fiberboard (MDF), particleboard, oriented strand board (OSB) veneer and plywood have been effectively manufactured from rubberwood trees. Malaysia exported RM 1.4 billion worth of MDF and particleboard in 2019. These bio-composite products are composed mainly of rubberwood (almost 90 percent), the rest coming from other forest timber species. Hence, rubber tree utilization in Malaysia almost reached zero-waste: sawn timber, veneer plywood, bio-composite materials are converted into high value-added furniture and building components and other products.

Hevea brasiliensis is an important crop not only to Malaysia but to Asia, Africa and Latin America with total cultivation of 10 million hectares globally. It is predominantly a smallholders' crop primarily producing latex, of which 70 percent are manufactured into tires. Globally, the rubber cultivation industry is supporting approximately 40 million families. With rubberwood production upon replanting, smallholders can obtain additional income from harvested rubber trees contributing to improve their livelihoods. Harvested rubber trees can be sold to saw millers, veneer and plywood mills and to bio-composite mills for the production of medium density fiberboard, particleboard and oriented strand board.

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7 An original equipment manufacturer (OEM) traditionally is defined as a company whose goods are used as components in the products of another company, which then sells the finished item to users

Innovative finance for forestry[8]

Dr. Bas Louman, Program coordinator, Tropenbos International, the Netherlands

Introduction

Investments in forestry stand out among investments in economic sectors, due to the nature of forestry activities. For example, the production of prime material requires much land and time, and land is being occupied for a long time. There is also a long-time span between investments into creation of new plantations and the first financial benefits. Similarly, if improvements need to be made in, for example, genetic material or management practices, the results of such improvements usually can only be measured after one or even several tree generations. This long-time span for investments to mature, leads to uncertainties: what will be the future demand for products (and services)? What will be their price? Will the forest or plantation be affected by extreme weather conditions, fires, pests and diseases, or land conversion? What policy and regulatory changes will affect future use of the forests or plantations? And, for the processing industry, will the supply of future prime material be affected by new policies and regulations, or by social or environmental conflicts? All questions that an investor would like to see answered before making decisions on whether or not to invest in a forestry initiative. For such investors, these perceived risks are a major issue, and if investing in forestry, they usually want to be compensated for the risk by high returns, or want their risks to be covered by insurance, guarantees or another form of third-party involvement that reduces the investor's risk.

As a result, investments in innovations in forestry lag ways behind those in other sectors. At the same time, society increasingly recognizes the importance of forest products and services. Over the past 10-15 years, therefore, international initiatives sought for innovative ways to attract more finance to the sector. In this presentation I want to highlight some of the most common innovations in finance that surged during that period, although some of them may have been developed before. In particular, I want to look at those innovations directed at reducing risks for the investors by sharing the risks with others and possibly in different proportions. This will be followed by some final remarks on how innovations in finance could be facilitated to support the upscaling of innovations in forest technology.

Reducing risk by sharing

Many local innovations exist, but here I want to briefly discuss three innovative finance structures that have been applied globally, although as yet with little use in the forestry sector.

- Blended finance: "financing models that combine commercial and other financial sources to stimulate investment with complementary risk and return appetites" (Rode *et al.*, 2019)
- Green, social, sustainability, or climate bonds: fixed income instruments that represent a loan made by an investor to a corporate or governmental borrower, where the proceeds will be exclusively applied to eligible environmental and/or social projects (ICMA, 2018). Climate bonds currently mainly relate to emission reductions (in forestry: carbon credits)
- Crowdfunding: pooling of small amounts of capital from a potentially large pool of interested funders (Short *et al.,* 2017). Unlike in other financial transactions, there is a direct link between borrowers and lenders although, in some of its more recent developments, financial institutions have become intermediaries, but in a slightly different role than their traditional roles. When funds are small, these may be donated or lenders expect non-monetary returns from their investments but, when amounts increase, lenders more often seek financial returns, or a stake in the new enterprise or initiative (equity) (Lehner and Harrer, 2019).

Blended finance

Blended finance is being promoted by large international institutions, such as the UN Finance Initiative or the Organization for European Co-operation and Development (OECD, 2018), in order to use the available public

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[8] Based on Louman *et al.* (2020).

finance to leverage private finance for the achievement of international development goals, such as the Sustainable Development Goals, the Convention on Biological Diversity and the Paris Agreement.

Public finance is often used to improve the enabling conditions, making it more attractive for private finance to invest in actions with positive environmental and social impacts. This can, for example, be done by providing public finance to a fund manager, who uses it together with private investments to lend to beneficiaries. The enabling factor can be, for example, that the public finance is used: to provide technical assistance to the beneficiaries; to embed the financed activities in the local socioeconomic and ecological environment (e.g.: land use planning); to reduce the interest rates that need to be paid for by the final beneficiaries; or to cover first loss, if final beneficiaries are not able to pay back their loans. In this way, public finance contributes to reduce the risk for private investors when investing in activities that for them have many uncertainties, and therefore are considered to be risky. Blended finance is considered particularly useful to facilitate investments in new development projects and is being used often in the energy and infrastructure sectors, and more recently also for investments oriented at making agro-commodity value chains deforestation free.

Green, sustainability or climate bonds

The principles for green, sustainability or climate bonds are similar. The main difference lies in the criteria used to determine the eligibility of the initiatives to be financed. Since most bonds relate to medium and longer term loans, they require an issuer that has shown to be stable and to be able to manage funds. It, therefore, usually requires more mature organizations, often fund managers, banks or large corporations. They also require third-party certification to monitor that proceeds are really used for the objectives stated at the time of issuance. Because they promise a fixed return rather than a variable profit based on the economic performance of the beneficiaries, bonds are considered to be less risky, but also provide lower returns. For the beneficiaries, an advantage is that the initial investment does not have to be paid back until the bonds mature.

In 2018, the average size of this type of bonds was slightly over USD 100 million, with an average duration of 10 yrs (CBI, 2019). This makes them particularly useful for large scale forestry operations such as planting fast-growing trees, where initial costs are high and benefits accrue in the future. However, bonds for the land use sector are currently constrained by the lack of good quality (meeting bond criteria) and scalable projects to finance. Bonds can also be useful for financing payment for environmental services schemes, such as payment for avoided carbon emissions or carbon sequestration. One of the challenges for this type of bonds is to define what is the green, sustainable or climate contribution of the investments.

Some examples:

1. *Tropical Landscape Finance Facility (adapted from Louman et al., 2020)*

The Tropical Landscape Finance Facility (TLFF) is an example in which blended finance is combined with the issuance of bond-like notes. It is a recently set-up facility that manages funds from a variety of public and private investors and uses these to make green investments in tropical landscapes that should contribute to create local employment opportunities as well as conservation of the tropical forests. The TLFF was established by a multi-stakeholder group: UNEP, World Agroforestry Centre (ICRAF), investment manager ADM Capital and BNP Paribas, later joined by the WWF. Its objectives are to provide sustainable rural jobs, rehabilitate degraded lands and provide clean electricity.

The TLFF consists of a Grant Fund and a Lending Platform.

The TLFF Grant Fund is capitalized by multilateral and bilateral entities and philanthropic donors/foundations, and focuses on enhancing capacities to generate greener livelihood opportunities, strengthen wildlife conservation, protect forest cover, create resilience to climate change and increase the availability of renewable energy for rural communities. The fund provides technical assistance, and co-funds early-stage development costs, with the United Nations Office for Project Services (UNOPS) serving as a fund trustee. This arrangement ensures that development funding is leveraged with significant investments through the TLFF[9].

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[9] See: https://www.tlffindonesia.org/grant-fund/#Grantfund

Through the Lending Platform, TLFF aims to mobilize international capital at a scale that will incentivize sustainable agriculture, renewable energy and deforestation-free supply chains in Indonesia through strict lending criteria. It aims to decrease the environmental damage that often accompanies business-as-usual investing and at the same time improve rural livelihoods. ADM Capital is the manager of the platform and a driving force, bringing long-term experience in private debt investment and innovative funding models. BNP Paribas arranges long-term commercially priced, long-tenor debt for individual projects[10].

As a lending platform, the TLFF provides long-term loans to sustainable agriculture, forest conservation and renewable energy sectors such as Medium-Term Note programme (BNP Paribas) for 5, 7 and 15 years, recognizing different risk levels and attracting different type of investors. USAID provides a 50 percent guarantee for the USD 30 million tranche of longer-term (15 years) bonds. The *&Green* fund blends finance and invests in TLFF through buying notes, whose proceeds can only be used to further invest in jurisdictional projects, while part of the notes are guaranteed by USAID.

The TLFF is currently used to finance new rubber plantations (Michelin) and conservation areas in Indonesia in the context of a jurisdictional approach.

2. *Sumatra Merang Peatland Project*[11]

This is a simpler example, where a fund manager issues carbon bonds, the proceeds of which are lent to a borrower who cedes carbon credits to the fund. The fund uses these credits either to pay back the bond holders with credits or to trade the credits and make cash payments to the bond holders. In this case, it is a collaboration between Mirova/Althelia (issues bonds, manages fund), Pt Gal (borrower) and Forest Carbon (adviser).

This project:

- complies with the Verified Carbon Standard (VCS) and the Climate, Community and Biodiversity Standard (CCB);
- reduces drivers of deforestation by supporting community selected projects and peat land protection and restoration;
- provides climate, livelihoods (including gender), and biodiversity benefits;
- generates tradable carbon credits: bond purchasers can opt to be paid in carbon credits or in cash;
- helps Pt Gal to comply with environmental standards for its pulp and paper producing plantations

Crowdfunding

Although crowdfunding is not really an innovation in itself, digitalization of communication and financial services allowed it to take new forms and dimensions. The more conventional type of crowdfunding, depending on people that think alike and have some information on the initiators of the crowdfunding initiative, is generally limited to geographic areas with people with sufficient income to invest in such initiatives. Digitalization has made it possible for people from all over the world to invest in projects anywhere and of any type. However, providing some form of reliable knowledge on the initiatives to be invested in, and on the borrowers of the funds, remains a prerequisite for successful fundraising. Several digital platforms have been created to facilitate such knowledge and connect borrowers and lenders.

The Kiva platform[12] is an interesting example, aiming at providing funds to start-ups or small enterprises through a network of local banks. This reduces the risk of fraudulant fund raisers. In addition, they have started to use a digital verification system to verify identity and credit history of the borrowers. While the Kiva platform raises funds from individuals for small scale projects (although not exclusively), the Impact Partners[13] platform is more oriented towards attracting funds from impact investors. The latter platform, working more like a fund manager, is able to raise considerable funds and invest them in businesses with a demonstrated positive social

[10] See: https://www.tlffindonesia.org/lending-platform/#InvestmentApproach
[11] Adapted from https://ecosphere.plus/sumatra-merang-peatland/
[12] See: https://www.kiva.org/
[13] See: http://impactpartners.iixglobal.com/

impact. In both cases, the platforms offer opportunities for investments at different rates of return and risks, and ensure the monitoring of the investments.

Final remarks

Different innovative finance options can support innovations in the forest sector but target different scales and different phases of such investments. Often a combination of innovative finance options is the best solution, with grants important at early stages, followed by concessional loans and blending with commercial money, where the latter may be raised through bonds. Crowdfunding is better suited for small scale initiatives and start-ups and can be used to provide initial funding that may be needed to leverage grants or loans. All options require strong financial infrastructure in order to conciliate the scale of and local knowledge on investment initiatives with the desired scale and risk perception of the investors.

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3.2 Breakout groups: guiding question and expected outcomes, by James Roshetko (ICRAF/FTA)

During the first session, participants were split in four breakout groups, by technology cluster. Each breakout group focused on one technology cluster, as follows:

- Group 1 on digital technologies;
- Group 2 on biological technologies;
- Group 3 on technical innovations (processes and products);
- Group 4 on innovative finance and social innovations.

Guiding question:

From your experience, what are the 3-5 most promising innovative technologies for sustainable forestry and sustainable forest management in the next ten years in the Asia-Pacific region?

Expected outcome:

Based on the experience of participants, each group was expected to identify the 3-5 most promising technologies and to highlight their potential contribution to sustainable forestry and sustainable forest management in the region in the next ten years.

In each breakout group a chairperson, was chosen to moderate the discussion and report to Plenary. Each chair was assisted by a rapporteur.

3.3 Breakout groups: reports to Plenary

This section summarizes the main points of the discussions held in each breakout group during Session 1. More detailed notes of these discussions, as shared by the rapporteurs, can be found in Appendix 2.

Breakout Group 1: Digital technologies

Chair: Shahrukh Kamran,
Rapporteur: Nathanaël Pingault.

Our breakout group focused on digital technologies and identified several innovative technologies that seem very promising for sustainable forestry in the Asia-Pacific Region.

Among these are:

1. *Drones (aerial or land rover) can be used to perform a variety of functions:*
   - real time and participative monitoring of forest illegal activities,
   - catch insects,
   - seed blasting,
   - provide 3D pictures of forest stands at different levels (not only from above canopy but from inside), in particular in cloudy areas where satellite imagery is not efficient.

Drones might be quite expensive and not easily affordable, in particular for smallholders.

2. *Remote-sensing and spatial analysis:*

Open-source data sets based on satellite and other remote-sensing observations can be another interesting source of information that can be used in particular for forest protection and biodiversity conservation.

3. *Sensor networks:*

Sensor networks is another source of information and a very promising area for research and development that emerged in recent years. Such networks can provide real time data on many topics including soil, climate, biota. These data flows can feed integrated models, using Internet of Things, big data analysis, artificial intelligence and machine learning. Such models can help for instance predicting yields or creating insurance schemes.

Overall, digital technologies can help improve real time information and knowledge on forest stand dynamics, support modelling and precision forestry. Digital technologies can also support information sharing and capacity building (see for instance the use of virtual reality for training), improve working conditions, increase transparency and participation in forest governance.

As a conclusion, digital technologies have a huge potential. However, when developing digital technologies, we must keep in mind their human end-users. Digital technologies must be linked to people: in particular they must be made accessible to smallholders in developing countries.

Breakout Group 2: Biological technologies

Chair: Tony Page,
Rapporteur: Alexandre Meybeck.

Broad range of technologies. Big differences between countries.

In many contexts, basic selection and the use of quality genetic material to improve productivity and income generation would be an innovation, requiring not only appropriate techniques but also social innovations to deploy improved material to smallholders. It could be facilitated by a certification system of quality genetic material.

DNA timber tracking, by assigning a tree or wood product to a specific population or region can have multiple uses to control trade, fight illegal logging, link specific qualities to a specific area.

Plantation trees adapted to local conditions, in particular to recurring extreme events, are often lacking, particularly in the Philippines and in the Pacific. Identification of promising indigenous species, domestication and selection would make an important contribution to the development of local timber production and value chains, as well as to improved livelihoods.

Genetic tracing, associated to geo-localization can link specific genetic material to specific local climatic conditions and support the adaptation of natural forests by using for an area (A) the material collected in an area (B) that is already experiencing a climate close to the one expected in the future in the area (A) of plantation.

Breakout Group 3: Technical innovations (processes and products)

Chair: Lyndall Bull,
Rapporteur: James Roshetko.

Several types of technologies were identified that have significant potential to contribute to sustainable forestry and sustainable forest management in the next ten years. Those various technologies can be categorized under four of the technologies discussed in the introduction of the session:

- improved harvesting and transportation,
- improved industrial processing,
- engineered wood products, and
- bamboo and rubber products.

It was also emphasized that **improved varieties of priority species (including bamboo, rubber and various timbers) and clones** of those species are priority innovations that hold great promise.

Further, it was acknowledged that there are many **under-utilized species** that have been largely ignored and also hold value, although currently not fully recognized.

A principle uniting the prioritization of these technologies was the importance of making more efficient use of the forest resources, improving recovery rates and decreasing waste. These efforts should build on strong research collaborations and include a focus on moving wood products up the value chain. It was also stated that these technologies, including improved varieties/clones and under-utilized species, have the potential to decrease the pressure on natural forests which continue to decrease, largely due to land conversion. It was also felt that moving towards multi-species and multi-product forest production systems would be superior to single species emphasis.

It was stressed that the technologies need to be developed, adapted or adjusted specifically for the conditions and needs of smallholders and small-scale (local) enterprises as, collectively, they are major land managers at the global level and significant suppliers of many forest commodities. The availability and suitability of the technologies will vary by scale (small to large) and species. There are financial and institutional barriers to the adoption and adaption of the technologies and, thus, there is a need for collaboration across the financial, industrial, development and government sectors.

Final thought was that there is a need for integration with technologies from the other clusters (digital technologies, biological technologies, financial innovations and social innovations).

Breakout Group 4: Innovative finance and social innovations

Chair: Vincent Gitz,
Rapporteur: Nguyen Quang Tan.

Three key technologies discussed by the participants are: (1) the use of drone, remote sensing and satellite imageries; (2) information technology with mobile apps; and, (3) artificial intelligence.

These key technologies have a wide range of uses. The key uses of remote sensing and information technologies are monitoring and reporting land-use changes, reporting illegal activities, tracing the sources of timber and forest products, monitoring and measuring forests, sharing information to the local communities more effectively. Artificial intelligence has been commonly used outside of the forestry sector and is expected to be used in forestry in the next ten years, for instance to forecast forest fires and other disasters.

In addition, two key financing innovations have also been discussed by the group: (1) payment for ecosystem services (PES), and (2) carbon financing. PES through bank system is being practiced in Vietnam and is expected to become a key financing mechanism for sustainable forest management in the next 10 years. Forest carbon financing, which is being tested in Lao PDR and Vietnam (and other countries), is expected to help enhance access to the international finance market for local communities.

4 Session 2: What technologies for what functions (application)?

James Roshetko (ICRAF/FTA) introduced session 2 reminding the participants that innovative technologies can perform various functions along the forest value chain. Among these functions are (not an exhaustive list): tree improvement (germplasm selection, production and breeding); forest monitoring; forest management (tree planting, tree growing, forest protection); wood harvesting; wood processing (first and second transformation); quality control; traceability; transport; distribution; final use of wood-based or non-wood forest products (for, e.g., medicine, energy, packaging, construction material, furniture…); reuse and recycling; waste management; marketing; community empowerment; etc. He illustrated his intervention with a matrix showing the various technologies that can be applied to perform various functions.

4.1 Expert presentations

Rao Matta (FAO) introduced the three experts invited to present specific applications of innovative technologies.

Forest technologies application in Vietnam

Dr. Vu Tan Phuong, Academy of Forest Sciences, Vietnam

I am working in Hanoi. I will talk about forest technologies applied in forest management in Vietnam.

The first technology, commonly used in many countries for forest management, is remote-sensing. In Vietnam, we use remote sensing since 1990 for our national forest inventory. We use the data for detecting forest cover changes and also for forestry planning. Now, we are not only looking at forest cover changes but, along with the ground survey, we also estimate wood stocks, as well as GHG emissions and removals from the forest sector. Our national forest inventory is implemented every five years since 1990, so we are now in its fifth cycle. We have been using the different types of remote-sensing images, from low- to high-resolution, for forest classification and mapping.

The second technology we are trying to apply in forestry is LIDAR technology to estimate wood stocks and biomass without ground measurement. This technology, which requires a strong scientific and modelling basis. is not commonly used but we are currently doing some studies.

The third technology, already developed in Vietnam, is a fire watch/warning system that uses both remote-sensing information and climate information. Forests in Vietnam can be highly vulnerable to fires. This tool is managed by the forest protection department. It provides real-time information, for the forest manager to react quickly when a fire occurs. This information on forest fires is integrated in weather forecast news for specific locations and areas. We also maintain a database on historical forest fire, so that people can access the information and data and map forest fires and hotspots. Forest managers can assess in real-time the risk of fires in each location. So, it is a very helpful tool for the people especially in the dry season, where the forest fire risk is commonly higher. Maps of forest fire risks can be used at local, district, provincial or national levels for fire prevention.

In Vietnam, we have been working with biotechnology for tree breeding and variety development, using genetic markers. We aim to improve timber productivity and the quality of planting material. We are also working on disease- and drought-resistance, especially as we are now facing the impacts of climate change. We also use micro-biotechnology and bioproducts to help decompose fire material, thus contributing to reduce the fire risk. Bioproducts are also used, instead of chemicals, for wood preservation or as biofertilizers. We use tissue culture for variety improvement. We are now working on gene isolation, DNA barcodes and nanotechnology for selected species, particularly for some rare, precious or endangered species.

In Vietnam, we have about 4,500 wood processing facilities, but with quite limited application of innovative technologies. Some companies are applying or developing innovative solutions. For example, some companies already use Computer Numerical Control (CNC) to optimize product design or wood processing. We still rely on hydro-power for wood drying but this is changing. Some innovative drying technologies, using alternative energy like solar energy, help reduce the pressure on the power sector in Vietnam. Thermal technologies, such as microwave plasma, are used to change wood properties (e.g., improve appearance, durability and water resistance of timber) according to our expectations.

Artificial intelligence (AI) is used for wood identification to check the legality of wood imports from 100 countries; and for plant species classification.

In 2007, the Ministry of Agriculture and Rural Development issued a decision to promote the application of innovative technologies in the forestry and forest management. Forest managers are encouraged to apply the following innovative technologies: (i) gene technology for tree breeding, variety development, seedling production and forest intensification, biotechnology for forest protection, genetics identification and species classification; (ii) remote sensing for forest monitoring, forest disease management, forest fire risk and natural disaster warning; (iii) automation to reduce workload, improve work conditions and optimize wood processing or wood preservation. There are the key areas. We already have a strategy, a policy to encourage the application of these technologies. This is how Vietnam is now applying the technology in forestry management and forestry development. Thank you very much.

Innovative practices in the woodworking industry in China

Dr. Shengfu Wu, National Forest Products Industry Association, China

Dr Shengfu Wu offered broad perspectives on the development and evolution of the wood industry and the role of innovative technologies.

Background

Wood is the only construction material which is environment-friendly, renewable, sustainable, biodegradable, low-carbon and carbon sink.

China has very rich resources on both bamboo and planted forests. China has developed comprehensive different solutions on the woodworking industry which suits modern and traditional technics.

China is a big exporter of timber products such as plywood, flooring, door sets, wooden furniture, wooden toy, photo frame, cabinets etc. Low-profitable, labor intensive woodworking industries, with heavy work and low wage have shifted to China and other developing countries. Chinese products and solutions are key to the sustainable supply of the world mechanical woodworking industry.

Developing the woodworking industry requires hard work rather than long talks: working hard and diligently is the only way.

Poverty alleviation is the most important issue in poor countries, especially for all those forest workers who are food insecure.

Innovative technologies

Innovation in the woodworking industry happens every now and then, on machinery, technology, management, productivity, recovery, efficiency, energy-saving, eco-friendliness, etc. For instance:

1. New cultivation techniques such as clonal culture, especially on the eucalyptus and poplar:

China has developed clonal species adapted to dry or wet conditions, mountain or plain areas, cold, warm or hot temperatures.

In addition, the government encourages tree planting every year through institutional policies. The Tree Planting Policy is the most important policy or method holding promise for improving sustainable forestry and sustainable forest management. The re-forest policies include: reforestation to prevent desertification, slope hill reforestation, agriculture forest, wind protection forest, Along the see or river forest, national planting scheme, cutting ban etc. They are the key to increase the forestry land and forest reservation.

2. Engineered bamboo products:

Bamboo is a green resource and regrows by itself. Engineered bamboo products include: cross-laminated bamboo (CLB), bamboo scrimber[14], engineered bamboo beams, engineered bamboo flooring, engineered bamboo veneer, etc.

3. Customized processing 5G tech:

The development of 5G wireless communications open considerable perspectives by automating industrial technologies and utilizing other enabling technologies such as artificial intelligence (AI) and machine learning, facilitating automation of physical tasks based on historical information and knowledge, or improved outcome like reduction of energy and natural resources consumption.

