

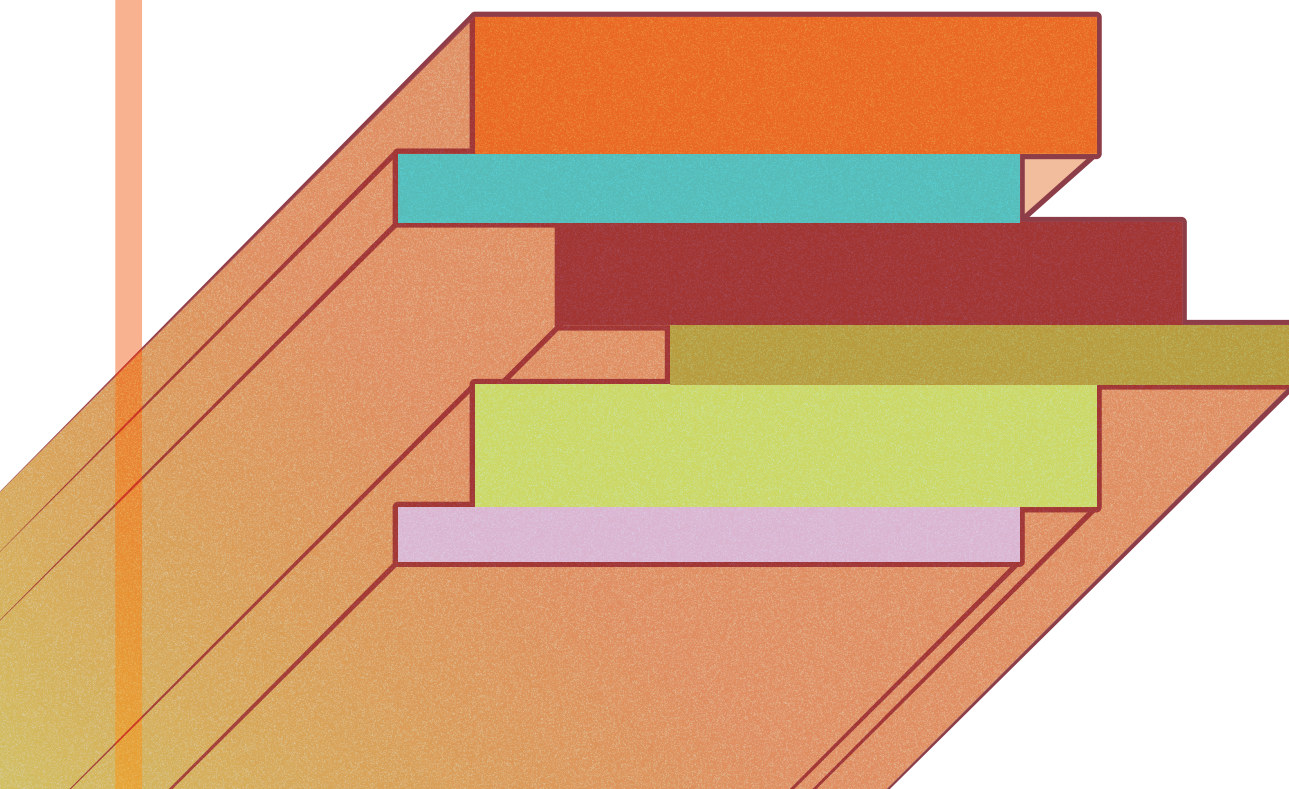


RESEARCH  
PROGRAM ON  
Forests, Trees and  
Agroforestry

# FTA 2020 Science Conference

Forests, trees and agroforestry  
science for transformational change

**14-18 | 21-25**  
September 2020



## Book of Abstracts

Corrigendum of 10.03.2021



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**Forests, trees and agroforestry  
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# Foreword

FTA, initiated in 2011, is the largest research for development research program on forests, trees and agroforestry. From 14 to 25 September 2020, FTA ran a fully digital internal scientific conference that gathered all researchers involved in FTA from its partner organizations. FTA is led by the Center for International Forestry Research, in partnership with Bioversity International, CATIE, CIRAD, the International Network for Bamboo and Rattan, Tropenbos International and World Agroforestry, and has links with dozens of scientific and development institutions. The purpose of the conference was to present the most exciting research results, exchange experiences and lessons learned, and reflect on the way forward until the end of FTA's phase 2, with a particular focus on impact.

The conference was organized along six broad technical work streams, inspired by ongoing dialogue with CGIAR and in international policy discussions:

1. Inclusive value chains, finance and investments
2. Towards resilient and diverse landscapes and food systems
3. Transforming livelihoods through agroecological approaches with trees
4. Nature-based solutions to address the climate crisis
5. Inclusive governance for sustainable landscapes
6. Designing, implementing and evaluating research for development impact

The conference also included plenary sessions and two sessions addressing hot/controversial issues in the scientific and development fields, in which FTA has a specific role in helping to disentangle the issues:

- Competing understandings of the restoration problem and solutions
- Systemic approaches in a 'silver bullets' world.

Finally, emerging issues for research for development in the area of FTA were discussed as a thread of the conference and within a