4. *Environment-friendly products for living environments:*

The indoor or living environmental requirements are getting severe, creating challenges but also offering considerable opportunities for higher-quality environment-friendly products under development. Adhesive without added formaldehyde as well as water-based paint for home finishing, which replaced alcohol soluble

[14] A bamboo fiber-based composite made from crushed bamboo fiber.

resins, are widely used in China. Such good experiences and technologies can be shared with the Asia-Pacific region and the World. Especially in the pandemic season, more environment-friendly products shall be developed as part of “building back better”.

5. Responsible purchase policy

China National Forest Products Industry Association has developed an industry standard called “Timber Legality Verification” and the associated third-party has started the verification work in China. We prioritize purchase of timber sourced from certified or legally verified forests. We develop green products, improve technologies and processes to reduce consumption of energy and natural resources. Local materials shall have logging, transporting and processing licenses to keep them legal.

Special attention is paid to imported logs (different countries have different levels of risk and are thus treated differently), It is advised not to use high-risk materials.

Such a responsible purchase policy can also contribute to prevent corruption for all the decision makers.

Geospatial Solutions to Conservation

Dr. Oliver Coroza, Center for Conservation Innovations Ph, the Philippines

In this summary paper, we tackle the topic of geospatial solutions to conservation by citing the top three issues we encountered in dealing with conservation work in our areas of interest, namely:

1. the information gap on forest cover and other spatial features;
2. the lack of a systematic functionality for monitoring spatially explicit observations of reforestation or of drivers and agents of deforestation and forest degradation; and,
3. the absence of a forest cover classification in the language of our stakeholders.

For each of these issues, we resolved them by applying solutions available to us through the use of geospatial tools.

Information gap on forest cover and other spatial features

In the localities where we have been helping out in conservation work in relation to sustainable forest management, we found a gap in information pertaining to spatially explicit forest visualization. Local community's interest for more precise forest information primarily stems from the desire to know the breadth and width of their forest domain. In particular, they wanted to know the areas where reforestation or assisted natural regeneration might be implemented, as well as the places where forest is being degraded and cleared, so that forest patrols can be concentrated on those areas.

We can say that paper or analog forest maps might provide this kind of information service, but this will be far from meeting the realistic needs. For example, users may want to be able to make quick calculations of areas, pinpoint coordinates quickly, manipulate data to provide the visualization needed. For instance, they may want to indicate proximity of roads and river networks where disturbance of forest might be prevalent. This information gap might be solved by building capacity of proponents in using geospatial tools like geographic information systems (GIS), global positioning systems (GPS), as well as mobile and web apps for mapping. Open-source technologies, such as QGIS, Google Earth Engine, MapIT (mobile GIS app), Landsat Explorer (a web-based app) to name a few, can facilitate the access of all the target beneficiaries to the information they need given their lack of financial resources. We work in collaboration with NGOs in the Kandal province of Cambodia and in the Quezon province of the Philippines, and with a group of government people concerned with managing biodiversity and protected areas in the Philippines. We find that there is a need to quickly look at these maps while we are in the field. Mobile GIS installed in a mobile gadget can be very helpful, especially, locating those spots where reforestation work can be initiated. We should then go digital in the field.

Lack of a systematic functionality for monitoring spatially explicit observations of reforestation or of drivers and agents of deforestation and forest degradation

Data sheets might be stacked somewhere, in the corner of a room, gathering dust, because the patrollers do not have time to compile and encode them so that they can be analyzed and reported. GPS gadgets might be left on a table, also gathering dust and rusting, because they don't seem to be part of every day's gear like a cellphone. There are still kilometers of protected forest remaining to be visited and monitored, but they are days away by foot. You might need to bring a bulky species guidebook to help identify threatened flora or fauna and then record them. The availability of touchphones or smartphones, as versatile gadgets with built-in GPS and camera, plus software development kits made possible the creation of mobile apps, which can help overcome the shortcomings in traditional field record-keeping and forest patrolling.

In our short stint in the Pacific Islands of Samoa, we helped sort out their GIS database and we developed for them, using a commercial app, the Samoa Mobile System for Monitoring Critical Landscapes. This mobile app helps documenting reforestation activities in designated woodlots, livelihood in vegetable farms, and recording their location and visual status using the built-in GPS and camera of smartphones. By pressing a button icon on the app, the data collected is sent over to an online central server once the smartphone is within reach of a Wi-Fi signal. The data collected can then be summarized with statistics on a laptop using a dashboard display option. However, adoption of the app was minimal due to the expense involved in software licensing.

An enhanced version of another mobile app called WiForFish, using open-source app, integrated monitoring of wildlife, fisheries and mangrove forests and is being used both by forest guards and sea wardens in the Philippines. This app can be supplemented with surveillance from drone cameras to do rapid patrol in far-fetched areas.

Lack of a forest cover classification in the language of our stakeholders

A government agency in the Philippines managing protected areas expressed the clamor of conservationists and biodiversity scientists to have a forest cover map with class categories that clearly reflects the characteristics and roles of the ecosystems in forest formation types. In this case, forest cover maps with ecological categories are intuitive. For example, when you see a forest cover map based on this kind of classification, it is easy to figure out: at which elevation a given forest type can be found; what are the flora and fauna species highly associated with this forest type; what soil and rock substrates are present; what are the possible local climatic characteristics; what is the moisture regime; and, what are the ecosystems services integral to this forest type.

The solution implemented was to apply remote sensing and species niche modelling using machine learning algorithms and train these to recognize the forest formation types from satellite or drone imagery. The approach does not disrupt the national forest classification system based on FAO's classification, because it can easily dovetail with it. Hence, we can produce a forest cover map that not only meet international norms but also make it understandable to the biodiversity conservation community.

There is a similar aspiration to develop such a localized classification of forest cover in local languages, e.g., of indigenous peoples' communities. However, this might be a formidable task considering that more than a hundred ethnolinguistic groups exist in the country. Nevertheless, who knows, there might be a research interest on how to adapt this tool to the main indigenous people groups.

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4.2 Breakout groups: guiding question and expected outcomes, by James Roshetko (ICRAF/FTA)

During Session 2, participants were split in three breakout groups to discuss the following guiding questions.

Guiding questions:

What can be the contributions[15] of innovative technologies to sustainable development (covering its social, economic, and environment dimensions) in different contexts? How does the application of innovative technologies affect different functions[16] throughout the value chain and to which extent this contributes to sustainable development in the forest sector?

Expected outcome:

Based on their experience, participants were expected to identify the main contribution(s) of different technologies to sustainable development in different contexts. Participants were invited to focus on the 3-5 most promising technologies identified in Session 1, with illustrative examples featuring other technologies possible. The objective was to identify parameters/criteria that influence positive outcomes.

In each breakout group a chairperson, was chosen to moderate the discussion and report to Plenary. Each chair was assisted by a rapporteur.

4.3 Breakout groups: reports to Plenary

This section summarizes the main points of the discussions held in each breakout group during Session 2. More detailed notes of these discussions, as shared by the rapporteurs, can be found in Appendix 2.

Thomas Hofer (FAO), who moderated this session, highlighted the interlinkages existing among the four technology clusters as well as the important contribution that youth can make to the innovation debate. He also underlined the potential of innovation to support climate change adaptation and local communities' resilience.

Breakout Group 1

Chair: Vincent Gitz,
Rapporteur: Nathanaël Pingault.

During this second session, we focused on innovative technologies, in particular digital technologies, on the functions they perform and on their potential contribution to sustainable development. Innovative technologies have a huge potential but can also be conducive to social, economic or environmental damages. The promise/potential of a given technology might not cover equally the three dimensions of sustainable development.

For instance, on the one hand, drones are very efficient monitoring tools. They can perform many functions, e.g., forest monitoring, illegal activities tracking, seed blast, etc. They can access remote

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[15] For instance: reduced costs and improved productivity; reduced ecological footprint; reduced waste; low-carbon technologies; job creation; improved governance; strengthened participation in decision making; strengthened transparency and accountability; real time monitoring and reporting; improved access to natural resources; improved access to information; improved access to credits and markets; etc.

[16] Among these functions are (not an exhaustive list): germplasm selection, production and breeding; forest monitoring; forest management (tree planting, tree growing, forest protection); wood harvesting; wood processing (first and second transformation); quality control; traceability; transport; distribution; final use of wood-based or non-wood forest products (for e.g. medicine, energy, packaging, construction material, furniture…); reuse and recycling; waste management; marketing; etc.

areas without the costs and collateral environmental damages linked to the construction of a road (or other permanent infrastructure). They can collect information even in cloudy areas inaccessible to satellite-based remote-sensing tools. They can create new skilled jobs (including drone operators). On the other hand, due to limited financial resources and limited technical capacity, most of the smallholder farmers or foresters might be unable to access / afford such technology. Drone operations also raise some legal issues (e.g., flight over private lands and privacy protection) and need a specific legal and regulatory framework adapted to fast evolving technologies.

Mobile phone applications can help for forest monitoring, illegal activities tracking and forest management (e.g., estimates of wood stock or prediction of yields in forest strands). They can be more accessible to smallholders: their cost can be limited, above all when they use open-source software and datasets. Experiences from Pakistan, Laos and Vietnam show that such technologies, where real-time data from the ground feed open online datasets, can contribute to empower local actors and increase participation, transparency and accountability. There is however an issue of standardization of such tools, at national but also international level. Capacity building and technical training of local actors is key for technology adoption and implementation.

Breakout Group 2

Chair: Tony Page,
Rapporteur: Nguyen Quang Tan.

1. *Broad range of technologies and large differences between countries*

Many technologies are already available, but we need to better understand the process of technology adoption. Adoption is context specific: for instance, tissue culture and clonal deployment of cultivars, might be applicable in some countries, not in others. Often, a simple lack of access explains the lack of adoption: for instance, improved germplasm might be accessible to institutional investors but not to smallholder growers.

2. *Basic selection and quality genetic material to improve in productivity and income generation would be an innovation*

Participants discussed the advantages of improved germplasm for smallholders. Social innovations are required for localized deployment of improved material to smallholders in many countries. This would require a supportive government and private sector willing to share improved germplasm with smallholder sector. A simplified certification system for quality genetic material may be a way to support commercialization.

3. *DNA timber tracking to control trade, fight illegal logging, link specific qualities to a specific area.*

DNA timber tracking has a wide range of application but can be particularly useful for conservation purposes. Cost of DNA sequencing has reduced significantly over recent years making it available for wider use. Developing DNA tracking requires: international legislation governing the legal supply of timber; consumer demand for sustainable timber; and, certification schemes tracking the product throughout the supply chain.

4. *Locally adapted and commercially-viable plantation trees that can be more resilient to changes in climate*

Plantations are often dominated by a relatively narrow range of exotic species. Indigenous trees, typically more resilient, may offer an alternative, particularly in those regions affected by more frequent and intense tropical typhoons. Developing viable local species will require funding and institutional support as many local species will need to undergo, at least, very basic form of domestication to ensure adequate seed supply and allow these species to grow in a plantation situation.

5. *Biological technologies, discussed in the group, make important contributions to bioeconomy and bioenergy.*

Biotechnology can help convert plant biomass into renewable energy, enabling both specific production of bioenergy or better utilization of by-products as bioenergy. Bioproducts (for instance bamboo products) can be used in a wide range of situation to replace fossil fuels, plastic products or energy-intensive construction material (e.g., concrete and steel). Many bamboo species can grow well on marginal or degraded lands, thus contributing to environment conservation and land restoration. Biochar can enhance carbon sequestration and soil regeneration. It is also a good amendment for soil biodiversity.

Breakout Group 3

Chair: Lyndall Bull,
Rapporteur: Marco Piazza.

Based on the innovative technologies identified in Session 1 (with focus on *processes and products*), the group's discussion highlighted the following points:

Think "small"

It is important to:

- focus on small-scale technologies for smallholders, who are the most vulnerable, who have significant forest resources, and who should be the ultimate beneficiaries of technological advances;
- focus on technologies that can capitalize on and make efficient use of, for example, small diameter trees, understory vegetation, waste and processing by-products, as well as under-utilized species.

There is a need to ensure that there are appropriate technological advances all along the value chain to ensure value addition and, consequently, appropriate increases in the returns to smallholders

Beyond technology

Technologies often already exist: the challenge is on adoption and utilization.

The scarcity of data on local farmer products' demand and resources is a challenging element. Data limitations on supply and demand at local, regional and global levels are likely to impact investments and, consequently, adoption of technologies that may improve economic, social and environmental outcomes for smallholders.

Innovative financing options should be explored to facilitate adoption of technological solutions that improve economic, social and environmental outcomes for smallholder forest owners.

Technological issues need to be addressed also from the point of view of policy and institutional set up. Often, the government and public institutions are not well-equipped to finalize, commercialize and encourage widespread adoption of innovative technologies. Appropriate linkages and partnerships with the private sector are needed.

There is a gap between technology developers and users. Training and extension are key requirements for widespread and successful adoption.

Technologies needs to be transformed, adapted to context, in order to be adopted successfully with local engagement, creating a relationship based on shared value-added.

There is a need to ensure that combination of technologies and mechanisms to monitor and potentially monetize different forest values, including the value of ecosystem services, are integrated into the thinking around both product and process technologies.

5 Session 3. Innovative technologies: challenges and opportunities for the forest sector.

James Roshetko (ICRAF/FTA) introduced Day 2 discussions that focused on the challenges and opportunities, strengths and weaknesses, benefits and negative impacts, barriers and enabling conditions associated with the application of specific innovative technologies in the forest sector.

5.1 Expert presentations

Rao Matta (FAO) introduced the three experts, from different stakeholder groups (government, academia and research, civil society), invited to present three case studies, covering not only technical but also social innovations. Building upon the presentations, he identified among the main challenges: training, resource constraints and infrastructures.

Social innovations in community forestry: an application and success case from Nepal

Lok Mani Sapkota, RECOFTC, Nepal, in collaboration with Kalpana Giri and Shambhu Prasad Dangal

Background

Community forestry (CF), an initiative that reorganized systems with the aim of increasing the roles of local people in governing and managing forest resources, is a strong example of social innovation (RECOFTC, 2013). It is a proven effective approach to tackle both societal and environmental challenges at the same time. It does such reorganization of systems, functions and processes in ways that empower local communities to manage their forest resources and enhances their well-being through their participation in broader engagement.

In Nepal, CF was introduced in the 1970s to avert the widely perceived crisis of Himalayan forest degradation through active engagement of local communities. The program received strong policy support (e.g., through the 1989 Master Plan for Forestry Sector and the 1993 Forest Law) in addressing challenges facing the society while delivering on its early objectives. Under the program, families using a forest form a collective group called community forest user group (CFUG), register with a government agency (Division Forest Office), develop and implement an operational plan (also known as management plan) with the support of government and civil society stakeholders. CFUGs collectively manage forests, including harvesting forest products as prescribed by the management plan, distributing these products to the members at subsidized rates and selling the surplus to markets at competitive rates, thus generating financial resources for the CFUG. The major premise of CF then is to have communities safeguard the forest resources and in return, get management rights for subsistence use.

Because of its potential to contribute on multiple fronts, in addition to sustainable forest management, community forestry has morphed to different models, on top of the aforementioned CF model, to achieve multiple specific objectives.

- <u>Collaborative forest management</u> (Dhungana *et al.,* 2017): management of block forests through the partnership among central government, local government and local communities in fulfilling forest product needs of wider population groups.
- <u>Pro-poor leasehold forest program</u> (Laudari and Kaini, 2013): improve livelihood of ultra-poor through forest-based income generating activities.
- <u>Community forestry program in protected areas</u> (Jana and Poudel, 2017): fulfil forest product needs of local communities and support in community development, while also contributing to conservation goals.

Under those CF modalities, nearly half of the population in Nepal, organized in more than 30,000 user groups, manage nearly a third of the national forest area. This large geographic coverage makes the program stronger in tackling societal challenges.

Key social innovations from community forestry in Nepal

In addition to contributing to increased forest cover from 38 percent in 1986 to 40.4 percent in 2015 (Nepal and Canada, 1986; Nepal, 2015), community forestry has provided robust institutions to systematically address gender and social inequalities. It did so in the following ways.

- <u>Creating enabling spaces for women's leadership in the public sphere of decision-making:</u> CFUGs identify both men and women as family heads with an authority to participate in CFUGs decision making, including the selection of leadership. It also proposes legal mandates and quotas to ensure women get into decision-making positions within the CFUG governance process. This is a positive leap in a society which considers men as family heads by default and does not acknowledge women's decision-making roles in public spheres. Since inception, CF's enabling spaces have: contributed to cultivate women leaders especially at local / grassroots level; increased sensitivity of CF networks to the need of gender and social inclusion; and helped to recognize women's role in public spheres of decision-making. While the structural barriers are still existent, CF spaces, policies and processes can be said to create an enabling catalyzing effect to engage with women in a new role of leadership and decision-making.

- A democratically elected and inclusive community institution: CFUG members collectively select their leaders, ensuring at least half of the positions, including the key ones, are filled by women, if required through election. The leadership body, which is known as the Executive Committee, should also have fair representation of other marginalized groups such as poor and ethnic groups. Because of the inclusive structure and democratic decision making, CFUGs were among the very few institutions to survive in rural areas during armed conflicts around the 1990s and 2000s. CF has made a great contribution in sharpening leadership skills of hundreds of women enabling them to run local governments.
- Adoption of a holistic development model: CF is providing resources for management of forest as well as for community development, by having holistic operational plans of the CFUGs. In implementing such plans, they spend at least a quarter of their income in the conservation and management of forest resources. Similarly, at least 35 percent of resources are spent in uplifting marginalized groups (women, poor and other vulnerable groups) through actions that directly reduce their vulnerabilities and develop their capacities. The remaining resources are used for other developments such as construction and maintenance of much needed infrastructures such as schools, local roads, and drinking water systems. CFUGs also have revolving funds and emergency funds to financially support the needy members which they identify through a participatory well-being ranking. The well-being ranking also enabled the CFUGs to provide forest products to community members at subsidized rates.
- A network of communities to safeguard their rights: CFUGs are organized into a national network, commonly known as FECOFUN (Federation of Community Forest Users Nepal) to safeguard rights of local communities and promote collaboration among CFUGs and with other stakeholders. With thousands of communities as its members, and capacity to mobilize them through provincial and municipal sub-committees, FECOFUN provides agency to local communities to engage with other stakeholders, including the state, regarding the decisions that affect them.

The strengths of the program contributing to social innovations

The key strengths of the program that contributed to social innovations are:

- A progressive design: Supportive rights that included commercial harvest and development of enterprises by CFUGs, enabled CFUGs to meet forest products needs of community members and ensure community resources development, contributing to the high interests of local communities to engage. Recognition of women's equal roles in families and communities provided an enabling environment for women and ensured participation of all members in the program.
- Strong support from key stakeholders: The state provided strong legal back-up and mainstreamed it as one of the major programs in the forestry sector. Similarly, donors provided resources and knowledge to implement and improve the program. Strong participation of civil society members in implementation of the program helped fill gaps in state agencies' support to forest managing local communities.

Weaknesses in the promotion of social innovations

The key weaknesses of the program that has been undermining CF's ability to tackle societal challenges are:

- Inability to break sectoral walls: Despite CF's strong contribution to multiple sectors such as social development, infrastructure, education, health, CF is limited within the forestry domain in policies and programs. This has been constraining the growth of CF and hampering the realization of opportunities to build on early success of the program to address due inequalities, which span across sectors, and emerging societal challenges.

- Limited adaptation at programmatic level: Contexts in rural areas of the country have changed significantly from when the CF program was designed three decades ago. The new context means changed needs and capacities of local communities and emerging opportunities. However, CF programs have not been able to strongly show capacity in dealing with the changes and tapping on those opportunities. Although CFUGs have adapted to a certain extent, following the program cycle, adapting to changes taking place at community level through revisions and renewal of operational plans every 5-10 years, the national CF program has not changed much.

Challenges for social innovations through CF

Following are some of the challenges that CF in Nepal need to deal with to continue addressing societal challenges

- Shifts in societal transitions and regard to forest systems: Local demand has been changing. For example, there is a substantially reduced demand for firewood and fodder, which were of high demand by local people a couple of decades ago. Likewise, there is less interest in subsistence use of CF, as the young generations are looking for financially tangible returns on their investment (e.g., labour). This requires shifts towards more active forest management from the initial concept of "subsistence use" or passive management. What roles, responsibilities and rights will be played to address the aspirations of local people while contributing to national economy is a key area of interest for the government and has become an issue of debate in Nepal. Does CF need a mixed approach and, if so, what new reorganization of systems, roles, processes (another layer of social innovation) is needed, are still questions that need to be sorted out.
- Complex and bureaucratic procedures: Despite its good practices, CF is victim of perennial issues of weak governance and limited capacities of the overall state mechanism to deliver. This weakness has been creating hurdles to CFUGs for example in sustainable harvest of forest products, through interconnected but inconsistent decisions, cumbersome bureaucratic processes and rent seeking attitude of the actors involved.
- Weak market linkage and finance: Although a large number of CFUGs are sending surplus forest products to the market, the management of community forests is not effectively linked to markets. The management of community forests is not always informed by market demand of forest products. This has contributed to, for example, the country's reliance on imported timber to meet domestic needs, despite the potential of community forests to contribute in filling the gap. This also means that a large share of CFUGs struggle to stay afloat, also in the context of reduced support from funding agencies, with about a third of CFUGs unable to renew their operational plan in lack of financial resources to cover the cost of the process.
- Continued need for support and decreasing assistance: The number of CFUGs has been increasing, with transfer of leadership every five years in general. They are expected to provide leadership in achieving multiple objectives following formal processes, which are often complex. Given limited capacity of state agencies to support and drying-up external assistance to CF, the incoming leaders of CFUGs are not getting the needed capacity-building support, for example, on responsive governance, organizational and financial management, and productive forest management. This has reportedly contributed to issues such as weak governance of CFUGs, weak capacity to innovate and, ultimately, sub-optimal delivery on emerging needs of local communities.

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Using DNA to identify illegal and conflict timber in global supply chains

Andrew Lowe[1,2], Eleanor Dormontt[1], Arif Malik[1] and Darren Thomas[2]

[1] *Advanced DNA Identification and Forensics Facility, University of Adelaide, Australia.*

[2] *Double Helix Tracking Technologies, Singapore*

Introduction

Globally, illegal logging is one of the largest illicit trades, worth over USD 30 billion a year, with few prosecutions (Dormontt *et al.,* 2020). Whilst illegal logging is perhaps best known as a tropical forest issue where, in some countries, it can account for up to 90 percent of all traded timber, there are also major problems with illegal logging in temperate countries (Lowe *et al.,* 2016), and illegal logging activity in the US has been estimated at USD 1 billion annually.

To support legislation that promotes legal trade and prevents trade of illegally logged wood, a range of scientific methodologies have been applied to timber identification to provide independent verification of origin, from wood anatomy, to chemical and DNA methods (UNODC*,* 2016).

Maple – case study

One target of illegal logging in the Pacific Northwest of North America is bigleaf maple (*Acer macrophyllum* Pursch), a timber highly valued for its grain and translucent pattern, popular for use in string instruments such as guitars. The illegal removal of old growth maple trees from National Parks along the west coast of North America is a significant and increasing problem. Motivated by the discovery of a cluster of illegally felled bigleaf maple trees in Washington State, the US Forest Services worked with us at the University of Adelaide to develop a DNA profiling tool to identify the timber in supply chains back to felled stumps.

128 single-nucleotide-polymorphic (SNP) loci were designed to capture inter-individual variation in bigleaf maple (Jardine *et al.,* 2015). Using these markers, a DNA reference database was developed consisting of 394 individuals from 43 sites across the range of the bigleaf maple. The assay was subject to a strict forensic validation procedure based on the Scientific Working Group on DNA Analysis Methods validation guidelines for DNA analysis methods to ensure reliability for forensic purposes. A range of sample types (leaf, cambium, timber) were analyzed to represent the variety of case-samples that may be encountered, and mother-trees and seedlings compared to confirm Mendelian Inheritance of the markers.

The assay was demonstrated to work effectively at low DNA concentrations (<1 ng/µL) and to have high species specificity. Based on the reference data, the FST[17]-corrected probability of identity (P_{ID}) was 1.785×10^{-25}, meaning that the chance of the assay returning a match between samples that did not originate from the same tree (or clone) was vanishingly small. The resulting publication was the first to apply forensic validation criteria to an assay developed for individualization of timber (Dormontt *et al.,* 2020). Using the developed assay, several pieces of wood seized from a sawmill were compared with samples from illegally felled stumps in the Gifford Pinchot National Forest and a match detected. In a subsequent legal case in 2016, four defendants pleaded guilty to violations of the Lacey Act 2008, the first domestic prosecution under this legislation.

Teak – case study

In addition to being used to identify illegally logged timber, DNA fingerprinting and genetic profiling can support claims of legality in timber supply chains. A critical timber supply chain in this respect is teak. Teak timbers are sought after the world over and are prized for their durability and water resistance, making it ideal for the construction of super yachts, high-quality furniture, veneer, carvings and turnings. The high demand for naturally grown timber, due to its perceived structural superiority over that grown in plantations, has led to a

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[17] The fixation index (FST) is a measure of population differentiation due to genetic structure. It is frequently estimated from genetic polymorphism data, such as single-nucleotide polymorphisms (SNP) or microsatellites. It is one of the most commonly used statistics in population genetics.

black market in "conflict teak", where illegally harvested timbers are laundered into legitimate supply chains. These illegal activities are strongly associated with environmental and human rights violations.

In Myanmar, forestry systems have management and paper documentation practices introduced by the British and Germans to authenticate the source of teak, but the global movement of illegal timber has made further assurance necessary. One of the primary ways that illegal timber enters the market is through being mixed into legitimate supply chains, accompanied by fraudulent documents. Teak logs confiscated from illegal logging groups are resold into the market rather than being destroyed, so this has become controversial for customers in the European Union which requires illegal timber to be excluded from supply chains completely. Whilst mixing of legal and confiscated timber can be controlled in certified supply chains, the EU has raised doubts as to the reliability of paper verification.

We sought to determine the potential for using genetic profiling to support legal verification in teak supply chains in two ways: (i) through assignment of samples back to their population of origin; and, (ii) through individualization of matched samples from the same tree along supply chains. These tests were applied to the supply of teak from natural populations in Myanmar and plantation populations in Indonesia.

To achieve these aims we applied a set of 132 neutral SNP loci (Dunker *et al*., 2020) to over 1,000 tree samples taken from across the natural range of teak in Myanmar, Thailand and Lao PDR, and samples from naturalized populations and plantations in Indonesia Lao PDR and Papua New Guinea (Dormontt *et al.,* 2019). Population genetic structure across the natural range of teak in Myanmar produced self-assignments that were 69 percent accurate to the level of fine-scale collection site. Using assignment of the five most likely reference collection sites within a 100 km radius buffer, allowed the correct origin of samples to be identified in over 95 percent of cases. This approach was effectively utilized in blind samples (not collected from the same specific sites used in the reference data) to verify the claimed origin and support demonstration of due diligence. DNA fingerprinting methods were also used to match blind samples of sawn timber from the log yard to cut tree stumps, and accurately traced each piece of timber to its individual tree stump in the forest or plantation.

In Indonesia, DNA was used to trace teak timber along a large plantation supply chain from the Perhutani Forest Management Unit at Cepu, Central Java. The assignment of plantation material back to its population of origin was successful in verifying supply chain integrity.

Overall, across the Myanmar and Indonesia case studies, we found that individualization of matched samples provides the highest level of certainty with respect to verification of intact supply chains, although it is also the most logistically challenging. Therefore, application should be reserved for the most tightly controlled supply chains.

Summary

Our results show that genetic identification and profiling can be utilized for a broad range of timber species to identify cases of illegal logging and support verification of supply chains, both through individual matching of samples from the same tree, and assignment back to genetic populations of origin. These methods can be applied to both natural and plantation grown teak, but care must be taken with implementation and interpretation to consider the logistics of the supply chain in operation, the types of samples and the availability of reference data for the claimed origin of the timber.

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Use of innovative technologies in sustainable forest management in Bhutan

Dr. Lobzang Dorji, Director of the Department of Forest and Park Services, Ministry of Agriculture and Forests, Bhutan

Sustainable Forest Management in Bhutan

Forests cover about 2.7 million ha (71 percent of the total Bhutan area), of which 0.9 million ha (about 23 percent of the country area) are situated within national parks, wildlife sanctuaries and strict nature reserve (FRMD, 2016; LULC, 2016). Broadleaf forests cover 65 percent (almost 1.8 million ha) and conifer forests 35 percent (over 0.9 million ha) of the total forest area. Bhutan aims to protect, manage and conserve forest and biodiversity resources to ensure social, economic and environmental well-being and happiness of present and future generations. The principles of forest management in Bhutan have changed over time with the changing scenarios; from solely focused on timber extraction for economic purpose to conservation and now sustainable forest management through scientific management. Today, forest management in Bhutan is an amalgam of five main management regimes viz: (i) protected areas, including (ii) national parks and biological corridors; (iii) forest management units; (iv) community forests; and, (v) local forest management areas.

Use of innovative technologies in sustainable forest management.

Bhutan has taken positive steps to sustainably manage the national forest resources. The use of innovative technologies, in conjunction with sustainable management principles, could ensure the effective achievement of long-term sustainable management goals. This is especially relevant with the changing scenarios in terms of local governance, people's participation, increasing threats of climate change and international commitments and agreements to which Bhutan is a member. Considering the importance of such innovative technologies, there has been a major emphasize and inclusion of some of these technologies into the current sustainable forest management practices in the country. Broadly, the application of innovative technologies can be categorized into the following areas of sustainable forest management in Bhutan.

1. Forest information and database

Information systems are one area of technology that has a big impact on forest management. Sustainable forest management relies on timely and accurate information for informed decision making and for national forest monitoring purposes. Among the databases currently employed in Bhutan are:

- The Forest Information Reporting and Management System (FIRMS) is an online database system designed to streamline the information management system of the Department of Forests and Parks Services (hereafter referred to as "the Department") by capturing all information and data pertaining to the forestry resources and services. This database aims at facilitating planning, monitoring and evaluation of programs and sub-programs within the Department.
- The Spatial Monitoring and Reporting Tool (SMART) is another interactive interface where decisions of the management administered during SMART patrol planning can be physically implemented by the SMART patrol team at various levels.
- The Spatial Decision Support System (SDSS) is yet another interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision-making while solving a semi-structured or unstructured spatial decision problem which are characterized by many actors, many possibilities, and high uncertainty. This system integrates database management systems with analytical models, using expert knowledge, where analyses and results can be viewed through graphical display.

All these databases contribute to the central database maintained at the Departmental headquarter which is also the central data repository.

2. Forest and wildlife resources assessment

The National Forest Inventory (NFI) and the National Wildlife Survey (NWS) involve collecting data and information on forests and wildlife resources for compilation, assessment and analysis to enable appropriate policy and management decisions. The Department has already carried out a first round of national forest inventory and wildlife survey which provided the quantitative baseline required for sound forest management in the country. The NFI was carried out by drawing national survey grids (2,424 sampling plots) aided by the use of innovative technologies like Open Foris collect tool, Trimble GPS with in-built survey designs using mobile apps for data collection, and subsequent data analysis using the CLAC (R-statistical) Package. The NWS involved the use of radio telemetry and camera traps laid at predesigned grids. Generally, the NFI and the NWS were carried out by field crews and enumerators with minimal use of GIS and remote-sensing technologies. However, immense opportunities are foreseen in employing remote-sensing and GIS technologies in future assessments and surveys.

3. Remote-sensing and GIS

Remote-sensing (RS) is the science of acquiring information about the Earth's surface without actually being in contact with it. Most frequently used RS data include optical satellite, lidar and radar imageries. Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. RS and GIS are complementary technologies that, when combined, enable improved monitoring, mapping, conservation and management of forest and wildlife resources. The Department has already used RS and GIS technologies to some extent in carrying out some important activities, like land use and land classification exercise or forest resources potential assessments. However, many areas of opportunities for more extensive use of RS and GIS technologies would deserve further exploration, such as: NFIs, NWSs, assessments of pest and diseases outbreaks, studies of forest structures and species shift dynamics. Additionally, use of un-manned aerial vehicles (drones) offer a relatively risk-free and low-cost technology to systematically observe natural phenomena at high spatial-temporal resolution.

4. Timber extraction and processing

Timber extraction in Bhutan strictly abides by the low impact logging principles so as to minimize the adverse impact to the surrounding environment. Currently we use low impact logging technologies like cable cranes with craning range of 500-1,500 meters for timber extraction. Use of other logging machineries like Telly loggers, Swing yarders, tractor-mounted mini-cable cranes, Penz log loader and trucks for transportation are also used for timber extraction activities.

With regards to timber processing, we have various types of sawmills operating in Bhutan, such as Indian sawmill, Wood-mizer, Timberking, Norwood, Mebor, Lucas and Solee. Natural Resources Development Corporation Limited (NRDCL), the only authorized logging firm, has also ventured in the production of glue laminated constructional timbers. Some of the wood processing units in the country are also already using the latest wood-processing technologies like Computer Numerical Control routers[18], High Frequency vacuum drying machines, wood-paneling machines, etc.

However, there is still a need of more efficient processing technologies delinking end-use products from raw wood characteristics and, especially, facilitating the use of less preferred broadleaved timber species which are currently grossly under-utilized. Further, there is also a need of technologies allowing more efficient processing, less waste and more recycling of wood as there is still high timber wastage during processing. We are also in need of better technologies for production of value-added products for export and import substitution.

Opportunities and Challenges

With a strong natural resource-base of 71 percent of the country area covered by forests, strong policy and actions for sustainable forest management, emerging local information and communication technology (ICT) industries and strong political support, Bhutan has ample opportunities to further enhance sustainable forest management through adoption and inclusion of innovative technologies into sustainable forest management practices. However, there are also various challenges, like rugged and fragile mountain ecosystem, inaccessible geographical terrain, under-developed wood-based industries, small local market-base and competitive

[18] A computer numerical control (CNC) router is a computer-controlled cutting machine.

international markets, inadequate capacity and skills of existing human resources, and limited financial resources, that hamper successful adoption and implementation of these innovative technologies in Bhutan.

References and further reading

FRMD. 2016. *National Forestry Inventory.* Ministry of Agriculture and Forests, DoFPS. Thimphu.

LULC. 2016. *Land Use Land Cover map of Bhutan.* National Land Commission (NLC), National Land Commission Secretariat (NLCS). Thimpu.

5.2 Breakout groups: guiding question and expected outcomes, by James Roshetko (ICRAF/FTA)

During session 3, participants were distributed in two breakout groups to address the following issues:

Group A focused on:

- the environmental negative and positive impacts of innovations, e.g.: biodiversity protection, prevention of deforestation, fragmentation and forest degradation, climate change mitigation and adaptation, pollutions, access to natural resources; and,
- the economic negative and positive impacts of innovations, e.g.: reduced costs, improved productivity, reduced ecological footprint, reduced waste and improved resource efficiency, income, access to credits and markets.

Group B focused on:

- the negative and positive impacts of innovations in terms of employment and working conditions;
- the other social and cultural impacts of innovations, e.g.: food security, health, education and access to information, impacts on vulnerable groups (e.g., women, the poor, minorities, etc.),and on cultural heritage.

<u>Guiding question:</u>

What are the main <u>impacts</u> of innovative technologies, positive and negative, current and potential, <u>and for whom</u>?

<u>Expected outcome:</u>

Based on their experience, participants were expected to select, among the 3-5 promising technologies identified in Day 1, a few case studies (one technology in one context) and to identify, for each case, the main impact(s) of the innovative technology in the given context.

In each breakout group a chairperson, was chosen to moderate the discussion and report to Plenary. Each chair was assisted by a rapporteur.

5.3 Breakout groups: reports to Plenary

This section summarizes the main points of the discussions held in each breakout group during Session 3. More detailed notes of these discussions, as shared by the rapporteurs, can be found in Appendix 2.

<u>Breakout Group A</u>

Chair: Lok Mani Sapkota,
Rapporteur Alexandre Meybeck.

In tropical countries, most of the forestry, with mainly an economic focus, results in a simplification of ecosystems. Innovative technologies can support more multifunctional and diverse forests, including plantations, through:

- Innovative methods to assess forests contributions (biodiversity, carbon, water). Such methods could facilitate links to innovative financial mechanisms (PES, carbon credits), reducing transaction costs and facilitating adoption by smallholders.
- Providing more diverse species to smallholders, including dual purpose species[19].
- Identifying more diverse species for plantations.

[19] Species that produce more than one type of products or benefits.

Innovative technologies in production processes can:

- Increase resource efficiency (reduce waste);
- Facilitate the use of more diverse species, including low-value species;
- Increase potential use and value-addition for smaller trees, from shorter rotation, shortening return of investment, increasing opportunities for smallholders and also for investment from innovative finance;
- Facilitate the use of wood to substitute fossil fuel-based products.

A range of techniques can be used to control illegal logging as long as there is a legal framework and an implementation framework. Low-cost and easy-to-implement methods are needed, for instance for DNA identification methods.

Harvest-related innovations can make it possible to access areas previously untouched, opening a new production potential but with consequences on the biodiversity of these previously pristine areas.

There are trade-offs between the number of people employed and productivity. The problem can be quite severe in wood processing. Number of people employed has been reduced by automation. Innovations adapted to small-scale producers could support more employment than if only targeting large-scale facilities. More sophisticated mills should help improve safety of people.

Breakout Group B

Chair: James Roshetko,
Rapporteur: Nathanaël Pingault.

Our breakout group discussed the positive and negative impacts of innovative technologies, reviewing the technologies clusters identified on Day 1.

Digital technologies

Drones and remote-sensing systems can collect real time information, even in remote areas or in crisis or conflict areas, with limited operational costs and with no or limited collateral environmental damages. UAV technologies generate new skilled jobs for drone pilots, field observers and technicians. However, barriers that limit the potential uses of this technology include lack of or inappropriate legal and regulatory framework (licensing permits, privacy, flight over private lands), as well as limited access to the information generated by privately managed UAV and digital technologies.

Digital technologies (e.g., mobile apps) can empower smallholders and local actors, facilitating capacity building, data collection and information sharing, and allowing local communities to contribute actively to forest monitoring, management and governance. Mobile apps, especially when based on open-source datasets and software, can be easily accessible to smallholders and local communities, provided they receive the appropriate training to use them.

Biological technologies:

DNA tracking is useful for timber and can also be applied to non-timber products. It is being used for instance to improve bushmeat traceability and facilitate veterinary controls.

Germplasm and genetic material have huge opportunity to empower communities, securing sustainable timber supplies, facilitating restoration provided that they are available and affordable.

Indigenous and/or under-utilized species represent a huge untapped potential. Domestication and cultivation of under-utilized species can be a powerful tool to meet a growing and evolving demand for forest products and limit the pressure on natural resources. Local provenance and local species should be promoted for better resilience and sociocultural impact. Harnessing this potential requires huge research and development efforts and investments. Participants noted the risk that, when commercialized, a species previously under-utilized might become over-exploited.

Innovative finance and social innovations

Payment for ecosystem services and carbon credits can contribute to both sustainable forest management and sustainable development for local communities. However, as prices increase, these schemes attract big companies, institutional investors and local elites who try to reap all the benefits. This dynamic of "capture by outsiders and local elites" might lead to the marginalization or even exclusion of local communities which risk to lose their tenure and access rights to forests and natural resources.

In theory, blended finance is a powerful tool to enhance synergies between different funding sources and mobilize additional resources. Responsible investment and green funding also hold potential to combine commercial and sustainable objectives. In practice, viable examples of such mechanisms working at scale on the ground seem limited.

Crowdfunding seems a promising innovation, increasing participation and mobilizing actors beyond the traditional institutional investors. However, experience shows that it may also facilitate fraud: many people launch crowdfunding projects, misrepresenting or obscuring the intended purpose, then disappearing after collecting the money.

6 Session 4. Barriers to and enabling conditions for technology uptake and upscale

6.1 Breakout groups: guiding question and expected outcomes, by James Roshetko (ICRAF/FTA)

James Roshetko (ICRAF/FTA) presented the organization and expected outcomes of breakout group discussions. During session 4, participants were distributed in two breakout groups, each group focusing on a subset of transformations[20]:

Group A discussed:

- the transformations needed to ensure that innovative technologies effectively contribute to sustainable development (in its three dimensions: social, economic, and environmental); and,
- the transformations needed to support technology transfer and dissemination;

Group B discussed:

- the transformations needed to accompany the populations at risk of being marginalized by technological advances; and,
- the transformations needed to better adapt existing policies and legal frameworks to fast evolving technologies.

Guiding question:

What are the main technical, socio-economic and institutional barriers that prevent the uptake and upscaling of innovative technologies in the forest sector and what transformations are needed to overcome these barriers?

Expected outcome:

Based on their experience and building upon the discussions (and case studies identified) in the previous breakout group session, participants were expected to identify 3-5 priority transformations needed to support innovation.

[20] In terms of: regional cooperation, additional investments, infrastructure development, institutional changes, research and development, education and capacity building.

In each breakout group a chairperson, was chosen to moderate the discussion and report to Plenary. Each chair was assisted by a rapporteur.

6.2 Breakout groups: reports to Plenary

This section summarizes the main points of the discussions held in each breakout group during Session 4. More detailed notes of these discussions, as shared by the rapporteurs, can be found in Appendix 2.

<u>Breakout Group A</u>

Chair: Lok Mani Sapkota,
Rapporteur Alexandre Meybeck.

Forestry is still considered a conservative sector and it has an aging workforce both characteristics that do not play in favor of industry transformation. Innovation has been more in processing and on the large scale: how this innovation culture could be enlarged to smallholders and small enterprises?

In many countries there is not a clear strategy on a long-term forestry research perspective. It would be good to have more data and visibility on future demand and potential supply from an independent source as a background to the need for innovation.

There are policy-related barriers to smallholders getting involved in plantations because a lot of policies have been designed for either natural forests or large-scale plantations.

To facilitate adoption of innovative technologies, we need to look at three things:

- the technology per se, its characteristics and how it can be adapted to the context;
- the larger economic context;
- the specific context (farm, enterprise) where the technology is going to be used by individual adopters. Many of these technologies are not scale-neutral.

Demonstration effect is key to dissemination.

An important point is knowledge about what innovations are available and adapting them to context, customization. To do this, we need people that know both the innovation and the context. We need a lot of support to ensure success. We need to understand the market.

It is important to distinguish two types of innovations and users. For control and monitoring, governments and big actors need a network of research, service provision, technology transfer, learning, requiring institutional support. To improve harvesting, transformation, products, innovations need to be turned over to the private sector and the market. The question is what technology needs to be developed where: is it more government-led or market-led? It then requires mechanisms for technology transfer and dissemination: places for exchanges like this workshop, education opportunities, match making with industry partners.

Intellectual property (IP) can be a significant barrier to the development of new technologies, especially when public money is involved (risk that an innovation stays in the shelf…). In Australia, there has been a significant evolution in Universities that were holding back to their IPs and are now handing them to the private sector.

Forestry is often isolated, does not collaborate enough with other sectors. We need more collaboration, including with the agriculture and the water sectors; technologies cut across sectors.

We need also to look broadly to technologies being developed in other sectors and that can be transferred to forestry like machine learning.

A lot of innovations have been driven by profitability. Corporate social responsibility (CSR) can play a role for issues related to water use efficiency, soil and land degradation. This could probably drive the next wave of innovations for a sustainability agenda.

Breakout Group B

Chair: Shahrukh Kamran,
Rapporteur: Nathanaël Pingault.

Our breakout group discussed the technical, socio-economic and institutional barriers that prevent innovative technologies adoption and identified priority areas of progress/work to overcome these barriers:

Address information asymmetries, facilitate training and capacity building

Digital technologies can play a critical role to facilitate information sharing and support negotiations.

In Malaysia, where rubber small producers are not correctly informed about the market price, the government played a critical role to ensure a level playing field and facilitate a win-win dialogue between small producers and the rubber industry.

More generally, participants highlighted the importance of education, communication, capacity building and extension services to facilitate technology adoption, especially by smallholders and local communities in developing countries.

Encourage multi-stakeholder partnerships and collaboration

In Malaysia, an innovative financing pack was introduced for rubber plantation, where the government provided the funding (USD 250,000 for 2007-2021) in the form of low interest loans. Loans can be paid back only after timber harvesting. The government recently agreed to reinvest the loans repaid in new plantations, thus transforming the initial one-off budget in a permanent revolving fund. Such innovative finance mechanisms can act as a catalyzer, overcoming the lack of enthusiasm of private banks for investments in the forest sector, perceived as very long-term investments with high risks and low returns.

Enhance transparency and participation

Innovative technologies can support citizen science and facilitate the involvement of local communities in forestry related monitoring, management and governance.

In Cambodia, a mobile app was produced enabling local communities to participate in forest patrolling. However, the current national legal framework (requiring permits to patrol) does not allow an optimal use of this technology.

Legal frameworks might need to be adapted so that the data and knowledge generated by these new technologies can be legally used for law enforcement. Information generated by new technologies might also become very sensible when it contradicts official data reported through governmental processes.

Adapt innovations to the local context

Traditional habits can prevent the adoption of a technology, despite its benefits for human health and the environment. For instance, in Vietnam, people refused to use modern stoves because, traditionally, the fireplace is central in the community social life. Before adopting modern stoves, people need to be convinced that the place to cook and the place for social interactions do not need to be the same.

6.3 Keynote address: Enabling conditions for innovation, by Ravi Prabhu (ICRAF/FTA)

At the end of Day 2, Ravi Prabhu (ICRAF/FTA), Director Innovation, Investment and Impact of CIFOR-ICRAF, gave an inspiring talk to draw main lessons from the first two days and provide useful insights to prepare the last day's discussion on recommendations.

These last two days, I heard many inspiring thoughts. We had fascinating talks, especially in my group today. I think that everybody is recognizing that, once again after Rio in 1992, we are at a crossroad. There are some signs pointing to the forest sector as a focus for investment, a focus of attention, and as the possible source of several nature-based solutions.

In that context, all your presentations and interventions about innovative technologies, whether geospatial technologies for monitoring and data collection or innovative ways to treat timber, were truly inspiring.

I think that we, in the forestry sector, really need to grab the opportunity offered by innovative technologies that we lost in Rio in 1992.

There are multiple challenges to be addressed (climate change, land degradation, water, the ability to absorb large numbers of people into decent jobs). All of these challenges can also be seen as opportunities for the forest sector. This will require to think beyond what we have been considering as the core forestry technology so far. I will come back to that.

One of the big challenges in the forestry sector is that the price of timber and forest products is still too low because not all the production is sustainably sourced. It is fantastic to see what you can do with DNA fingerprinting but, if nobody cares this technology essentially does not get used. So we need regulations to force people to trade only sustainable timber. The experience of FLEGT is mixed, at best, in trying to get legal timber onto the market.

Research pays. I think that, as a group of people involved in either developing or using the innovations, we need to make a much stronger case for investment in research than we have been able to make in the last few years. Investments in research are dropping in many countries, particularly in developing countries.

Research is not only about product development but has to be considered as part of a larger innovation system that will deliver the kind of sustainable results that everybody wants. To obtain this kind of results on large land-use systems like forestry or agroforestry we need to think about layering and piggybacking a number of products and ecosystem services.

For me, there is an opportunity for technology development and social innovation not fully grasped so far. There are areas where we can see some of this happening. Technologies tend to look like silver-bullets, but there are very few guns that can actually fire silver-bullets effectively. So, we need to bundle technologies, to put them in the context of an innovation system. We have to see how we can upgrade value chains so that technologies pay-off.

I think that those are the challenges that groups like this one can and should take on. During these two days, I heard a lot of interesting thoughts on collaboration and partnerships. This seminar is a great example of the power of exchanging ideas. This is a role that FAO is actually set-up to endorse and I would really encourage FAO to invest much more. I also hear a number of people saying let's get beyond Zoom but, you know, I'm really thankful that we have Zoom under these conditions of pandemic, although we do also need face-to-face meetings.

Regarding the whole issue of social innovation: if we continue to focus on timber production, we will move towards robotization and automation. I think we have to think beyond that. We need to think about fiber, food, ecosystem services and, above all, we have to start looking at decent jobs. Jobs generating decent living conditions because other industrial sectors are going to get more automated. Agriculture and forest will have to absorb a lot of people whose jobs are disappearing in other sectors.

We can do this by focusing on value-addition that human can provide and ensure that the jobs pay-off.

I think there are some new frontiers: nutrition, fiber, energy, chemicals. These are areas we have only started scratching the surface regarding the possible contributions of forests and trees. In the shelterwood systems of Nigeria, a hundred years ago, they cut out all the fast-growing species because their entire system was based on hardwoods. After 30 or 40 years, they realized that, thanks to technological advances, there was a huge market for these fast-growing species. So, let's be careful, over the horizon, things can look very different when compared to what current technologies can deliver.

I have heard a lot of conversations around intellectual property and intellectual property rights. How do we protect intellectual property and turn it into something that we can actually reinvest in the kind of research we need for sustainable systems? Forestry will continue to be a large-scale business. This brings up all the thorny issues of governance, tenure, rights, and interactions with local communities. In 1978[21], the forestry community finally woke up to that: forests are about people.

I want to conclude here. Thanks to the people who have for two days certainly enriched my life. I spend far too much time on administration, far too little time on actual science. This workshop has been great. I really enjoyed your conversations and your presentations. I think we are well positioned, it we identify the new frontiers within the current climate and context, to start addressing the issues related to the management of forest as a whole: the issues of fires, carbon, water, jobs, biodiversity and land degradation, and then of course green value chains. Thank you.

7 Session 5. Recommendations

James Roshetko (ICRAF/FTA) introduced Day 3 discussions aiming at elaborating possible recommendations for decision-makers on how to best enhance the adoption of innovative technologies in the forest sector in the Asia-Pacific region.

7.1 Breakout groups: organization and expected outcomes, by James Roshetko (ICRAF/FTA)

Key points and main insights emerging from the discussions during the first two days, were compiled by the CIFOR/ICRAF organization team and led to a set of draft recommendations for decision-makers that shall be considered as inputs to be reviewed by the breakout groups. These draft recommendations were directed to the four following categories of actors: (i) public actors; (ii) private actors; (iii) civil society and local communities; (iv) research and academic institutions.

Participants were split in two breakout groups to work collectively on these draft recommendations, Group A focusing on the first two categories of actors, Group B on the last two.

Each group was expected to formulate 3 to 5 recommendations for the application of innovative technologies in the forest sector, considering, as appropriate, different scales (local, national, regional and international).

For each group a chairperson was identified ahead of the session to moderate the discussion and report to Plenary. Each chair was assisted by two rapporteurs (as shown in the table below): the first

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[21] When the Eighth World Forestry Congress highlighted in the Jakarta Declaration the vital contribution of forestry and forest resources to rural development. See: http://www.fao.org/3/x5565E/x5565e06.htm

one was charged to take notes of the discussion, while the second one had to share and modify in real-time the set of recommendations discussed.

Breakout groups	Session 5
Group A	Chair: CTS Nair Rapporteurs: Alexandre Meybeck; Li Yanxia
Group B	Chair: Wu Junqi Rapporteur: Nathanael Pingault; Nguyen Tan

7.2 Breakout groups: draft recommendations

This section reproduces the draft recommendations, as revised by each breakout group. These draft recommendations will need further refinements, in particular to address the comments received during the subsequent Plenary session (see next section). More detailed notes of the discussions held in each breakout groups, as shared by the rapporteurs, can be found in Appendix 2.

In breakout group B, participants have decided to highlight the main keywords in each recommendation.

Recommendations to international actors (Group A)

1. Create awareness on the potential of innovative technologies for the implementation of the sustainable development goals (SDGs) and encourage for a global commitment of all actors.
2. Encourage, facilitate and support governments to create appropriate legal frameworks and to use innovative technologies to ensure transparency and law implementation.
3. Identify and prioritize areas of actions and investment, in an evidence-based way, as well as data needs.
4. Encourage and promote networking between governments and between actors, at national and local levels, including (liaising with the private sector and research) demonstrating available technologies on a wide scale (to be implemented at national and local levels in collaboration with other actors).
5. Address intellectual property rights (IPR) related issues, striking a balance between incentive to innovate and large adoption (to be implemented by governments in collaboration with the private sector).

Recommendations directed to governments (Group A)

1. Develop the legal framework where information from digital technologies can be used for tracking, monitoring, certification, and law enforcement purposes.
2. Develop and adapt improved harvesting, transportation and processing technologies for use by smallholder and small-scale operators.
3. Address the financial and institutional barriers that impede the adoption of innovative technologies (primarily digital and process/product innovations).
4. Create enabling legal framework for innovative ideas and for development and adoption of innovative technologies, including by addressing legal barriers faced by smallholders and other technology users.
5. Develop and implement capacity building strategies for development, adoption and adaptation of innovative technologies.
6. Create and enforce necessary safeguard measures to ensure that innovative technologies contribute to the SDGs and do not harm ecosystems and marginalized groups.

7. Create enabling conditions for multi-stakeholder participation in development, adoption, and adaptation of innovative technologies.
8. Facilitate data pooling and data sharing and provide access to necessary data.
9. Increase funding to science and technology in developing countries.
10. Create a multi-stakeholder advisory group, involving researchers and users to assess the potential of available technologies and prioritize actions to be undertaken in order to facilitate innovation development and adoption.
11. Improve national R&D systems, linking to other sectors, looking at different value chains in landscapes, looking at diverse products. Connecting to private research. Work towards a "blended" system with common orientations to pursue global objectives.
12. Facilitate application and dissemination of findings from public research institutes including through extension and the private sector.

Recommendations to local actors (Group A)

Many of the recommendations above will need to be implemented at local level (networking, demonstrating…).

Recommendations directed to private actors (Group A)

1. Disseminate supplies of improved quality germplasm to farmers, communities, and development agencies to enhance livelihoods, facilitate land restoration, and secure sustainable supply of forest and tree commodities.
2. Deploy technologies to allow smallholders to play their role in the markets.
3. Create an innovation fund to provide seed capital for innovations in the forestry sector.
4. Provide farmers and local communities with training in business/enterprise skills and post-harvest processing that yield high-value commodities that meet market-quality specifications.
5. As part of their corporate social responsibility (CSR) policies, support the development and use of innovations that contribute to the realization of the SDGs.
6. Respect local culture and the welfare of different ethnic groups in developing or adopting new/ innovative technologies.
7. Comply with safeguard measures to ensure that the ecosystem and marginalized groups are not harmed by innovative technologies.
8. Contribute to data pooling and data sharing.
9. Provide necessary capacity building for relevant actors.

Recommendations directed to civil society [and local communities] (Group B)

1. Develop mutually beneficial shared-value business strategies with the private sector that facilitate the efficient supply of high-value commodities that meet market specifications and bring local benefits.
2. Contribute, in collaboration with governments and research organizations, to implement effective extension systems and community of practices regarding the use of innovative technologies (digital, process and product, and biological innovations).
3. [For local communities] Openly share their traditions and culture and collaborate with concerned actors in adapting innovative technologies to their contexts.

4. Demonstrate the social, economic and environmental benefits of innovative technologies to different groups, particularly the marginalized ones.
5. Consider / Identify the positive and negative impacts of innovative technologies and advocate for (more) appropriate social and environmental safeguards.
6. Facilitate representation of and access to information by marginalized groups in necessary dialogues and fora with government and private sectors.
7. Establish a youth-centered constituency and increase the engagement from the youth sector that will serve as a community for knowledge, citizen science, and adoption of innovative technologies for the forestry sector.

Recommendations directed to research and academic institutions (Group B)

1. Identify priority areas for research, including tree domestication programs for the most promising indigenous and/or under-utilized species.
2. Engage in the development of social and institutional innovations to bring their [transdisciplinary/participative?] research and technology results through to the adoption and utilization stages [Community of practices].
3. Develop internships and fellowships, including in research projects, people with experience in the field [Capacity building].
4. Develop a clear strategy, in collaboration with private sector, for long-term research integrating the needs of smallholders and small-scale enterprises as well as long-term perspectives on the evolution of market demand.
5. Take into account relevant local culture and knowledge, as well as the welfare of different ethnic groups as well as safeguard requirements in developing new/ innovative technologies [Indigenous knowledge].
6. Support national and local government in developing and implementing roadmap to adopt new/ innovative technologies.

7.3 Plenary discussion on recommendations

Thomas Hofer (FAO) praised the work done on recommendations in the breakout groups but called for further refinement of these recommendations during the next steps of the roadmap, considering the main points raised during Plenary discussion.

The roadmap could include recommendations directed specifically to the Asia-Pacific Forest Commission with the view to facilitate access to and adoption of innovative technologies across the region.

Draft recommendations were directed separately to each stakeholder groups and more than 5 draft recommendations were suggested for each stakeholder groups. Further work is needed to: avoid overlaps; enhance collaboration across stakeholder groups that need to act together in a synergistic way; and, articulate actions needed at different scales, from local, national to regional and global. Most recommendations cannot be isolated from one another: they have to be articulated and implemented in combination. Organizing and presenting the recommendations by topic or by situation (i.e., by sub-region, country, landscape or specific context), rather than by stakeholder group could help address these concerns.

General challenges recurrently emerge in such discussions, such as: capacity building, network building, or involvement of local communities. However, generic recommendations will not suffice to address these issues. To be operational and useful for policy- and decision-makers on the ground, recommendations need to be more specific and adapted to the local context: they need to cover the "how", not only the "why".

Given the diversity of situations encountered in the region, it seems impossible to craft a short set of actionable recommendations that would at the same time be adapted to all these situations and avoid to give the impression of a shopping-list. More generic overarching recommendations might be needed to offer a general framework and open the way for sustainable forest management in the region. However, the roadmap could have different levels of reading: each recommendation could be illustrated by a specific successful case-study that could inspire other actors, showing them practical and solution-oriented pathways that could be adapted to and implemented in their own context.

Different countries and sub-regions have different experiences on specific topics. For instance, Nepal has a huge experience on community forestry and on social aspects of technology and forestry while Vietnam has had strong experience and emphasis on trade issues. Case-studies illustrating each recommendation could also facilitate experience-sharing across countries and regions.

8 Wrap-up and next steps

8.1 Next steps (FTA)

Vincent Gitz (CIFOR/FTA) and James Roshetko (ICRAF/FTA) reminded the participants that this interesting and very rich discussion on possible recommendations marked the end of this workshop but is only a starting point in the overall process of elaboration of the roadmap. The recommendations will be further refined based on the inputs received during this workshop and through the open consultation and interviews organized in parallel. All participants will be kept informed of and associated to the next steps of development of the roadmap.

An important milestone in this process will be the World Forestry Congress, to be held either online or physically in Seoul, Republic of Korea, next year (date to be confirmed[22]). This event will provide a wonderful opportunity: to further discuss the main findings and key recommendations of the roadmap; and, to pay a specific attention to the inputs and perspectives that young people can bring in this debate on innovation.

8.2 Closing remarks, by Thomas Hofer (FAO)

This is the end of a very successful 3-day 'online' workshop.

Looking back to these three days

Over Day 1 and 2, we identified key innovative technologies, which hold the greatest potential for the next 10 years. These technologies were structured into 4 clusters: (i) digital technologies; (ii) biological technologies; (iii) technical innovations (on processes and products); and, (iv) innovative finance and social innovation. We discussed their functions/application, their positive and negative impacts, as well as barriers and enabling conditions for their uptake and upscaling.

Today, we pulled together all that input into draft recommendations for key stakeholder groups, namely: (i) public actors; (ii) private actors; (iii) civil society and local communities; and, (iv) research and academic institutions. The discussion we just had now on recommendations will be very useful for the next steps of the process. These recommendations represent an ultimate and important output from this workshop.

[22] After careful consideration of the continued and unprecedented challenges of the COVID-19 pandemic, it has been decided to postpone the XV World Forestry Congress, which was scheduled to be held from 24 to 28 May 2021 in Seoul. As soon as the new information becomes available, the practical details of the postponement, including the new dates, programme preparations and logistics, will be announced here: https://www.wfc2021korea.org/

Very interesting case-studies and examples were presented during this workshop. They illustrate the very diverse experiences of different countries in the region and highlight the huge potential existing for experience sharing across the region. We also heard about different realities and needs across the region.

Also, during the workshop, we had 11 excellent presentations from colleagues focusing on key innovative technologies and major issues regarding their current and future application. In this context, I would like to particularly appreciate the inspiring talk from Ravi Prabhu at the closing of the 2nd day.

About 50 individual experts and youth were actively engaged during this 3-day workshop, which is a manageable size to ensure rich and productive discussion. We can all feel content and proud in having contributed to this critical process.

Reminding the big picture

Last year was launched the third Asia-Pacific Forest Sector Outlook Study. These three days, we moved a very important step forward in the development of our roadmap as a follow up of the Outlook study: we made huge progress since last year.

This workshop is a puzzle piece, an important step in the continuing process of development of the roadmap. In the next few weeks, you will receive from us further information regarding the outputs of this workshop and the next steps in the development of the innovative technology roadmap study. We may follow-up with you bilaterally regarding case-studies or clarification of inputs to and outputs from the workshop. So, while the workshop ends today, the process and your involvement will continue!

I remind you of the youth call for abstracts and of the individual consultations ongoing in parallel. Many more experts are involved than have actually been able to participate to the workshop.

FAO, CIFOR, ICRAF, and FTA thanks you all for your time, sincerity, and contributions to make the workshop a success

Thanks to the colleagues from FTA (CIFOR and ICRAF) and FAO that organized this workshop: James, Vincent, Nathanaël, Alexandre, Rao). I would like also to thank the people behind the scene: particular thanks to Fabio Ricci and his support team who pulled together this Zoom online workshop with participants from across the world.

Good-bye for now and stay tuned!

Appendix 1. Agenda of the workshop

This appendix reproduces the detailed agenda of the workshop, as circulated to all participants ahead of the workshop.

This innovative forest technologies workshop will consist of three online sessions, to be held on November 2020, 30th and December 1st, from 13h00 to 17h00, and on December 3rd from 13h00 to 15h00, Bangkok time (UTC+7). Afternoon sessions, Bangkok time, will facilitate the involvement of participants from the different countries and time zones of the region.

This forward-looking workshop will invite regional experts, working on various innovative technologies and coming from different countries and realities, to share their experience and exchange their views, highlighting the extreme diversity of situations existing in the region. This workshop will examine the technical, social, economic and institutional bottlenecks preventing technology access, uptake and upscaling. For each category of technologies, it will discuss their positive and negative impacts, especially in terms of livelihoods and employment for local communities. Participants will be invited to share their own experience of the use of innovative technologies in the forest sector. Based on these discussions, participants will also be invited to formulate key recommendations for decision-makers, on the use of innovative forest technologies for sustainable forestry and sustainable forest management.

To stimulate the discussions, a number of experts will be invited to make short presentations (6 min) on specific case studies (i.e., one innovative technology applied in one context) or specific issues of interest for the workshop.

To facilitate more inclusiveness and active participation most of the discussions will be realized in breakout groups (10-12 persons each, including one Chair and one rapporteur), with guiding questions and expected outputs. For each breakout group session, each group is expected to provide a 1-2 pages report addressing the guiding question.

Day 1: Monday 30th November 2020

Introduction

13.00: Opening and welcome, by Thomas HOFER (FAO)

13.10: Introduction, by Vincent GITZ (CIFOR/FTA)

Presentation of the roadmap: work done, expected outcomes of the workshop

Session 1: Typology of innovative technologies

13.20: Introduction, by James ROSHETKO (ICRAF/FTA)

Presentation of the four clusters of innovative technologies: (i) digital technologies, (ii) biological technologies; (iii) technical innovations (processes and products); (iv) innovative finance and social innovations.

13.30: Expert presentations on specific technologies or uses moderated by Rao MATTA (FAO)

- Dr. Junqi Wu, China, International Bamboo and Rattan Organization (INBAR), Harmonized System code for monitoring international trade of bamboo and rattan.
- Dr. Tony Page, Australia, University of the Sunshine Coast, on the selection, breeding and dissemination of improved teak germplasm in Papua New Guinea.
- Dr. Jalaluddin Harun, Malaysia, former Director General of Malaysian Timber Industry Board (MTIB) and Fellow of the Academy of Sciences Malaysia (ASM), overview of rubber wood related technology impacts (economic, social, environmental).

- Dr. Bas Louman, Tropenbos, on innovative finance for forestry and sustainable investment.

13.55: Introduction to the breakout groups, by James ROSHETKO (ICRAF/FTA)

Organization of breakout group discussions and expected outcomes.

14.05: Breakout groups discussions

Participants split in four breakout groups, by technology cluster.
Each breakout group will focus on one technology cluster, as follows:

- Group 1 on digital technologies;
- Group 2 on biological technologies;
- Group 3 on technical innovations (processes and products);
- Group 4 on innovative finance and social innovations.

Guiding question:

- From your experience, what are the 3-5 most promising innovative technologies for sustainable forestry and sustainable forest management in the next ten years in the Asia-Pacific region?

Expected outcome:

Based on the experience of participants, each group is expected to identify the 3-5 most promising technologies and to highlight their potential contribution to sustainable forestry and sustainable forest management in the region in the next ten years.

15.05: Break

Session 2: What technologies for what functions (application)?

15.20: Expert presentations on specific technologies or uses moderated by Rao MATTA (FAO)

- Dr Vu Tan Phuong, Deputy Director in Charge of international cooperation, Vietnam Academy of Forest Sciences, on the use of innovative technologies for forest management and on the integration of innovative technologies in forest policies.
- Dr. Wu Shengfu, China, China National Forest Products Industry, on the impacts of innovative technologies in the wood panel industry.
- Dr. Oliver Coroza, the Philippines, Center for Conservation Innovations Ph (NGO) – geospatial solutions to conservation

15.40: Introduction to the breakout groups, by James ROSHETKO (ICRAF/FTA)

Presentation of the matrix technologies x functions (application).
Organization of breakout group discussions and expected outcomes.

15.50: Breakout groups discussions

Participants split in four breakout groups, each group focusing on one technology cluster (same group than for the previous session).

Guiding question:

- What can be the contributions[23] of innovative technologies to sustainable development (covering its social, economic, and environment dimensions) in different contexts? How

[23] For instance: reduced costs and improved productivity; reduced ecological footprint; reduced waste; low-carbon technologies; job creation; improved governance; strengthened participation in decision making; strengthened

does the application of innovative technologies affect different functions[24] throughout the value chain and to which extent this contributes to sustainable development in the forest sector?

Expected outcome:

Based on their experience, participants are expected to identify the main contribution(s) of different technologies to sustainable development in different contexts. Participants are invited to focus on the 3-5 most promising technologies identified in Session 1, with illustrative examples featuring other technologies possible. The objective is to identify parameters/criteria that influence positive outcomes.

16.50: Wrap-up and next steps, by Vincent GITZ (CIFOR/FTA)

17.00: End of Day 1

Day 2: Tuesday 1st December 2020

Introduction

13.00: Opening and introduction of Day 2, by Vincent GITZ (CIFOR/FTA)

13.05: Report of Day 1 breakout groups to plenary moderated by Thomas Hofer (FAO)

Short reports of the four breakout groups (5mn by group), by each Chair:
Followed by a short session of Q&A (10-15mn) at the end.

Session 3. Innovative technologies: challenges and opportunities for the forest sector.

13.40: Expert presentations on specific case studies, moderated by Rao Matta (FAO)

- Lok Mani Sapkota (RECOFTC, civil society), from Nepal (currently living in Thailand), on social innovations in the application and success of community forestry.
- Dr. Andrew Lowe, Australia, University of Adelaide, on the use of DNA markers for timber traceability, and potential for other uses.
- Dr. Lobzang Dorji, Bhutan, Director, Department of Forests and Parks Services, Ministry of Agriculture and Forests.

14.05: Introduction to the breakout groups, by James ROSHETKO (ICRAF/FTA)

Organization of the breakout group discussions and expected outcomes.

14.15: Breakout groups discussions

Participants will be distributed in four breakout groups to address the following issues:

- Group 1 will focus on the environmental negative and positive impacts of innovations, e.g.: biodiversity protection, prevention of deforestation, fragmentation and forest degradation, climate change mitigation and adaptation, pollutions, access to natural resources.
- Group 2 will focus on the economic negative and positive impacts of innovations, e.g: reduced costs, improved productivity, reduced ecological footprint, reduced waste and improved resource efficiency, income, access to credits and markets.

transparency and accountability; real time monitoring and reporting; improved access to natural resources; improved access to information; improved access to credits and markets; etc.

[24] Among these functions are (not an exhaustive list): germplasm selection, production and breeding; forest monitoring; forest management (tree planting, tree growing, forest protection); wood harvesting; wood processing (first and second transformation); quality control; traceability; transport; distribution; final use of wood-based or non-wood forest products (for e.g. medicine, energy, packaging, construction material, furniture…); reuse and recycling; waste management; marketing; etc.

- Group 3 will focus on the negative and positive impacts of innovations in terms of employment and working conditions.
- Group 4 will focus on the other social and cultural impacts of innovations, e.g.: food security, health, education and access to information, impacts on vulnerable groups, and on cultural heritage.

Guiding question:

- What are the main impacts of innovative technologies, positive and negative, current and potential, and for whom?

Expected outcome:

Based on their experience, participants are expected to select, among the 3-5 promising technologies identified in Day 1, a few case studies (one technology for one context) and to identify, for each case, the main impact(s) of the innovative technology in the given context.

15.15: Break

Session 4. Barriers to and enabling conditions for technology uptake and upscale

15.30: Introduction to the breakout groups, by James ROSHETKO (ICRAF/FTA)

Organization of the breakout group discussions and expected outcomes.

15.40: Breaking groups discussions

Participants will be distributed in four breakout groups (same groups than for previous session).

Each breakout group will focus on a subset of transformations.[25]

- Group 1 will identify the transformations needed to ensure that innovative technologies effectively contribute to sustainable development (in its three dimensions: social, economic, and environmental);
- Group 2 will identify the transformations needed to support technology transfer and dissemination;
- Group 3 will identify the transformations needed to accompany the populations at risk of being marginalized by technological advances;
- Group 4 will identify the transformations needed to better adapt existing policies and legal frameworks to fast evolving technologies.

Guiding question:

- What are the main technical, socio-economic and institutional barriers that prevent the uptake and upscaling of innovative technologies in the forest sector and what transformations are needed to overcome these barriers?

Expected outcome:

Based on their experience and building upon the discussions (and case studies identified) in the previous breakout group session, participants are expected to identify 3-5 priority transformations needed to support innovation.

16.40: Enabling conditions for innovation, by Ravi Prabhu (ICRAF/FTA)

Keynote address to draw main lessons from the first two days and provide useful insights to prepare Day 3.

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[25] In terms of: regional cooperation, additional investments, infrastructure development, institutional changes, research and development, education and capacity building.

16.50: Wrap-up and next steps Thomas Hofer (FAO)

17:00 End of Day 2

Day 3: Thursday 3rd December 2020

<u>Introduction</u>

13.00: Opening and introduction of Day 3, by Vincent GITZ (CIFOR/FTA)

13.05: Report of Day 2 breakout groups to plenary

Short reports of the four breakout groups (4mn by group), by each Chair.
Followed by a short session of Q&A (10-15mn) at the end.

<u>Session 5. Recommendations</u>

13.35: Introduction to the breakout groups, by James ROSHETKO (ICRAF/FTA)

Organization of the breakout group discussions and expected outcomes.

13.45: Breakout groups discussions

Participants will be distributed in four breakout groups, to discuss and formulate key recommendations for decision makers from different spheres of society (public or private sector, civil society, research) at different scales (from local to regional). The Zoom Chat can be used during breakout groups to collect individual recommendations.

<u>Expected outcome:</u>

Each breakout group is expected to formulate 3 to 5 recommendations for the application of innovative technologies in the forest sector. Each group will focus on one sub-set of recommendations as follows:

- Group 1 will focus on recommendations directed to public actors;
- Group 2 will focus on recommendations directed to private actors;
- Group 3 will focus on recommendations directed to civil society and local communities;
- Group 4 will focus on recommendations directed to research.

As appropriate, each group will consider recommendations at three different scales/levels: local, national, regional/international.

14.45: Report of breakout groups to plenary moderated by Thomas Hofer (FAO)

For each group: short report (5mn) by the Chair, followed by a short session of Q&A (5mn)

15.10: Plenary discussion on recommendations, moderated by Thomas Hofer (FAO) and Vincent GITZ (CIFOR/FTA)

15.55: Conclusion Thomas HOFER (FAO)

16.00: End of Day 3 – End of workshop.

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Appendix 2. List of participants

The table below contains basic information on the people that registered for or attended to the technologies workshop, as filled by the participants themselves in the registration form.

Family Name	Given Name	Gender	Duty country	Organization
Abdul Bahar	Nur Hazwani	Female	Malaysia	Tropical Rainforest Conservation and Research Centre
Almoite	Clarence Gio	Male	Philippines	Benguet State University
Animon	Illias	Male	Thailand	FAO
Aziz	Dania	Female	Malaysia	UPM
Bontuyan	Philip	Male	Lao PDR	GIZ
Bull	Lyndall	Female	Italy	FAO
Coroza	Oliver	Male	Philippines	Center for Conservation Innovation, Philippines
Dickinson	Chris	Male	South Korea	Global Green Growth Institute (GGGI)
Dorji	Lobzang	Male	Bhutan	Department of Forest and Park Services
Gabriel	Marie Jessica	Female	Denmark	University of Copenhagen
Ganguly	Indroneil	Male	United States	University of Washington
Ganz	David	Male	Thailand	RECOFTC
Gitz	Vincent	Male	Indonesia	Center for International Forestry Research (CIFOR)/FTA
Harun	Jalaluddin	Male	Malaysia	Academy of Science Malaysia (ASM)
Hasna Farhatani	Naura	Female	Indonesia	International Forestry Students Association (IFSA)
Hofer	Thomas	Male	Thailand	FAO
Jinger	Dinesh	Male	India	ICAR-Indian Institute of Soil and Water Conservation, Research Centre-Vasad, Anand, Gujarat
Kamran	Shahrukh	Male	Germany	Eberswalde University for Sustainable Development
Keenan	Rod	Male	Australia	University of Melbourne
Kieft	Johan	Male	Indonesia	UN Environment, Tropical Landscapes Finance Facility
Lee	Kyuho	Male	Thailand	Environmental Science Program, Chiang Mai University
Li	Yanxia	Female	China	International Bamboo and Rattan Organisation (INBAR)
Liagre	Ludwig	Male	Luxembourg	Rio Impact
Louman	Bas	Male	the Netherlands	Tropenbos
Lowe	Andrew	Male	Australia	University of Adelaide
Matta	Rao	Male	Thailand	FAO
Mavinkal Ravindran	Krishnanunni	Male	Denmark	University of Copenhagen
Meybeck	Alexandre	Male	Italy	CIFOR/FTA
Midgley	Stephen	Male	Australia	Salwood Asia Pacific Pty Ltd
Nair	C T S	Male	India	Independent Consultant - Formerly FAO official
Nasi	Robert	Male	Indonesia	CIFOR
Nguyen	Quang Tan	Male	Viet Nam	World Agroforestry (ICRAF)
Oetomo	Bangkit	Male	Indonesia	Tropical Landscapes Finance Facility
Page	Tony	Male	Australia	University of the Sunshine Coast
Payn	Tim	Male	New Zealand	Scion
Phuong	Vu Tan	Male	Viet Nam	Vietnam Academy of Forest Sciences
Piazza	Marco	Male	Thailand	FAO
Pingault	Nathanaël	Male	Italy	CIFOR/FTA
Prabhu	Ravi	Male	Kenya	ICRAF
Reza	Selim	Male	Ethiopia	INBAR
Roshetko	James	Male	Indonesia	ICRAF/FTA
Sapkota	Lok Mani	Male	Thailand	RECOFTC
Saputra	Angga	Male	Indonesia	IPB University

Sarzynski	Thuan	Male	Vietnam	CIRAD
Sheikh Ab Kadir	Abdul Aziz	Male	Malaysia	IRRDB
Sihanath	Dalaphone	Female	Laos	International Finance Corporation (IFC)
Steel	E. Ashley	Female	Italy	FAO
Togado	Raiza Mae	Female	Philippines	Department of Environment and Natural Resources
Wicaksono	Satrio Adi	Male	Malaysia	European Forest Institute
Wu	Junqi	Female	China	INBAR
Wu	Shengfu	Male	China	China National Forest Products Industry Association
Yong	Harry	Male	Malaysia	Forestry Department of Peninsular Malaysia

Appendix 3. Breakout group discussions: rapporteurs' notes

This Appendix reflects the rich and extensive discussions held in breakout groups during the three days of the workshop, as reflected in the notes shared by rapporteurs.

Session 1: Typology of innovative technologies

Breakout Group 1: Digital technologies

Shahrukh Kamran: Among the most promising technologies we could quote:

1. Machine learning, big data science
2. Remote sensing and spatial analysis
3. UAV technologies
4. Acoustics and camera trapping
5. Tree-ring analysis for individual tree growth trend

Drones can be used to catch insects in agroforestry areas. Land driven drones can provide 3D images of the forest strand, not from over the canopy but directly from inside. Machine learning can be combined with drone technology to produce accurate estimations of wood stocks and quality in forest strands, that can be made available on mobile apps.

Thuan Sarzynski: Drones are a very interesting technology but they can be very expensive. They need to be made accessible to farmers.

My master thesis is related to satellite-based remote-sensing observations. Such data can be analyzed with open-source tools, such as Google Earth engine, free but sometimes complicated to use. Online groups and forums exist where one can quickly learn how to use these tools and their related programming code. I used and merged satellite imagery from Landsat and radar data from a Japanese satellite. Satellite imagery is an interesting technology that can be used to protect forests and biodiversity.

Tim Payn: Drone and remote-sensing satellite-based observations are very interesting technologies. Sensor networks is another promising area that have emerged in recent years. Climate, soil and water sensors can be used altogether to generate data flows that can feed models. Scan and sensor technologies can be used for soil mapping. These technologies have proven to be very successful in experiments. Their potential use is linked to big data and machine learning.

Junqi Wu: Digital technologies can help for bamboo utilization and resource management. Satellite imagery could be used to assess and monitor bamboo and rattan resources, on which local communities rely for their livelihood. There is a need to adapt the most promising and appropriate digital technologies, already used in the forest sector and for wood production, to the specificities of the bamboo and rattan sector. It is necessary to promote international cooperation on specific methodology of bamboo and rattan assessment, based on the successful technologies we used for tree resources.

Engineered bamboo products can provide high-quality alternative to timber and reduce the pressure on forest resources. How to encourage people to use bamboo resources to produce high-tech, high-value innovative products, such as bamboo panels or engineered bamboo, including for international markets? There is a big gap here because most bamboo resources still go to traditional products for local communities.

Tim Payn: New information and data generated by drones and satellites can help intensify forest management. Digital technologies can help modelling forest dynamics and support precision forestry. They can also be used for training in virtual reality.

Thuan Sarzynski: As the most promising technologies, I would suggest:

- remote sensing for mapping (current and suitable areas);
- Internet of Things for sensors (climate and soil), to predict yield or help create insurance schemes;
- Artificial Intelligence and machine learning to analyze sensors' data and predict yield.

Shahrukh Kamran: We need to identify the best indicators for forest resources monitoring and assessment, as well as the main drivers of land use and land cover changes.

Marie-Jessica Gabriel: Open-source tools can be used by rangers and foresters to collect and analyze data about forest illegal activities. Such tools can help rangers to detect early illegal activities inside forest, even in remote areas, uneasily accessible. Automatic report of data collected to a central server allows real-time data sharing. Standard reporting can also facilitate comparative studies. This is a promising technology because it improves greatly the effectiveness of patrols and law enforcement, can monitor wildlife and give signals on illegal activities. Forest managers can follow the work of the rangers in the field. Artificial intelligence can also be used to design patterns to patrol the whole forest not following always the same routes. Such tools also allow collaborative management of forests, empowering local communities, enabling them to participate to the monitoring of illegal activities.

Thuan Sarzynski: Terra-I and Global Forest Watch are great example of technologies providing alerts to forest rangers!

Angga Saputra: As the most promising technologies, I would suggest: (i) drone technology; and, (ii) Mobile app for species identification, such as I-Naturalis (community science based). Such apps can enable local communities to contribute to wildlife monitoring, generating data that can then be analyzed by experts.

Tim Payn: There is a need to link digital technologies to human needs: they can help improve health and working conditions. For instance, technology can be used for human physiology monitoring (e.g., assess stress levels in firefighters or forest workers).

As the top-most promising technologies, I would suggest:

- digital data from remote sensing;
- geospatial analytical tools and systems;
- use of virtual reality in training

Oliver Coroza: Another most promising technology is the improvements in location technologies, such as the advances in GPS electronic chips to increase accuracy of localization under forest canopy. Accurate GPS readings should help improve ground truthing of high-resolution satellite images.

Shahrukh Kamran: It is also important to have all the stakeholders at the same mindset.: the use of unmanned aerial vehicles (UAV) during a research project on agroforestry landscapes may cause a severe conflict between farmers and hunters. UAV technology raises many legal, social and privacy issues.

Breakout Group 2: Biological technologies

Tony Page: There is a broad range of technologies with big differences in adoption and contexts between countries. In many contexts, basic selection and the use of quality genetic material to improve productivity and income generation would be an innovation, requiring not only appropriate techniques but also social innovations to deploy improved material to smallholders. It could be facilitated by a certification system of quality genetic material.

Rao Matta supports this statement. In the region, there are areas and species for which clonal multiplication is available; in other areas there is still a lack of quality planting material. In general, may be 90 percent of the material used in afforestation/reforestation is still unselected in many countries. We need to identify avenues to deploy improved planting material to smallholders.

Andy Lowe: DNA timber tracking, by assigning a tree or wood product to a specific population or region can have multiple uses, including: control trade, fight illegal logging, link specific qualities to a specific area. There are already genetic maps for species of interest and a Global Timber tracking network for 250 species for which illegal logging is a problem, either because they are heavily traded, threatened or likely to become heavily traded. The objective is to have secure value chains. To date quite a few data bases have been developed from research grants, official development assistance (ODA) or specific companies interested to show that they use legally sourced material. We have also done some work on teak; we can generate a profile for a natural or planted forest. It is difficult for clonal species but we can use isotopes or chemical signature, for a certain species in a determined area (as it depends on soil and water).

Tony Page: Techniques used for propagation, like grafting or tissue culture, depend on species (recalcitrant species) and context, including conditions of transport, availability of refrigerated transport. Importance of seed systems; a lot of tropical species seeds are difficult to store. There is already a big potential of improvement in applying known techniques. For instance, seed treatment, seed processing, dehusking can considerably increase germination from 10-20 up to 100 percent. For instance, for sandalwood, there is a lack of seed supply because of the need for treatment, processing, storage to make it available to smallholders. Certification of quality seed (appropriately sourced, treated, stored) would require institutional support. Genetic profile could also be used to make the link between seed and timber.

Clarence Gio Almoite: There are seed banks in the Philippines, but the source of the seeds is often unknown. There are nurseries in local communities and ministry of environment. We need to conserve and multiply trees of the primary forest. There is a long-term debate on the need to preserve primary forest and the threat of exotic species. When there is a natural disaster, plantations are generally more affected than natural forests because exotic species are not adapted to natural disasters in the region. Plantation trees adapted to local conditions, in particular to recurring extreme events, are often lacking, particularly in the Philippines and the Pacific. Identification of promising indigenous species, domestication and selection would make an important contribution to the development of local timber production and value chains and to improved livelihoods. There is a national informal group on indigenous species of interest in the Philippines; these species need to be better known in terms of economic potential, for instance the potential for timber of the species inappropriately denominated under the generic “Philippines mahogany”. We need species trials and to broaden the range of trees that can be grown, including to find trees that are more typhoon resistant. In Vanuatu, people would not plant exotic trees at all because they cannot resist typhoons. We need to allocate adequate funding to domestication.

Genetic tracing, associated to geo-localization can link specific genetic material to specific local climatic conditions and support the adaptation of natural forests by using for an area (A) the material collected in an area (B) that is already experiencing a climate close to the one expected in the future in the area (A) of plantation.

Breakout Group 3: Technical innovations (processes and products)

Rod Keenan:

- Small log technology
- Small-scale processing equipment to utilize small diameter logs
- Small-scale processing for veneer and other engineering products
- Improved harvesting and transport technology – a lot in Scandinavian countries
- Financial barriers: how to invest for small-scale companies and communities?
- Investment is currently dominated by larger corporate partners
- Small-scale harvest equipment and arrangements for ‘local level’ entities

CTS Nair

- Development of new materials
- Plastic and timbers combined to produce more durable furniture
- Investment in the technology to facilitate the development of ‘local entities’

Jalaluddin Harun

- More intensive breeding, including hybridization (specific for rubber) to develop varieties for faster growth, site adaption, or other characteristics
- The above should also be conducted to benefit farmers – combine latex production and wood production
- Rubber sector now should move-up the value chain – so that farmers become involved in it beyond their role of producers (timber and latex)

Marco Piazza

- Bamboo and rattan – overlooked (illustrative of other species also)
- Expand the example and experience with those species to others
- Previously, rubber was also overlooked … but there are still more innovations and new methods and processes that can be discovered and implemented
- Digital technologies are important to address cross cutting issues (mapping, planning, etc)
- Using fast-growing species can help protect existing forests

CTS Nair

- Managing the landscape for multiple products and services
- This is important as commodity prices fluctuate and, overall, the ‘return to land’ may be higher from multiple products and services

Jalaluddin Harun

- Agree we need to diversify the production model, especially for smallholder farmers … who have only 1 ha or less
- Use the improved production to protect the natural forests, so need to focus on the key species … but also include the species that have been under-utilized

Shengfu Wu

- Need to be clear that the technologies are available and suitable
- Technologies and species will need to be adapted to the country and site
- LVT (veneer timber)? LVL
- Popular veneers and processing and handling. Waste and small leftover pieces can now be utilized to make commercial products
- Also, we need to be clear about the product and use to determine the species that are appropriate
- For different species there are different appropriate uses and vice versa the use/product dictates the species (the wood characteristics of the species)
- Not just the technology but also the process and labour input have to be innovative. Need to maintain diligent and hard work.
- China developed new species for new conditions (see powerpoint)
- 5G technologies ….

Lyndall Bull

- It is more a question of utilizing the available technology and information than having to start 'new research'

General discussion

There needs to be some integration of technologies across the clusters.

Final Comments: what are for you the top-most promising technologies?

Marco Piazza

- Explore the potential of under-utilized species
- Move away from monocultures

CTS Nair

- Processing and harvesting technologies for smallholder and small-scale operators
- Reduce waste

Shengfu Wu

- Small-scale processing technology – training and safety
- Improved genetic material (and clones) for expanding species range and for climate change adaptation
- Integration into value chains and value-addition options for small-scale processes

Jalaluddin Harun

- Latex timber clones (LTC), and timber latex clones (TLC),
- Total utilization of biomass
- Processed products - particle boards, veneers, etc.

Lyndall Bull

- Emphasize smallholder and small-scale processors

James Roshetko

- Engineered products (such as cross-laminated timber – CLT), particle board, veneer, etc.
- Bamboo products
- Improved harvesting and processing technologies

Breakout Group 4: Innovative finance and social innovations

Dalaphone Sihanath about a forest plantation management project with the department of Forestry: The project helps forest plantation by developing instructions on plantation registration within the context of complicated procedures in Lao PDR. Private sector and other stakeholders are not interested in paying the costs. We use mobile phones technology to get GPS points through google map. The project develops a webpage, with the result of inventories reported by local people incorporated into the webpage to allow viewers and the government to see the plantation. Remote sensing is another important tool to access the trees in the country. ACIAR also supports the use of remote sensing for measuring the forest. The project also tests the use of drone to conduct tree inventories.

Lok Mani Sapkota: We worked with International Finance Corporation (IFC) to support mapping of smallholder plantations in Lao PDR. Under the initiative we supported Burapha Agroforestry Limited, helping them to develop an effective monitoring system for out-grower schemes. In doing so, Open Data Kit (ODK) and Mobile Application Device (MAD) were used to capture data from the field.

Similarly, in Indonesia, we provided capacity-development support to forest technicians and local communities to use Forest Watcher App to monitor and prevent forest fire. We also used web-based platforms to raise financial resources to support local communities. For example, we raised funds for Akar Tani Cooperative in Bantaeng in Indonesia through the Give2Asia platform.

Nur Hazwani Abdul Bahar: We use remote sensing to map forest cover and forest land use changes. A platform developed by anonymous group in Malaysia called “Global Watch” integrating information from the with information from Government forest agency. The results show which area is forest, which area is plantation, and other land uses. The platform gives access to an information that is needed by many people to understand the land use types and evolution and that often belongs to the government. Recently, NGOs engaged with local communities in conservation, based on the model from other countries like Indonesia where local communities are involved in seed collection, propagation. We are engaging with native / indigenous peoples, training them to identify and collect tree and plant seeds themselves in their backyards. The information is sent by a local officer, not the community because of bad network connection.

Vu Tan Phuong:

- Remote sensing technology: recently using LIDAR technology to measure the emissions from forests
- Mobile technology for bottom-up forest inventory
- Biotechnology: genetic selection, tree breeding. We use biotechnology to develop new varieties that adapt to climate change, resistant to disease, for paper production etc.
- Artificial intelligence for forecasting disaster, landslide, etc. AI can also be used to identify species
- Wood processing

Lok Mani Sapkota: The trainings done by RECOFTC are often face-to-face. With the COVID-19 pandemic, training is now going online, such as Community forestry 101, a free e-learning course on community-led forest management[26]. Those trainings are not for communities yet and there is a long way for technologies to change the communities. RECOFTC uses a cascading training approach to train people who train communities. No technology used in community training yet but it is coming.

Vincent Gitz: We may need to talk about what technologies are available and should be there, from the experience of the group, what are the needs for a given technology. Finance may be a bottleneck. Consumers are increasingly aware of not only the environmental dimension but also the social dimension. Is there a technology that helps bridge the gaps, knowledge and data; to raise awareness on where the wood comes from, how it has been grown, how is it benefiting the local communities; and to improve our understanding of the state of the forest. Inventories and surveys are expensive, lots of technologies are being used. We need to go there to see what are the trees there. Regarding innovative finance: how some of the characteristics of the forestry sector can be leveraged? Forestry has long-term but more stable returns. How can finance tools be mobilized to make the sector more attractive? How can technologies in the future can help?

Vu Tan Phuong: Vietnam is making payments for forest environment through the banking system. This can be considered as a financial mechanism for sustainable forest management. Viet Nam is also developing timber traceability system to track the legality of timber.

Dalaphone Sihanath: Carbon credits are used as a financing mechanism for Lao PDR in the context of plantation (money for selling carbon), from government to international market. Funds are mobilized for registration, as well as for remote sensing.

[26] See: https://www.recoftc.org/learning/e-learning-catalogue/community-forestry-101

Session 2: What technologies for what functions (application)?

Breakout Group 1

Vincent Gitz: During this session, we will discuss technologies, the functions they perform and how they contribute to sustainable development. Are some technologies conducive to social, economic and environmental damages? What are the parameters / criteria that influence positive outcomes? Technologies might not be promising at the same time on all dimensions of sustainable development. Our group is expected to focus on digital technologies but we can also mention other technologies if need be.

Shahrukh Kamran: UAV drone technology is an active form of monitoring. Drones are very efficient to get real time data and imagery, including in cloudy areas where remote-sensing cannot be used. They have low impact on environment. They can be used also for seed blasting, net blasting and tranquillizing wildlife, reducing the workload, improving working conditions and creating new skilled jobs. In Germany, everyone (farmers and foresters) can easily afford a small hobby drone but commercial drones can be expensive and have to fulfill with certification and other laws. In some countries (e.g., Pakistan), this technology is not affordable for many actors. Free flight controlling apps and open-source processing software can improve affordability. The use of drones raises many legal issues (certification, licensing, social and privacy issues). In some countries, there is no legal framework for the use of drones or drones are even banned. Without appropriate laws and regulations, you cannot open the door to new technologies.

Remote-sensing is a passive form of monitoring, able to cover vaster areas but less flexible than drones. This technology has the potential to access the inaccessible areas such as war-conflicted zones that may escalate pouching, deforestation and other environmental insecurities. Remote-sensing is less labor-intensive but requires ground truthiness. Standardized data is sometimes made publicly available but not in all formats and resolutions: high-resolution, such as LIDAR data, data are not freely accessible, except in a few countries. Remote-sensing tools must be adapted to national definitions of forest and land uses (e.g., Pakistan amended the tree height threshold used in FAO definition of forest from 5m to 3m but do they have high-resolution data adapted to this national definition?).

In Europe, the erection of wind turbines may get delayed because of legal constraints and opposition of various stakeholders (landowners, hunters, conservationists, ornithologists). Wind turbines can disturb or increase mortality among various species, such as migratory birds or bats. To mitigate stakeholder conflicts and species mortality, innovative technologies such as flickers for birds or acoustic blasters for bats can be implemented wherever necessary.

Vincent Gitz: It's good to mention legal and regulatory bottlenecks to technology adoption and upscaling. Affordability is also an important issue, especially for smallholders.

Dalaphone Sihanath: Drones licensing and use remain quite limited in Lao PDR due to national security regulations. Licenses are limited mainly to some consultant firms and private companies. Government also use drones for forest monitoring. Mobile phones provide low-cost access to innovative technologies. Mobile phone apps can be used to link timber smallholder producers to wood processing private companies. Mobile apps can be used to estimate wood volume, wood quality and fix wood prices.

Vincent Gitz: A possible area for recommendations could be to balance the different needs of the different ministries involved in the oversight of these technologies (e.g., drones) at national level.

Ashley Steel: I sit here as an observer. I'm interested in what sort of innovations can be promoted in countries on the ground.

Vincent Gitz: Everybody is allowed to take the floor: this is not a formal group. Feel free to share any issue FAO is encountering in the use of innovative (digital) technologies. What issues can appear when the use of innovative technologies is not covered in national legislation?

Ashley Steel: I'm interested in what countries can or are considering using innovative technologies to improve their monitoring and data collection process? How digital technologies (e.g. drones) can contribute to improve data quality at country level?

Vincent Gitz: How can different technologies (to observe forests or improve the value chain) be combined? Are there students or young professionals in this group: what are some of the challenges we face? What would be the solutions? What are our dreams for the future?

Marie-Jessica Gabriel: We developed a special forest monitoring and reporting tool, used to monitor forest illegal activities and contribute to forest protection and law enforcement. The problem here is not the cost (because it is an open-source tool, easily downloadable and usable) but the lack of technical capacity to use this tool. This tool allows you also to monitor the work of forest rangers and provide you systematic patterns for patrolling the whole forest. This tool enables local communities to participate to forest patrolling, creating jobs. It improves governance because you can monitor the forest in a more efficient way. It strengthens participation because you empower forest rangers and local communities. It strengthens transparency and accountability, enabling real time monitoring and reporting (with data collected on the ground immediately sent to a central online database), thus improving access to standardized information, easy to share and compare across sites.

Shahrukh Kamran: I agree we need to collect standardized data. Even non-technical actors are able to get and use such standardized data. In some countries there is no transparency, you don't even know where to find such data. Remote sensing is also a good tool to access remote areas, including conflict areas, particularly in this time of pandemic. We need a central station of data.

Vincent Gitz: It is both an issue of standardization and access to the data collected. In the chat you also pointed out the issue of privacy, anonymization of data.

<u>Breakout Group 2</u>

Chair's summary of the main points

1. *Broad range of technologies and large differences between countries*

Many technologies that can benefit the forest sector in the Asia-Pacific region are already available, but an improved understanding of the processes related to technology adoption is required. Adoption is context specific and what might apply in one country, such as tissue culture and clonal deployment of cultivars, might not be applicable for another country. Often, a lack of adoption can be associated with a simple lack of access. For instance, improved germplasm might be available for institutional investors but there are no established mechanisms for deploying that material to smallholder growers.

2. *Basic selection and quality genetic material to improve in productivity and income generation would be an innovation*

While smallholders tree growers will represent an increasing prominence in future wood supply, much production is based on unimproved stock. Economic advantages for smallholders would be greatly amplified if their woodlots were based on high yielding improved germplasm. Increased wood flows from the smallholder sector could support additional investment in downstream processing. For smallholders, a primary constraint is the lack of formal modes of distribution for improved material. For nations that have a lack of government or private investment in germplasm distribution systems, social innovations are required for localized deployment of improved material to smallholders.

A simplified certification system for quality genetic material may be a way to support commercialization. Deployment of improved genetic material can be facilitated through the commercialization of the improved germplasm through certified suppliers, this can be linked to a financial premium being paid on improved materials, or simply that the demand for improved materials and higher throughput can make production of improved cultivars more financially viable. The approach for certified seed/germplasm production would require a degree of initial institutional support. Firstly, the improved germplasm may need to be developed, and secondly there would need to be an independent administration of the certification process. If improved germplasm already exists in the private sector, then there would need to be support for this to be provided to smallholders, which can form the basis of contracted smallholder production as has been demonstrated for Eucalypt production in parts of south-east Asia. This would require a supportive government and private sector willing to share improved germplasm with smallholder sector.

Recommendations for different actors:

Public Institutions: Support is required for establishing genetic improvement programs for key plantation species. These can include both exotic species with known markets as well as indigenous species that are more likely to be adapted to local conditions but which have a potential strong international demand. Policy support is required for establishing a seed/seedling registration system as has been conducted in the Philippines. Genetic profiling technology can track the certified seed supply systems as well as the timber that is then derived from these sources.

Private actors require a willingness to deploy improved genetic material to small-scale growers.

Civil Society and Local Communities can influence social innovations to facilitate transfer of improved genetic material both from and to local growers. Social innovations are required for supporting participatory domestication strategies, particularly in the absence of external funding. Technical improvements to facilitate propagation and easier to conserve and transport of improved genetic material.

Research Organizations have a role to develop linkages with government, private and community actors to develop a domestication strategy that produces genetic material that is demanded by the market and suited to existing supply chains.

3. *DNA timber tracking to control trade, fight illegal logging, link specific qualities to a specific area.*

DNA timber tracking is a very important innovation that has a wide range of application but particularly for conservation purposes where identification is required. Cost of DNA sequencing has reduced significantly over recent years making it available for wider use. The enabling factors for this technology are: international legislation governing the legal supply of timber; consumer demand for sustainable timber; and, certification schemes that require tracking of product through the supply chain. DNA timber identification has particular advantage at the retail end of the supply chain, to check that the actual origin of the timber matches that of the declared origin.

Recommendations for different actors:

Public Actors: quite a few species DNA data bases have been developed using research grants, but they can also be funded by CGIAR.

Private Actors: Companies that are interested in demonstrating legality of supply from timber through their supply chains. International timber supply chains are very complex and wood products move through different legal entities along the chain. Genetic profiles for a natural or plantation forest, trace timber along the supply chain and then validate the trees from that supply chain.

Research Organizations are key service providers for developing the genetic profiles for the species or groups of species that are traded. Prioritized 250 timber species for illegal logging, these are those that are endangered, currently heavily traded. Species that are the next phase of timber to be traded will also require attention.

4. *Locally adapted and commercially-viable plantation trees that can be more resilient to changes in climate*

Plantations are often dominated by a relatively narrow range of exotic species eucalyptus, acacia, teak, mahogany, gmelina, rubber, falcata. Many of these are well suited to their new adopted countries, however they can be ill-adapted to certain regions, particularly those that are being affected by increasing frequency and intensity of tropical typhoons. Indigenous trees may offer an alternative in these regions, as they are typically more resilient than exotics. The challenge with developing viable local species will depend on their biological adaptability to being grown in a plantation situation, many species are adapted to growing under the canopy of a forest, and many are also slow growing. The right choice will also depend on the development of markets for the species, which can be problematic. There are examples of trees in some Pacific island countries that are well adapted to growing in their environment and have local and export markets for their products (sandalwood, *Canarium*). Another important barrier is that many species will need to undergo, at least, very basic form of domestication to ensure adequate seed supply: this would require funding, as well as government and/or institutional support.

Recommendations for different actors:

Public Actors: Policy support is required for the development of promising local species for plantations that have resilience to local climate extremes and that can be marketed domestically and internationally.

Private Actors: Adaptation of existing timber processing technologies to accommodate the physical features of local species.

Civil Society and Local Communities are central to identification of candidate species for development based on local knowledge of use and adaptations.

Research Organizations are key for developing technical innovations for domestication, production and commercialization.

5. *Biological technologies, discussed in the group, make important contributions to bioeconomy and bioenergy.*

Biotechnology can help convert plant biomass into renewable energy, enabling both specific production of bioenergy or better utilization of by-products as bioenergy. Biotechnology can help replace the use of plastic products: a lot of the technologies related to bamboo products are available or can be developed to convert bamboo into bioproducts for consumer and construction products etc. Such technologies will be financially and environmentally viable if the trees can be produced on lands marginal for agriculture and high value forestry. Many bamboo species can grow well on degraded lands and, thus, can contribute to environment conservation and land restoration. Biochar can enhance carbon sequestration and soil regeneration. There are constraints to industrial scale production of biochar that will influence its adoption as it is also a good amendment for soil biodiversity.

Detailed interventions

Tony Page: We've got two or three technologies but now it seems to be three to five so we can add to the list that we reviewed in the previous session. One of the technologies is plantation of locally adapted trees to support adaptation and evolution of climate change.

Our guiding question is: what can be the contributions of innovative technologies to sustainable development, covering the social economic and environmental dimensions of the different contexts, and how does the application of innovative technologies affect different functions throughout the value chain? It is about the previous technologies that we spoke about and we can add additional ones.

Alexandre Meybeck: What we mean by functions here was to designate the groups of operations or activities that you make all along the forest management to final product design stages. For instance, monitoring would be one group of functions, forest management, first transformation, these kinds of things. The question is how biological technologies can be used at these various steps including product transformation if we have genetic material more adapted to certain uses or including for marketing or fight against illegal logging using DNA tracing. For instance, we would apply the technique of DNA tracing to control illegal logging or for value-addition through better qualification.

Tony Page: The genetic profiling could help with conservation because genetic profiling can be used for determining particular provenances or particular genotypes that might be then used to infuse into new populations. Genetic technology can be used across a lot of variety of applications. The whole genome being produced for particular species is also important aspect. That applies in terms of improved resource generation through plantations. The genetic tracking can also be used for supply chains and forest management. Genetic technologies can be used for improving product formation, for instance pulp production. That could apply over to a given range of different species and even within a given species, different products can be developed.

Rao Matta: Within the category of biological technologies, I hear a lot about application of innovative technologies in the area of bioeconomy including the use of forest biomass as an alternative energy source. Some technologies are being developed to use wood as a substitute to materials that are considered “brown” (e.g., steel, concrete, plastic) and other materials promoted as part of a bioeconomy or circular economy. Research is going on to convert wood or forest biomass into renewable energy.

Tony Page: They could be related both to specific production of bioenergy or better utilization of by-products in terms of bioenergy.

Dinesh Jinger: We are living in the era of plastic. We are using plastic because it is cheaper than the products made from bamboo. For instance, we are using plastic bottles for drinking water. Instead of plastic, we can use products made from bamboo like toothbrush, carrying bag, cups, and even airports, made from bamboo. We are working on the potential of more than 10 bamboo species. We are not working on the products, but on soil and water conservation. So, my point is instead of plastic we should go for bamboo plantation and bamboo products to make our environment safer and economical.

Tony Page: A lot of the technology regarding bamboo products is related to engineering aspect in converting bamboo into usable products. should those conversions of bamboo be considered as genetic products of biological nature or mainly as an engineering product.

Dinesh Jinger: Growing bamboo is a biological aspect but making product out of that is engineering aspect. First for making engineering product, we have to grow bamboo. That will be considered as the biological because these species grow very well in the degraded lands or wasteland. Bamboo species can grow easily, so we can reclaim or rehabilitate those land also, which will come under the conservation of land and environment.

Tony Page: It's a good point. A lot of those engineering technologies for converting bamboo into these usable products already exist. They're not something that is going to be needed in the future because they already exist and it will be novel development of the use of them.

Alexandre Meybeck: If I may try to bundle together the comments from Rao about bioenergy and bioeconomy more generally and then on how to replace plastic, this might have consequences in terms of plant breeding. If we want to do bioenergy, we will be interested in plants that produce a lot of biomass quickly in difficult conditions. Bamboo is one of the species of interest. There are others, and there can be improvements inside the species. Then, when we think about making bioplastics or replacing plastics, it has very much to do with the chemical composition of the wood. Here again, there are possibilities to improve plant breeding, to improve the chemical composition or the homogeneity of the composition of various woods, which is also an issue for bioenergy. If you want the plant to function properly you need to have material which has the same kind of chemical composition. So, the end use has consequences on the genetic material that you want and on the information that can be linked to this genetic material. You said that if you want to do wood for pulp, you'll need to make sure that your seed is the seed for pulp.

Tony Page: Biochar becomes more prevalent. Are there particular species, and groups of species and is it also plant breeding to generate biochar products? Forestry has a long connection with biochar both in terms of carbon sequestration and also soil amelioration (the plants become less dependent on chemical fertilizers). Are there other biological aspects of that technology that are going to be important over the next coming ten years?

Clarence Gio Almoite: Biochar is good soil amendment and it is a good strategy for soil regeneration. However, there are some practices of making biochar even in the large-scale is like you're burning the entire farms. However, making biochar at small-scale is suitable for small-scale forestry farmers as practiced here in the Philippines. Farmers in the Philippines just burn the thinnings or the felt branches of forest trees. They just mix it. they don't have specific trees they use for biochar. They just burn it in the wild in a large area. After that, it will be fermented for at least two weeks and then it will be mixed in their soil. So that whatever type or species of trees they will plant will grow healthy. However, the knowledge and information about biochar everyday utilization must be disseminated well to the people because it is not well-known. Some people are using chicken bones for biochar. The use of trees, pruned branches and thinnings is not well-known. I think biochar is one of the best strategies when it comes to carbon sequestration and soil regeneration because as of now, we have less than 50 or 40 percent of soil biodiversity. It is a good amendment for soil biodiversity. It opens a promising future for the soil of the planet.

Dinesh Jinger: I agree with Clarence, but we know that for making biochar a huge quantity of heat is required to burn the woody component. For making biochar, instead of carbon sequestration, we generate additional emissions of greenhouse gases like CO_2 during the pyrolysis of the woody component, aggravating the climate change issue. How can we say that it is a good soil amendment? There is a little misconception going on all around the world whether it is helpful in the carbon sequestration or it creates the climate change global warming.

Alexandre Meybeck: I personally do not disagree with what has just been said. But we have seven minutes left, we should focus on the guiding question and expected outcomes. Thinking about biological technologies: a lot of it is about plant breeding and the techniques linked to it and how it can contribute to sustainable development in all its dimensions.

We've already stressed the importance it can play to improve livelihoods, to adaptation to climate change, to use more renewable energy and renewable materials. But it's very dependent on the general conditions of a specific country. For instance, if you can have refrigerated trucks or not. I was impressed in your presentation by the stress you made on the importance of the local market as a start for innovative technologies and this may be something that we would like to point out.

Tony Page: If you're speaking from the smallholder perspective and if your government is wanting to contribute to reforestation, help local production and they're starting from scratch. In places like Vietnam where there are vibrant safeguards, smallholder safety is not an issue, and there's a vibrant market. In places like Papua New Guinea and parts of Indonesia there has to be a local market for early low-quality products coming out from those plantations. As supply builds up, they can access larger markets. The other thing that we talked about in terms of plant breeding and domestication is the right tree and the right product going into the right supply chain that has a market. There's no point producing a low-density, non-durable timber if there's no market for it. Plant breeding must be adapted to the needs of the supply chains and markets. You need to know the market opportunities to develop the appropriate breeding strategy and selection criteria.

Vu Tan Phuong: Bio-technologies apply mainly in tree breeding, clones improvement. In our case, we have a very high demand on land, so expansion of forest area has a very limited potential. One way to meet the increasing demand of timber and other timber-based materials is important so bio-technologies can help improve the productivity, diversifying planting materials and also help reduce pressure on the natural forests. Secondly, Vietnam is vulnerable to climate change and the situation is changing so we need new varieties of planting materials to adapt the new conditions.

Breakout Group 3

Summary of the main points

Following the discussion in Session 1, in which the group was asked to identify promising innovative technologies for sustainable forestry and sustainable forest management in the next ten years, in the Asia-Pacific region, the discussion continued guided by the overarching question: *What technologies for what functions (application)?*

The discussion proceeded in a participatory manner and the majority of contributions could be summarized into two main concepts which are further outlined in the bullets below. The first is **"think small"**, meaning that the focus of technological innovations should be directed at small-scale level and small-scale producers, with the goal of strengthening the linkages between local communities and local enterprises. The ultimate beneficiaries of technological innovations should be smallholders, which are the most vulnerable and manage significant forest resources.

The second key concept is **"beyond technology"**, meaning that technological innovations alone are not sufficient. Significant efforts and innovations should be placed in ensuring that adoption mechanisms are in place, that appropriate training and institutional framework are present and, in this context, the role of the private sector was also recognized. The following bullets further outline the main contributions and recommendations that emerged from the group discussion.

- Importance to focus on small-scale technologies for smallholders, who are the most vulnerable, manage significant forest resources, and should be the ultimate beneficiaries of technological advances.
- Focus on technologies that can capitalize and make efficient use of, for example, small diameter trees, understory vegetation, waste and processing by-products as well as under-utilized species such as rubber wood, bamboo, rattan, mangroves.
- Ensure that there are appropriate technological advances along the value chain to ensure value-addition to the resource, and consequently, appropriate increases in the returns to smallholders
- Technologies often already exist: the challenge is more on adoption and utilization.
- The scarcity of data on local farmers' products demand and resources is a challenging element. Data limitations on supply and demand at local, regional and global levels is likely to impact investments in and, consequently, adoption of technologies that may improve economic, social and environmental outcomes for smallholders.
- Innovative financing options should be explored to facilitate adoption of technological solutions that improve economic, social and environmental outcomes for smallholder forest owners.
- Technological issues need to be addressed also from the point of view of policy and institutional set up. Often, government institutions and public actors are not well-equipped to finalize, commercialize and encourage widespread adoption of innovations. Appropriate linkages and partnerships with private sectors are needed.
- There is a gap between technology developers and users, training and extension is a key requirement for widespread and successful adoption.
- Technologies need to be transformed in order to be adopted successfully with local engagement, creating a relationship based on shared value-added, to reduce transaction costs, achieve economies of scale, facilitate supply of commodity, and improve economic returns for all parties

- Ensure that the combination of technologies to monitor and potentially monetize different forest values, including the value of ecosystem services are integrated into the thinking around both product and process technologies
- The deployment of the technology should not disenfranchise local producers and local enterprises. Efforts should be made to integrate them into the new value chains. Part of these may be done by enabling them to adopt new roles and responsibilities, including in logistics and transportation, organization of collection points, etc.
- There is a potential for integrating process and product innovations with ‘innovative finance’ (green bonds, blended finance, ‘responsible investment’) and with social innovations regarding ‘community forestry’ in places where communities are given responsibility to protect and manage the forest but there is no capacity in forest management, enterprise / business development, or wood processing.

Detailed interventions

James Roshetko:

- Focus on smallholder / small-scale technologies as they are the most vulnerable – opportunities for more efficient use, for example reducing waste, increasing returns.

CTS Nair:

- Ecosystem services: relationship forest-water as a critical issue. What technologies are available for hydrological patterns and resources?
- Green products + innovative finances linked to payments for ecosystem services (PES).
- Use of small dimension timber – reduce waste – processing by products used for other uses.

James Roshetko:

- Small-diameter trees including from thinnings – as well as under-utilized species.

Lyndall Bull:

- Often technologies already exist – applications and utilization.
- Scarcity of data on product demand and local farmers resources.
- Investments require data.

CTS Nair:

- “Data” divide like a digital divide.
- Policy and institutional issues.
- Not just a purely technology issue but also political and institutional issues.

James Roshetko:

- Technology needs to be transformed in order to be adopted successfully.
- Need for engaging local communities.
- Build a relationship along the value chain – “assign” roles along the value chain. Shared-value market relationships.

Lyndall Bull:

- What would it take to invest into adoption for a given technology?

Jalaluddin Harun:

- Examples from China and bamboo as a successful example of high-value transformation of bamboo.

CTS Nair:

- Which institutions are dealing with technology development and dissemination?
- Most are policy organizations rather than technological and research organizations. ← bottleneck to adoption
- On the contrary – private sector

Lyndall Bull:

- Gap between technology developers and users

James Roshetko

- Training as a key requirement

Session 3. Innovative technologies: challenges and opportunities for the forest sector

Breakout Group A

Lok Mani Sapkota (Chair): First, please provide elements on negative impacts on environment.

Lynda Bull: Harvesting related innovations can make it possible to access areas previously untouched.

CTS Nair: In tropical countries most of the forestry was simplification of ecosystems with economics as unique focus.

Tony Page: There is also simplification of plantations, with a small number of species. There is interest in dual use trees; some under-utilized species can be of interest as dual use.

Dinesh Jinger: Eucalyptus is widely used but has been criticized for its consumption of water and allelopathic effect[27]. There are other fast-growing species that could be interesting and that do not have these negative effects.

Andrew Lowe: Illegal logging has major negative impacts. A range of techniques can be used to control it as long as there is a legal framework and an implementation framework. We need low-cost and easy-to-implement methods for DNA identification for instance. To counter simplification of forests that are driven by economic considerations, there are payments for ecosystem services (PES) and carbon schemes. But these have been shown to be difficult to implement for smallholders with huge transaction costs: *de facto,* financial and legal frameworks are excluding smallholders.

Alexandre Meybeck: Innovations can improve resource efficiency all along the value chain, including better use of resources during transformation and use of rare woods as veneer, particle boards allowing the use of less valued species and pieces. Precision harvesting associated with good control and monitoring can also contribute to reduced degradation.

CTS Nair: The number of commercially valuable species has increased. This can support multiple use management taking advantage of the diversity of species. What tools for multifunctional management, to assess biodiversity, carbon stocks, water flows? There could be innovations in these areas. It would bring increased benefits from big public forests and bring diversity of species to smallholders.

Alexandre Meybeck: Innovations facilitating assessment and monitoring of multiple benefits could also be linked to financial innovations like PES and carbon schemes, if accepted by legal frameworks,

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[27] Some studies have shown that various Eucalyptus species can yield allelopathic chemicals which may be effective in suppressing understorey vegetation. However, not all eucalyptus species have these effects and the even eucalyptus species do not have these effects on all sites and conditions.

and facilitate adoption by smallholders. An important area for further work would be better assessment of the role of trees and forest in water circulation, including atmospheric, so that it can be better integrated in policies and measures.

Chair: Please provide inputs on social impacts.

CTS Nair: There are trade-offs between the number of people employed and productivity. The problem can be quite severe in wood processing. The number of people employed has been reduced by automation. Innovations adapted to small-scale producers could support more employment than if only targeting large-scale.

Lyndall Bull: More sophisticated mills should help improve safety of people. New engineered wood products have the potential to use low-value products with economic and environmental benefits, and also to replace fossil fuel-based products.

Tony Page: Such innovations will allow to use small trees, with shorter rotation periods and a quicker return on investment, which is a big advantage for smallholders.

Lyndall Bull: This could be linked to innovative finance.

Breakout Group B

Shahrukh Kamran: Sensor networks, big data and machine learning have a huge potential.

DNA identification and tracking are not only useful for timber but also for non-timber products. For instance, it can also be used for monitoring bushmeat trade and facilitate veterinary control. For example Tengwood Organization has created the first bushmeat types classification manual and posters for airports, used by IUCN Switzerland.

Positive aspects of UAV technologies: Drones and gliders can be used for mapping and monitoring. Less noise and limited environmental disturbance with drones, satellites, etc. Inaccessible sites become accessible very rapidly. Limited operational expense (limited staff requirement; limited expenses fuel, vehicles, …). UAV technologies create new skilled jobs, not only for pilots but also for field observers and technicians. UAV and remote sensing can improve working conditions, facilitating the control and observation of inaccessible areas.

UAV technologies also have negative aspects, including: restrictions on flying over other people's land, licenses, permission from government agencies; and very weak legal framework or even drone ban in some countries. Affordability is also an issue: there are free drone controlling apps but no free operating software: access to high resolution data can be very costly. Drones can also be used to track illegal activities.

Remote-sensing can provide information, even during crises and in conflict areas.

Time will lead to opportunities for new technologies. Tools already exist but we need to know where we want to use them. We need professionals to operate these technologies. Specific datasets need to be created in the forestry sector.

James Roshetko:

Germplasm and genetic material have huge opportunities to empower communities and integrate them in value chain, securing sustainable timber supplies, facilitating forest and landscape restoration. We need training and capacity building to advance sustainable management of forests and make high-quality germplasm available to local communities involved in community forestry.

There is a huge interest for indigenous / under-utilized species. But a lot of the basic R&D work has not been done. Basic species trials have not yet been done. Investments are required to address this issue.

Some negative impacts are expense in funds and time to plan and conduct this early R&D work.

Clarence Gio Almoite: Further exploration of under-utilized species could have many positive impacts. Local provenance of species should be promoted for better resilience and socio-cultural impact. Under-utilized species could help restore primary forests. By many aspects further exploration of under-utilized species would be similar to what is currently happening in the bamboo and rattan sector.

James Roshetko: Any negative impact on or from the under-utilized species?

Clarence Gio Almoite: Uses, characteristics, and genetic variation (and potential) of such species are not known. It will require time to gain that information. Most under-utilized species are under appreciated because slow-growing. Some scientists and foresters in the Philippines are trying to produce fast-growing species for plantations. Exotic plantation species might be more vulnerable to natural disasters, such as floods or typhoons.

Krishnanunni Mavinkal Ravidran: A potential negative impact for using under-utilized species is that when they become commercialized, there is a risk of intensification and over-exploitation. Example of teak species in Ghana. There is a need to ensure a sustainable harvest of such species. Better governance and commercializing ethics are required.

Jalaluddin Harun: Malaysia has 2,500 species of timber trees. Under-utilized species can have good, valuable properties. We need to better understand growth, characteristics, possible uses and germplasm availability for such under-utilized species. When trees become marketable, the main issue is that species with limited availability might quickly become over-exploited, especially for those which are fast-growing. There is a huge potential for domestication and cultivation to increase availability and meet the growing demand for such species for building, furniture, etc.

Rao Matta: We often consider innovative technologies from a positive point of view, but we need to consider also their negative impacts. There are always some kind of initial resistance to innovative technologies (example of resistance to the introduction of ATMs in India).

Innovative technologies can help improve efficiency (in forest monitoring, tree planting and forest management, forest industries). Employment is a different issue: innovative technologies can bring strong efficiency gains and benefit to local communities (see the example of Nepal presented by Lok Mani Sapkota) but they can have also negative impacts (e.g., destruction of unskilled jobs). Innovative finance can bring together people, helping them to access financing opportunities, credit and markets. Mobile app technologies can help for extension, information sharing, exchanges of views, and networking (e.g., for self-help groups or crowdfunding apps). Equity and social justice are big issues, depending on how technologies are implemented in the field? Who is implementing them, with which safeguards? Modern technologies have the potential to bring in more justice and equity and enhance the livelihoods of local communities engaged in SFM.

Shahrukh Kamran: We are focusing on smallholders with no technical mindset. We need to make technologies easy to use for them. We need to choose appropriate indicators, easily understandable for non-technical mindsets. Education and research cooperation are key for technology dissemination and adoption.

Nguyen Quang Tan: Payments for ecosystem services (PES) and carbon markets provide obvious evidence of positive impacts and of financial benefits for local communities. However, there are also negative impacts. For instance, as PES or carbon credit prices increase, big actors enter the market, trying to reap all the benefits by getting access rights to forests, thus risking to marginalize or even exclude local communities. Such trends can reverse devolution of forest to local communities. We need to discuss what kind of transformations would be needed to avoid such negative impacts.

James Roshetko: Such phenomena of “capture by local elites” have become a concern in some countries of the region.

Nguyen Quang Tan: “Capture by elites” can occur at small-scale or large-scale, at local or national levels.

James Roshetko: 'Payments' – the provision of money – attracts attention of powerful people, both within and outside the community / area. Rewards for ecosystem services (RES) can be a solution; instead of direct payment the rewards are investments that benefit the community of ecosystem service providers.

Nguyen Quang Tan: Social safeguards are needed to protect access and tenure rights of local communities to forests and to ensure that their rights are not captured by more powerful actors. As PES and carbon prices increase, the disadvantage of local communities should not be neglected. Rewards for Environmental Sources (RES)[28] is also a way of managing those issues.

James Roshetko: Innovative Finance is excellent to access new and synergistic sources of funding, combining government, private industry and finance, and development funding sources. Responsible investment and green funding hold potential to combine commercial and sustainable objectives. The drawback here is that viable examples of innovative finance working on the ground seem limited.

Nur Hazwani Abdul Bahar: We need more training on what to do with data generated by remote sensing. Governments need to be suggested solutions rather than trends that they are already aware of. Remote sensing and drone technologies help local communities and NGOs to independently observe land use changes. Often, however, this observation (for instance, land clearance) arrives too late to prevent it from happening.

Rao Matta: Mobilizing innovative finance for sustainable forest management was part of my previous job. There can be dubious promises made with some innovative finance schemes, such as the 'teak investment' schemes that were very popular in India and other parts of South Asia and SEA. Experience shows that they may also facilitate fraud: many people launch crowdfunding projects, misrepresenting or obscuring the intended purpose, then disappearing after collecting the money.

Session 4. Barriers to and enabling conditions for technology uptake and upscale

Breakout Group A

Lok Mani Sapkota (Chair): If used well, innovative technologies can have both environmental and economic benefits. What are the barriers?

Tony Page: There are policy related barriers to smallholders getting involved in plantations because a lot of policies have been designed for either natural forests or large-scale plantations. We need appropriate legal frameworks for small-scale marketable plantations to enable smallholders to commercialize what they plant. It can be done by either adapting existing rules or creating new simple rules for smallholders.

CTS Nair: We need to look at 3 things:

- Technology per se, its characteristics and how it can be adapted to the context;
- Larger economic context;
- Specific context (farm, enterprise) where the technology is going to be used by individual adopters.

Many of these technologies are not scale-neutral. It is the same type of problems than the ones faced by agriculture: a big part of the population is not able to access technology because of an unfavorable environment.

Lyndall Bull: An important point is knowledge about what innovations are available and adapting them to context (customization). To do this, we need people that know both the innovation and the

[28] "Rewards for Environmental Services" (RES) are inducements (financial or not, like access to freshwater) provided to ecosystem stewards to give them incentive to enhance or maintain environmental services.

context, as well as a lot of support to ensure success. People are key. About innovations are often mentioned technological push and market pull: in forestry it is often resource push. We need to understand the market.

Andrew Lowe: For control and monitoring, governments and big actors need a network of research, service provision, technology transfer, learning, requiring institutional support. To improve harvesting, transformation, products, innovations need to be turned over to the private sector and the market. The question is what technology needs to be developed where: is it more government-led or market-led? It then requires mechanisms for technology transfer and dissemination: places for exchanges like this workshop, education opportunities, match-making with industry partners.

Lyndall Bull: It is important not to underestimate the importance of public support.

CTS Nair: Demonstration effect is key to dissemination. We need to demonstrate impact, enhancing convenience and productivity. Innovation can spread very fast. Champions play a key role. Again, there is a parallel with the agriculture sector where demonstrating has always been important.

Tony Page: There is a cycle of innovation. People need to see it first before adopting.

Lyndall Bull: I want to highlight the importance of data. As it stands, we do not have good data on what are the resources (supply) of smallholders. We need to have a better idea of the future of the demand from an independent source. It would help to develop the story of why we need investment in innovation in forestry. What are the data requirements? How to collect this data? And there could be technological options to do it.

CTS Nair: It is a competitive environment: information is not shared easily.

Andrew Lowe: There is also the question of ownership of data. Intellectual property can be a significant barrier to the development of new technologies, especially when public money is involved (with the risk that an innovation stays in a shelf). In Australia, there has been a significant evolution in Universities that were holding back to their intellectual properties (IPs) and are now handing them to the private sector.

CTS Nair: We would like everything to be open access but there is also the need for incentives to innovate.

Andrew Lowe: We need also to look broadly to technologies being developed in other sectors and that can be transferred to the forestry sector, like machine-learning.

Lyndall Bull: Forestry is still considered a conservative sector and it has an aging workforce, both characteristics that do not play in favor of industry transformation. Innovation has been more in processing and on the large-scale. How this innovation culture could be enlarged to smallholders and small enterprises?

CTS Nair: In most developing countries, there is not a clear strategy on a long-term forestry research perspective.

Chair: Forestry is often isolated: it does not collaborate enough with other sectors.

CTS Nair: We need more collaboration with agriculture, with the water sector. Technologies cut across sectors.

Chair: How the forestry sector can build this up-taking? Important to bring together resources and also users of technologies.

Andrew Lowe: I want to highlight the importance of partnerships and personal relations. Among the means, there is the system of fellowships for mature individuals with experience in the sector and who are given the possibility to explore other areas and seek cross-pollination. Those would be the people that can make the connections and bring innovations. A lot of innovations have been driven by profitability. Corporate social responsibility (CSR) can play a role for issues related to water use efficiency, soil and land degradation. This could probably drive the next wave of innovations for a sustainability agenda.

Lyndall Bull: Part of the role of organizations like FAO is to move industries towards the SDGs, to make the SDGs more tangible.

Andrew Lowe: Setting the agenda of innovation for the SDGs

Lyndall Bull: Create a demand to work with small holders, using the SDGs

Breakout Group B

James Roshetko: If you mention a barrier, please mention also the needed corresponding transformation.

Shahrukh Kamran: North-South cooperation and collaboration is a good way to overcome knowledge barriers and to facilitate transfer of digital technology. Barcoding is a very good way of getting around barriers. In some developing countries, the lack of appropriate infrastructure, of regulatory framework and the weak enforcement of existing laws and rules is leading to the marginalization of most rural populations.

Clarence Gio Almoite: Poverty and lack of knowledge also contribute to this marginalization in my country. Training and capacity building should be priorities for the government, to help marginalized communities and to prevent communities from becoming marginalized or dispossessed from their rights. Education and communication are key for sustainable forest management.

Shahrukh Kamran: The legal framework should be adapted to the technologies available in the country (e.g., example of the legal definition of forest in Pakistan: in which the tree height threshold has been reduced from 5m to 3m: monitoring and imagery technologies need to be adapted to this definition).

Jalaluddin Harun: Smallholder rubber farmers (with 1 to 10 ha) have difficulties to get a good price for timber when, after 25 years, they need to replace old rubber trees no longer interesting for latex production. Most of them are not aware of the value of rubber timber. Smallholders need to be assisted and empowered in their discussions with industrials to ensure they get the right price for timber. In this situation, public intervention is essential. In Malaysia, we established price references for rubber timber at sawmills. The government doesn’t impose a regulated price for timber but provides training and information on the market price of timber. It managed to negotiate higher prices for farmers with the processing industry. Poor farmers are the main beneficiaries of this intervention. But it also helped secure a sustainable timber supply and develop positive win-win relationships in the value-chain: rubber processors still make a good profit. Public intervention also helped stabilize timber price.

Shahrukh Kamran: Inappropriate political decisions can create more environmental stress. Government officials, community leaders and youth should be at same platform or mindset to accept and implement new technologies. There is a dire need of political and governance reforms that may have the forced trickledown effect on academic and other institutional reforms leading to community level reforms.

Jallaluddin Harun: The financing pack for tree plantation encouraged by Malaysian government covers nine species including rubber.

It is a good example of public-private partnership where the government provides the funding (USD 250,000 for 2007-2021) in the form of low-interest loans (3 percent). The loans enable borrowers to finance plantations and can be paid back only at the end of the cultivation period, with the gains from timber’s sale. 1,000 ha of trees have been planted. Tree planting is a very long-term investment and, usually, private banks are not very enthusiast. Tree plantation and cultivation was entirely managed by the private sector. The government recently agreed that the repaid loans will be reinvested in additional plantations so that the cycle continues: the initial donation of USD 250,000 is thus becoming a revolving fund. This is the first time we test this kind of scheme in Malaysia: I believe it has good chances of success. It also offers an opportunity for collaboration between the research sector and industry to develop high-value products from rubber and under-utilized species.

James Roshetko: As mentioned by Lyndall Bull, there is an opportunity for developing shared-value business strategies where farmer producers and processing industries collaborate for mutual benefits, each partner getting increased margin because the value chain has become more efficient.

An important transformation for ‘at risk populations’ and rural communities in general is training and capacity building in technologies use but also in assuming roles in other parts of the value-chain – could be semi-processing, transport, centralizing supply. Training and support are also needed to develop or enhance smallholder production systems, including not only timber but also other non-timber forest products (NTFPs). We need innovative extension services.

Jalaluddin Harun: Yes, extension services are very important. Extensive research has been conducted on rubber wood these past 30 years, that evidenced new possible uses of rubber timber. It can be converted in wood composite, in furniture (own design manufacturing). We now manage to get good prices for our products in export markets such as US, Japan, EU and Middle East. Manufacturer can be willing to pay higher price for timber if he gets a good price for furniture.

Krishnanunni Mavinkal Ravindran: Existing policies need sometimes to be adapted to suppress the barriers to adoption of innovative technologies. We have a citizen science project in Cambodia: we launched an app to monitor forest patrolling, enabling local communities to monitor the forest themselves and to get involved in forest management. However, since 2017, forest patrollers have to obtain a permit to do their patrolling work. This regulation does not allow the involvement of local communities in patrolling. In that case the technology exists but cannot be used because of the existing legal framework.

Nguyen Quang Tan: Social norms and traditions can become barriers to the adoption of energy saving and environment-friendly innovative technologies. In Vietnam people refused to use modern cook stoves because, traditionally, the fire place is a central place for social interactions. To adopt modern cook stoves, people need to be convinced that the place to cook and the fire place for social life do not need to be the same.

Shahrukh Kamran: This issue relates to cultural ethics. But sometimes, individual interests, commissions, and technological propaganda prevent the adoption of innovative technologies in a country.

Thuan Sarzynski: I worked on a REDD+ project in Vietnam with an NGO. We used a mobile app, developed by CIAT, to monitor deforestation and land cover changes with farmers. Farmers were enabled/trained to check on the ground the information/alerts generated by satellite imagery. However, there is no way to use the data generated for forest laws enforcement. The objective would be to use the new knowledge and information generated by the app for law enforcement. There are discussions to recognize these data as reliable and usable for policy and law enforcement, but it takes time: it is very slow.

Nguyen Quang Tan: Innovative technologies can become very sensible when they contradict data reported through governmental processes and impact for instance forest area assessment. Innovative technologies might be more precise than official data from governments. Governments might be reluctant to use these new technologies for their assessments.

Shahrukh Kamran: Local communities and industries may be reluctant to adopt new technologies due to fear of economic or job losses. As a result, in some countries, primitive technologies are still used for harvesting and no one is promoting innovation. There is no record of chainsaws, no harvesters. Old pulley systems, old Bedford trucks for transportation, use of agricultural tractors and draught animals for timber extraction, etc. Also, some local actors may be reluctant to use new technologies because they want to avoid transparency. The local forest communities are afraid of accepting new technologies due to lack of capacity building and the fear of risking to lose their jobs because of technologies. Such factors may induce the communities to contributing to false technological propaganda.

Rao Matta: How could we address this kind of challenge?

Shahrukh Kamran: We need to involve policy makers and leaders at local levels.

Thuan Sarzynski: Younger policy makers in rural areas are more open to change and can help empower farmers and foresters. Older ones are more reluctant to give more power to actors and to leave new technologies inform policy-making. We should focus on discussing with these young policy makers.

Rao Matta: Were the incentives given by the Malaysian government for smallholder rubber plantation a special policy or a program? This could be cited as an example for other countries to follow.

Jalaluddin Harun: It is a program initiated by the ministry of plantation, industry and commodities, not a policy. Procedure and guidelines were coming from the ministry. Now the program is coming to the end of the borrowing time and some of the plantations are ready for harvesting. Basically, the program doesn't really focus on smallholders (i.e., in Indonesia, less than 10 acres). On average, the borrowers have 1,000 ha in average. In 15 years, we managed to create new plantations on 126,000 ha. I personally feel it is quite a success due to public-private cooperation.

Rao Matta: The kind of challenges we face in other countries is that small landowners do not have proper papers. How do banks manage the loans? Do they hypothecate? We are looking to innovative solutions for current challenges. Investments take lot of time to get some returns. Do investors and landowners get a regular payment while the trees are growing? We have seen that kind of schemes in other countries like Latin America: they don't insist on papers because you don't have any land titles but in lieu of them they hypothecate standing trees and advance loans.

Jalaluddin Harun: Most of the land doesn't belong to the borrowers: they rent the land from the state government. They lease the land for let's say 30 years. Once we have the approval of the state executive committee, we process the loan. It is not like a bank loan where you have to own the land and ensure that if anything goes wrong with the plantation the bank will secure the land. These are long-term loans, on 15 years. It's not a short time. This is why 70 percent of the borrowers prefer to plant rubber trees because while waiting for the tree to produce timber, they produce latex, compared to acacia or teak where nothing is produced till the harvest. Initially it was supposed to be a one-off loan. However, the government recently agreed to transform this fund in a revolving fund. This is why I believe that this soft loan will generate a lot of economic activities in terms of forest plantation.

James Roshetko: One important transformation for "at-risk" population and rural communities in general is training and capacity building, especially to use local technologies (including digital tech, improved harvesting process of timber or NTFPs) so that these populations are not marginalized and can assume new roles in the value chain: breaking the centralization of supply. Local communities might not be completely aware of what the traders are looking for. Helping local communities understand the market specifications of the product is very important (good example being palm sugar). Farmers and traders both benefit from sharing information and talking to each-other. It's a social innovation when communities and the traders start talking to each other for mutual benefit. Actually, it is a win-win-win situation- farmers, traders and consumers benefit.

Jalaluddin Harun: This is what we call extension service. In Malaysia for instance, in rubber processing once a tree is harvested in the estate where cultivated, you have to react fast and treat the rubber tree and bring it immediately to the mill to avoid blue stain fungi (*Botryodiplodia theobromae*). Once tree converted from sawn logs into sawn timber, it needs immediate chemical treatment for preservation because rubber tree is rich in starch and sugar. If not treated, the value from rubber sawn timber wood will be very low. In Malaysia, we have established standing operating procedure for this.

Appendix 4. Draft annotated outline

Introduction

Background

The ‘Third Asia-Pacific Forest Sector Outlook Study’ (FAO, 2019), launched in June 2019 at the Asia-Pacific Forestry Week in South Korea, highlighted that the use of **innovative technologies**, including ICT technologies and new wood-based products, creates huge opportunities and challenges for sustainable forest management in the Asia-Pacific region. Nearly 300 forestry students and young professionals from more than 30 countries, consulted for this Outlook Study, found that the uptake of new technologies in the forest sector has been too slow and called for better opportunities for young people to learn and apply these new technologies. They highlighted the need for greater participation and transparency in forest governance in the Asia-Pacific region (FAO, 2019).

Following-up on this outlook study, FAO and CIFOR, lead center of the CGIAR research programme on Forests, Trees and Agroforestry (FTA), engaged in a collaboration to develop a roadmap on innovative forest technologies. In particular, FAO and FTA are preparing a technical paper on the use of innovative technologies in forestry and forest management in Asia and the Pacific with key recommendations (policy and concrete actions) for their application in sustainable forest management.

Purpose of the paper

The purpose of this technical paper is to evaluate how the application of innovative technologies in the forest sector can contribute to sustainable forestry and sustainable forest management in the Asia-Pacific region.

Preparation of the Study on Innovative Technologies

The study on innovative technologies in forestry and forest management was comprised of the following components: scoping paper, online inception workshop, web-based public survey, interviews and survey of experts, youth essay competition, innovative technology online workshop, internal review of the draft paper, and validation workshop. Each of these steps will be briefly described.

In conducting the roadmap study, FAO and FTA strove to be inclusive of all stakeholder groups and individuals involved or interested in the forestry, forest management and related sectors. Participation in the online inception workshop and web-based survey were open to all interested persons, as individuals or institutional representatives. Additionally, specific individuals and institutions were informed of the study and requested to participate in various components. This included government agencies, intergovernmental organizations, private sector firms, civil society organisations, academia, research institutions, as well as individual professionals. A paragraph will include main numbers related to categories of participants.

Specific efforts were made to engage youth, most explicitly through the essay competition. This combination of open and target approaches enabled broad and inclusive participation of forest planners to managers, technology developers to users, policy makers to field foresters, students to young professionals, and gender.

Content / Structure of the paper

This paper will describe the main challenges and opportunities associated with the application of innovative technologies in the forest sector. It will also describe the technical, economic and social barriers preventing the uptake and upscale of innovative technologies in the forest sector. It will consider the institutional changes needed to overcome these barriers and advance sustainable forestry in the region. It will finally suggest key recommendations (policy and concrete actions) to ensure that the use of innovative technologies effectively contribute to sustainable development.

1. Framing: concepts and definitions

1.1. Scope

Geographical scope

The geographical scope of the roadmaps covers the countries and territories of the FAO region of Asia and the Pacific (see: http://www.fao.org/asiapacific/countries/en/). This includes the five sovereign states in free association with New-Zealand or with the USA, as well as nine French and USA dependent territories situated in the region. However, it excludes France and the United States of America (USA) mainland, situated outside the region. The Russian Federation, although covering 29 percent of Asia, is also excluded because issues related to Russian forests are usually discussed within the European Forestry Commission.

The 49 countries and territories included in the scope of the innovative technology roadmap are listed here. Afghanistan, American Samoa (USA), Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Cook Islands (New Zealand), Democratic People's Republic of Korea, Fiji, French Polynesia (France), Guam (USA), India, Indonesia, Iran (Islamic Republic of), Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Maldives, Marshall Islands (USA), Micronesia (Federated States of) (USA), Mongolia, Myanmar, Nauru, Nepal, New Caledonia (France), New Zealand, Niue (New Zealand), Norfolk Island (Australia), Northern Mariana Islands (USA), Pakistan, Palau (USA), Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Timor-Leste, Tokelau (New Zealand), Tonga, Tuvalu, Vanuatu, Viet Nam, and Wallis and Futuna Islands (France).

Forest, forestry and the forest sector

Multiple and very diverse definitions of forest and wooded areas are used around the world, reflecting both the diversity of forest ecosystems and the diversity of human perceptions and uses of forests. This paper will use the FAO definition of forest used for the latest FAO Global Forest Resources Assessment (FRA2020): "*land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ"* (FAO, 2018a). This widely used and recognized definition allows compared analysis across countries at regional or global levels.

In the 'Third Asia-Pacific Forest Sector Outlook Study' (FAO, 2019), the terms "forestry" and "forest sector" are used interchangeably to encompass "all economic activities that mostly depend on the production of goods and ecosystem services from forests". During its 28th session (17-21 June 2019) held in Incheon, South Korea, the Asia-Pacific Forestry Commission (APFC), considering the "impacts of technological advancements on forests and forestry", also used this broad definition of forestry and the forest sector covering not only forest management but also forest industries (APFC, 2019).

1.2. Sustainable forest management

The global human population is 7.8 billion, with an estimated annual growth rate of 1.05 percent. While the growth rate has declined in recent years, the human population is projected to reach 8.5 billion in 2030, 9.7 billion in 2050 and 10.9 billion in 2100, according to the medium-variant projection of the United Nations (UNDESA, 2019a). Human population growth, and an increase in wealth, exerts pressure to convert forests to agricultural, industrial, and residential uses to satisfy the growing demand for food, fuel, wood fibre and other tree products, further intensifying the production pressure on the surviving forest systems. Simultaneously, these forest systems are expected to provide a diverse array of environmental services. Thirty years ago, the Brundtland Commission report identified the crucial global challenge to sustain the provision of forest products and services in ways that “meet the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). Sustainability in this sense does not mean keeping things the same, but rather requires the constant development of new ideas and options (innovations) to meet current needs and future challenges (van Noordwijk et al. 2008). The United Nations General Assembly (UNGA) recognizes “that sustainable forest management (SFM), as a dynamic and evolving concept, is intended to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations” (UNGA, 2008).

All types of forests should be under some form of SFM: natural forests (primary and secondary), woodlands, plantations, smallholder tree farming systems, and other ‘trees outside forests’. Short descriptions of each forest type will be provided in text boxes or an annex.

Details will be provided the linkages between the roadmap and the United Nations Strategic Plan for Forests 2030; the Sustainable Development Goals (SDGs) of the United Nations, and findings of the Global Forest Resources Assessment 2020.

1.3. Innovation as a process

This section will briefly summarize the main discussions on the notion of innovation in order to apply it to the topic at hand.

For the purpose of this study, the term “innovative” technologies embraces: (i) new technologies either in the generation phase, or in the pre-pilot or pilot phase, that could become mainstream or mature before 2030, as well as (ii) recent technologies emerging for new purposes or in new contexts. These technologies could perform better than currently utilized technologies, or even provide new functions.

Examining innovations, the study will distinguish: incremental vs. transformative and disruptive innovations; product vs. process innovations; technological vs. institutional innovations. Innovation covers products and processes; technologies and institutional changes. The relevance of agroecology and similar innovative approaches (HLPE, 2019) and related concepts (sustainable food and agriculture) will also be examined.

2. Innovative technologies in the forest sector

The APFC Secretariat (APFC, 2019) distinguished two types of innovative technologies impacting forestry: (i) those developed outside the forest sector, for example, information and communications technologies (ICTs) as well as geospatial technologies; and (ii) those developed within the forest sector, for example, production of new-generation wood-based materials such as engineered wood products, bioplastics, natural chemicals, bioenergy products, and pharmaceuticals.

Innovative technologies have the potential to provide new products and services, improve productivity and cost efficiency, thus generating further income and employment opportunities in the forest sector. Innovative technologies, including new processing technologies, have the potential to reduce waste and improve resource-use efficiency, thus increasing profitability of the forest sector and contributing to sustainable management of natural forest resources. They can also limit or avoid collateral environmental damages to ecosystems (e.g. pollutions, destruction of untargeted organisms or species). Product and process innovations can help to preserve natural and primary forests by opening new markets for certain wood products (e.g. small-diameter timber or fast-growing tree species).

These innovative technologies can be used in different contexts for different purposes. This chapter starts by identifying and presenting four main categories of innovative technologies: (i) digital technologies; (ii) biological technologies; (iii) technical innovations (in processes and products); and,

(iv) innovative finance and social innovations. The presentation of each category will be illustrated with concrete examples and case studies. Building on these presentations, the last section will then propose a framework to assess how different innovative technologies can perform different functions in the forest sector and pursue specific objectives.

2.1. Digital technologies

Digital technologies that facilitate efficient, accurate, cost-effective monitoring of forest and land resources are among the most important and consequential of innovative technologies. As a group those technologies are a key tool to verify that the deployment of technologies and general utilization are not increasing forest exploitation and degradation. They can help: monitor and map forest status and trends in the region; detect early forest fires and other natural or human threats; track illegal logging and other illegal activities; clarify forest tenure and access rights; thus, improving transparency and accountability and advancing forest conservation and sustainable management. Online platforms, such as SEPAL13, Global Forest Watch14 and others, are collecting and sharing largely 'real-time' data that can inform more reactive and effective sustainable forest management strategies. The Covid-19 pandemic provides an incentive to better use such digital platforms and tools. Digital technologies make monitoring more efficient, accurate, affordable and accessible. They can also highlight the ecosystem services provided by forests and help promote them, including through ecotourism. Digital technologies (e.g. social media, video-conferencing) can also encourage more active participation in decision-making and facilitate innovative governance mechanisms. These tools can also promote citizen science and citizen control. They can be very powerful, but they should be properly managed to ensure the quality of information.

ICT technologies

- (Big) data analysis and storage, cloud computing, shared user platforms and analysis sharing
- Timber tracking, certification and monitoring (harvesting)
- Emerging technologies such as artificial intelligence, machine learning, digital twin replica (concept) – these can be matched with geospatial technologies
- Tools that enhance transparency and participation, e.g.: social media, video-conferencing (these two apply to most categories – require adjust way of working and thinking)
- Crowd sourcing of data and citizen science

Geospatial technologies

- Drones or unmanned aerial vehicles (UAV),
- Satellite-based observations and other remote sensing technologies (RADAR, LIDAR), (including low-level micro-satellites – particularly for real time data collection property and forest areas)
- Forest Reference Emission Level (FREL) through LIDAR
- Global positioning systems (GPS),
- Geographic information systems (GIS),
- Optical data and optical data storage
- Mobile phone apps with automatic reporting (smart tech for real time 'M&E and reporting')
- Acoustic and camera monitoring,
- Monitoring and early warning systems.

2.2. Biological technologies / Innovations linked to biological processes

Genetic resources (germplasm) can be the single most important input in any tree production system. The genetic and physical quality of the germplasm used defines the upper limit of the system's potential yield, as well as, the productivity of other inputs (agricultural chemicals, labor, management, etc.). Independent of other inputs, the germplasm quality makes significant contributions to productivity. Genetic material can be the single most important input in any tree production system. The genetic and physical quality of the germplasm used defines the upper limit of the system's yield and the productivity of other inputs (agricultural chemicals, labor, management, etc.). Independent of other inputs, the quality of the germplasm makes significant contributions to productivity. Significant intra-specific genetic variation occurs regarding site adaptability, growth characteristics, wood properties, fruit production and many performance parameters of many tree species used for industrial to subsistent purposes. The genetic superiority in these traits can be captured through proper selection and/or formal breeding of the right populations and genotypes to improve niche complementarity, productivity, quality and profitability, when matched to specific planting sites and user requirements (Dawson *et al.*, 2014). DNA identification can improve traceability in forest value chains, contributing to the prevention of illegal timber and NWFPs harvesting. There are broad concerns regarding the availability and accessibility of quality germplasm, and the matching of the germplasm to site conditions and expected use of the product (reduced lignin content, biomass production, etc.). As quality germplasm is often in limited supply and not readily available, what steps can be taken to broaden access to quality germplasm at a reasonable investment. What approaches can be used to multiple larger quantities of quality germplasm to facilitate dissemination to users, including smallholder farmers and communities who often have the least access to formal germplasm sector.

- Genetic selection,
- Tree breeding,
- Mass production of and access to superior genetic material (i.e. clonal propagation)
- Innovative and effective germplasm dissemination (including genetic business plans)
- Other biotechnologies,
- DNA identification and tracking,
- Rapid multiplication of clonal (improved) material.

2.3. Technical innovations in products and processes

<u>Process innovations: innovative practices in the forest sector</u>

From forest management to industrial processes:

- refined site preparation, planting and management
- improved chainsaw technology reducing waste
- improved harvesting (e.g. RIL) and transportation
- improved industrial processing efficiency and recovery rate (reduce waste)
- improved processing technology for use of small-diameter logs - making secondary forests, plantations, smallholder systems viable sources of raw material

<u>Product innovations: a new generation of wood-based materials</u>

- New generation of wood-based materials such as engineered wood products, cross-laminated timber,
- bioplastics, natural chemicals,
- bioenergy products, alternative bioenergy species, and pharmaceuticals.
- nanotechnology,

2.4. Innovative finance and social innovations

A broad range of financial technologies and mechanisms - including blockchain, blended finance, green bonds, responsible investments and crowdfunding - can revolutionize finance for sustainable forest management. The challenge remains how to utilize and deploy these financial innovations.

Innovative finance technologies

e.g.:

- Blockchain,
- ICT-enabled mobile services, financial services and e-commerce that facilitate the access to resource, value chains, and transactions.

Innovative finance mechanisms

e.g.:

- Blended finance,
- Green bonds,
- Responsible investments,
- Crowdfunding,
- Improved transaction technology and value chain integration,
- e-commerce. Online trading for communities / small-scale producers to avoid paying commissions to middlemen/traders. Often not completely eliminate traders (who provide many functions) but make the product-value chain more efficient – reducing the nodes and transaction costs in the chain,
- Environmental service payments and rewards mechanisms.

2.5. Different technologies perform different functions: an assessment framework

Based on the previous discussions, this section will examine how the use of innovative technologies affect different functions throughout the product-value chain and the extent to which this contributes to sustainable management in the forest sector. Among these functions are (not an exhaustive list): species selection, genetic resource evaluation, production and breeding (best quality genetic material makes management viable – most important input that helps other input achieve potential; forest monitoring; forest management (design (spacing, site prepare), tree planting, silviculture, forest protection; wood and NWFP harvesting; wood and NWFP processing (first and second transformation); quality control; traceability; transport; distribution; final use of wood-based or non-wood forest products (for e.g. medicine, energy, packaging, construction material, furniture…); reuse and recycling; waste management; marketing; etc.

Assessing the strengths and weaknesses of each innovative technology in performing these different functions will ground an analysis of their advantages and disadvantages in different contexts. Such an assessment can offer a framework to compare very different innovative technologies, whether "modern" or "traditional", and help identify and categorize the most promising innovative technologies for the forest sector in the coming decade. Innovative technologies can not only perform existing functions better than currently utilized technologies but may also provide completely new functions, products and services. The way one technology performs one function, as well as its positive or negative impacts for people and the planet, may vary significantly across contexts and, even in the same context, may be perceived differently by different stakeholder groups. In addition, the social, economic and technical contexts are also evolving.

2.6. Application of technologies from other sectors

Application of the technologies to improve resource management outside the forest (including on agricultural lands) 'can' reduce production/use/pressure on the forest (particularly primary forests). Draw experience from sectors of artificial intelligence and agriculture.

Combining of technologies from various sectors – in the whole value chain – open minded, thinking outside the box

Technology used to improve planning and management of coastal areas (parks, ecotourism sites, …) enhances protection/sustainable management of the natural resources from production uses all the way to tourism. This can (should) lead to improved eco-tourism income opportunities for local people (in places where eco-tourism is established). In Malaysia, the technology applied to coastal areas also protects the fisheries in mangroves and other areas. Providing sustainable and improved income opportunities at a large and community scale.

Sharing capacity between sectors – ex Malaysian space agencies promote/facilitate precision and cost-effective M&E – apply aerospace technology to forest management

3. Innovative technologies: challenges and opportunities for the forest sector

The Fourth Industrial Revolution,[29] through extraordinary technological advances (e.g. artificial intelligence, digital twins, etc.), is merging the physical, digital and biological worlds in ways that create both huge opportunities and threats. This chapter will describe the main challenges and opportunities, advantages and disadvantages, associated with the application of innovative technologies in the forest sector in different contexts. This chapter will also consider the potential negative impacts of new technologies on local communities (access to natural resources, food security and livelihoods), natural ecosystems and biodiversity.

Innovative technologies can provide new products and services, reduce operational costs and improve productivity, thus generating further income and employment opportunities in the forest sector. The adoption and dissemination of innovative technologies will likely generate major shifts in forest value chains, modifying wood demand, including increased needs for high quality and diverse planting material, and the labor market. There is an assumption that technologies and their deployment are good and generally will improve conditions with benefits outweigh the risks. In some cases, traditional (previous) method may be as efficient/effective and less costly. There will often be a need to and mitigate possible negative consequences. The economic, social and environmental impacts of technologies should be closely monitored and analyzed before implementation. This can be a challenge as the development and adoption of innovative technology is often driven by conditions (lack of labor, high labor costs, etc.) and deployed piecemeal, gradually over time. Bottom-line: application of innovative technologies carries both threats and opportunities for sustainable forest management and society. As much as possible, the potential negative impacts of innovative technologies need to be anticipated and plans/approaches developed to minimize / manage the negative impacts.

Innovative technologies have the potential to generate new skills and new job opportunities (e.g. drone operator). Innovative, safer and greener jobs can help make the forest sector more attractive, in particular to young professionals, who will be the forest managers of tomorrow. However, innovative technologies, including automation, might also lead to the loss of many unskilled jobs and exclude many people with limited human or financial capacity to use them. Innovative jobs might benefit skilled external people more than local communities. many people with limited human or financial capacity to use them. Innovative jobs might benefit skilled external people more than local communities.

This chapter will be illustrated by recent and current trends as well as by outlooks for the future.

[29] See: https://www.weforum.org/focus/fourth-industrial-revolution

3.1. Key Challenges to Technology Uptake and Scaling

Two main barriers that limit the uptake and scaling of innovative technologies are: (i) the lack of capacity (in terms of infrastructures and equipment, human capital and financial resources); (ii) policies and regulations.

A major challenge is “scale-downing” innovative technologies, so that they can also benefit to traditional users, smallholders and local communities, even with limited human and financial resources, and in remote areas. In other words, technologies should benefit those who really take care of forests. Technology adoption is highly context-specific and very uneven across the region. To be adopted, a technology must be adapted to the local context (e.g. income and education levels, labour market, infrastructure, cultural values, etc.). This is why technology dissemination needs to follow a decentralized, bottom-up process, starting from local needs and engaging local communities. Investment, infrastructure (e.g. access to electricity and the Internet), education and capacity building will be key not only to facilitate access to innovative technologies, but also to support those at risk of losing their jobs because of technology (e.g. older, local, and unskilled workers). Public procurement and public support of research and development are powerful tools to support the uptake and upscaling of innovative technologies. Private sector, as part of multi-stakeholder approaches and partnerships, will be crucial for technology-transfer and dissemination.

Innovative technologies and their potential applications are rapidly evolving. The long timeframe of tree growing does not match the rapid evolution of technologies and rapid shifts in wood demand. In this changing context, policies often lag behind technological advancements and may restrict the use of new technologies (e.g. legal restrictions of drone flights; use of wood-based products in tall-building construction; etc.), thus limiting their potential benefits. However, strong regulations are needed to limit the negative impacts of innovative technologies. Regional and international cooperation, including further work to increase the harmonization and interoperability of national rules, norms and standards, is needed to support the uptake and upscaling of innovative technologies.

3.2. Shifts in wood demand/forest value chains in the context of bio-economy/green economy

Main trend in Asia-Pacific: increased demand for industrial roundwood and decreased demand for woodfuel (APFSOS III Ch3).

Low-carbon technologies hold a huge promise to address the challenges of climate change and sustainable development. Wood-based products can provide sustainable alternatives to traditional products, non-renewable and more energy-intensive. For instance, wood-based bioplastic can be used instead of fuel-based plastics for packaging, or cross-laminated timber instead of concrete and steel as construction material.

For instance:

Development of new engineered wood products enables new uses for wood products (e.g. construction of tall mass timber building with cross laminated timber) – likely to increase demand for industrial roundwood.

Better access to modern energy will reduce traditional biomass burning and reduce demand for woodfuel.

Development of internet and digital media as well as increased use of recycled paper will reduce the demand for graphic paper and for virgin fiber pulp. On the other hand, the development of e-commerce might increase the demand for paperboard and cartonboard used for packaging (e.g. APFSOSIII p100-101; and APFC §3, §9).

From local to global value chains: ICT technologies can allow SMEs to enter/access global markets.

3.3. Improved resource use efficiency

Innovative technologies can also reduce waste and improve energy- and resource-use efficiency, thus increasing profitability of the forest sector and contributing to the sustainable management of natural forest resources. Precision technologies can also limit or avoid collateral environmental damages to ecosystems (e.g. pollutions, destruction of untargeted organisms or species). The potential benefits of uptake of technologies (harvesting to processing technologies) to optimize production efficiency and minimize losses along the value chain should be highly considered.

This section will cover economic and environmental aspects linked under the concept of resource efficiency.

Enhanced productivity

Income generation and economic growth

- Recycling and value added to lower value wood
- Utilization of species not previously considered of commercial value

Reduced waste

Reduced environmental footprint?

Better resource use efficiency will lead to reduced environmental footprint (land, water, energy, GHG emissions).

On the other hand, innovative technologies, if not used wisely, can accelerate deforestation and forest degradation, habitat destruction and species extinction. Increased productivity and profitability are a further incentive for over-harvesting in natural forests or for replacing natural forests by intensive plantations. Increasing the risk of deforestation and forest degradation (increasing in particular the pressure on primary forests)

3.4. Increased needs for high quality and diverse planting material

“Plant the right tree, at the right place, for the right objectives.”

Planting material must be adapted to local conditions and might need to meet specific requirements in terms of: productivity, adaptation to climate change, drought tolerance, salt tolerance, pest resilience, etc.

Planting material must be adapted to the final objective and might need to meet specific requirements in terms of e.g.: proportion of cellulose, chemical composition, timber height, weight and diameter; or timber straightness. Product and process innovations can help preserve natural and primary forests by opening new markets for certain wood products (e.g. small-diameter timber or fast-growing tree species).

3.5. Employment and social justice

Innovative technologies have the potential to generate new skilled jobs (e.g. drone operators, ICT developers and operators, etc.). Innovative, safer and greener jobs can, in turn, help make the forest sector more attractive, in particular to young professionals. However, innovative technologies, including automation, might also lead to the loss of many unskilled jobs. This might marginalize traditional practices and impact negatively people, with limited human or financial capacity to adapt, involved in traditional labor-intensive management systems, common in the region. Innovative jobs might benefit external people with a different set of skills rather than local communities, exacerbating social inequalities.

Therefore, the choice of technologies must be adapted to local conditions (including: labour market, level of education, skills and capacities) and potential social impacts of technology adoption must not be overlooked.

4. Enabling the uptake and upscale of innovative technologies for sustainable forestry

At the large scale, innovative technologies increase effective production and reduce damage, leading to greater profitability. At the small scale (communities) transparency improves knowledge/awareness which can lead to jobs and income.

High capital needs may restrict people to embrace technologies. Appropriate technologies need to be embraced (that benefit the primary stakeholders), avoiding disruptive technologies. Increasing the opportunities for small-scale actors needs to be considered for improving livelihood opportunities. Technologies need to be adapted to the scale needed. More inclusive approach is needed than leaving some stakeholders behind. Popularizing technologies can help in greater transparency and accountability. Social media can help advance the actions for forests.

This section will analyze the technical, economic and social barriers preventing the uptake and upscale of innovative technologies in the forest sector. In particular, the study will explore: (i) the lack of capacity (e.g. limited access to natural resources, limited access to information, limited access to credit and markets, limited transparency and limited participation in decision making); and, (ii) restrictive policies and regulations lagging behind the rapid evolution of technologies and the rapid shifts in wood demand.

It will also consider the institutional changes needed in forest sector governance (land planning, land tenure and other relevant development policies), to overcome these barriers, to support the uptake and upscale of innovative technologies in the region, and to ensure that these technologies will effectively contribute to sustainable forestry and sustainable forest management. Regional cooperation, investment, infrastructure development, education and capacity building will be key to support technology transfer and dissemination, and accompany the populations at risk of being marginalized by these technological advances. The public and private sectors will have to work hand-in-hand to address these issues.

4.1. Innovative technologies uptake and upscale

This section will analyze the process of dissemination of innovative technologies and the actors involved (without overlooking the gender dimension). The rate of uptake of innovative technologies is far from uniform in the region, with use varying by country and sub-region. There is also a greater uptake of technologies to increase forest productivity and industrial efficiency in the planted-forest sector than in the management of natural forests.

Nearly 300 forestry students and young professionals from more than 30 countries, consulted for the APFSOS III Outlook Study, found that the uptake of new technologies in the forest sector has been too slow and called for better opportunities for young people to learn and apply these new technologies. They highlighted the need for greater participation and transparency in forest governance in the Asia-Pacific region (FAO, 2019).

4.2. Land tenure security: improve access to forests and natural resources

Land tenure security also improve capacity to invest in innovative technologies.

- Social forestry and community forestry management options

4.3. Access, education and training: improving uptake of information

Lack of access, investments and capacity, legislation (restrictions on products/ area), lack of literacy and basic education. Need to focus new job and training opportunities on populations effected by (unintended negative) impacts – often rural, limited formal education opportunity/achievements

Addressing access and capacity to use technologies are key to wider adoption of innovations.

Transfer to local communities very important: the technology, capacity to use the technology, and the access to the opportunities created by the technologies. Need a plan to be sure that benefits reach the communities. Target the youth (both genders) as the managers of tomorrow's forest and forest resources. In short, the technology should be accessible to local communities.

There are two related but different items here. Capacity building transition of professional who's jobs are threatened / eliminated by the 'new' technologies and similar focus for rural communities to assure they also benefit from the deployment of new technologies (some of the rural people are the low-skill laborers being replaced others are local residents not currently engage. Addressing youth's interest is a way of keeping youth on the farm and engaged in adequately lucrative career (not employment).

Even in rural areas, youth are often technologically savvy. This is huge opportunity to engage youth in forest related opportunities. Big opportunity to engage/deploy/employ the local community to monitor and gather information – win-win – employment and protect their environment.

Uptake of new technologies requires a minimum level of information and skills.

- ICT training and awareness – for broad array of stakeholders – rural residents, low-skilled laborers, field staff, established professional, to government staff/officials
- Effective locally oriented extension approaches
- Extension materials that deliver effective messages that are adoptable by target audiences
- Shared-value business strategy collaboration between farmer producers and traders, include group marketing approaches at the community level
- Preservation of Indigenous Knowledge (IK) could be effective and enhanced if matched with technological application
- Focus on youth

4.4. Sustainable value chains: improve access to credit and markets

Financial resources and secure output markets are needed to risk an investment in new technologies.

Needed physical and ICT infrastructures.

Environmental services rewards and payment schemes can be applied to improve returns.

If possible, give an idea of the investments needed in the region.

4.5. Forest sector governance: improve transparency and participation

Digital technologies and institutional changes can help strengthen participation, transparency and accountability in forest governance, thus advancing the sustainable management of natural resources.

Focus on SMEs, women, marginalized and vulnerable groups (that may otherwise be excluded from technology uptake), youth.

4.6. Cooperation with Government Agencies

The uptake and upscaling of innovative technologies in sustainable forest management should be matched with the application of relevant policy and regulatory tools to check and balance for any negative impacts of technologies, especially in the social values that accompany sustainable forest management (Jobs, the capacity of small and medium scale forestry enterprises to utilize these technological tools sustainably).

5. Innovative technologies for sustainable forestry: key recommendations

Based on previous chapters, this final chapter will suggest key recommendations (policy and concrete actions) to ensure that the use of innovative technologies effectively contribute to sustainable development.

This section could be organized by scale?

- International cooperation
- Regional cooperation,
- National strategy,
- Landscape and integrated approaches at the local level

This section could be organized by stakeholders (actions directed to various categories of stakeholder)?

- Intergovernmental organizations and governments should…
- Private actors should…
- Civil society and local communities should…
- Academic institutions should…

Or this section could be organized by topics, highlighting a few areas of focus / domains of intervention where the uptake and upscale of innovative technologies could make important contributions to sustainable forest management, for instance:

5.1. Strengthen regional cooperation to support the uptake and upscale of innovative technologies for sustainable forestry

In particular on cross borders issues: climate change, watershed management, technology transfer, regional trade of forest products, international finance for innovative forest technologies, support to least developed countries in the region, etc.

Also, there is a need to have a regional network (government level) to agree on technology use and share information (M&E, illegal trade, hotspot, primary forest management … very important here). Also, huge plus on technology deployment and cost sharing. Interoperability and coordinating harmonizing national / regional standards. Role of FAO or of the Regional commission?

Huge opportunity for south-south cooperation/technology exchange/development. More similar natural, social and economic environments.

5.2. Harness the potential of innovative technologies to improve monitoring of forest resources and track illegal logging and illegal trade of forest products

ICT technologies and geospatial technologies allow better monitoring of forest resources and forest sector value chains. Allow precision forestry and more sustainable management of resources along the value chain. Allow greater transparency and participation.

5.3. Develop the infrastructures needed to boost innovation and sustainable development in the forest sector

Physical infrastructures and ICT infrastructures needed, at regional, national and local level, to reach the objectives mentioned in Ch4 (improved access to information, resources and markets).

Creation of new value chains for new products.

5.4. Invest in innovative research, development and education models

Harness the potential of innovative technologies to develop new research, development and education models:

- Big data analysis
- Participative research and data collection
- New learning models (MOOCs, farmer-to-farmer networks and other horizontal knowledge sharing models…)

Invest in research and development on emerging technologies (not yet commercialized) and on the conditions under which they can contribute to sustainable development.

5.5. Create innovative governance mechanisms at all scales

Use innovative technologies to improve transparency and participation

Allow reactive forest governance based on real time accurate information (e.g. early warning systems)

Strengthen partnerships

Regulate the use of emerging technologies to limit their negative impacts and optimize their contribution to sustainable development.

5.6. Encourage youth participation in the forest sector

- improve human (youth) capacity in data access, processing and analysis
- improve training, knowledge and preparation for job market
- makes forestry and forest sector attractive profession for youth
- youth have internet access and proficiency

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Appendix 5. Expert presentations

This appendix lists all the Powerpoint presentations displayed during the workshop. The presentations can all be downloaded here.

1. Dr. James Roshetko, ICRAF/FTA, Indonesia: Introduction to Day 1 [pdf]
2. Dr. Junqi Wu, Director of Communications, International Bamboo and Rattan Organization (INBAR), China: Harmonized system code for monitoring international trade of bamboo and rattan [pdf]
3. Dr. Tony Page, Tropical Forests and People Research Centre, Forest Research Institute, University of the Sunshine Coast, Queensland, Australia: Development and deployment of teak germplasm in Papua New Guinea [pdf]
4. Dr. Jalaluddin Harun, former Director General of Malaysian Timber Industry Board (MTIB) and Fellow of the Academy of Sciences Malaysia (ASM): Rubberwood – Valuable source of plantation grown timber for high value-added products in Malaysia [pdf]
5. Dr. Bas Louman, Programme coordinator, Tropenbos International, the Netherlands: Innovative finance for forestry [pdf]
6. Dr Vu Tan Phuong, Deputy Director in Charge of international cooperation, Academy of Forest Sciences, Vietnam: Forest technologies application in Vietnam [pdf]
7. Dr. Wu Shengfu, National Forest Products Industry Association, China: Innovative practices in the woodworking industry in China [pdf]
8. Dr. Oliver Coroza, Center for Conservation Innovations Ph, the Philippines: Geospatial solutions to conservation [pdf]
9. Dr. James Roshetko, ICRAF/FTA, Indonesia: Introduction to Day 2 [pdf]
10. Mr. Lok Mani Sapkota, RECOFTC, Nepal: Social innovations in community forestry: an application and success case from Nepal [pdf]
11. Dr. Andrew Lowe, University of Adelaide, Australia: Using DNA to identify illegal and conflict timber in global supply chains [pdf]
12. Dr. Lobzang Dorji, Director of the Department of Forest and Park Services, Ministry of Agriculture and Forests, Bhutan: Use of innovative technologies in sustainable forest management in Bhutan [pdf]
13. Dr. James Roshetko, ICRAF/FTA, Indonesia: Introduction to Day 3 [pdf]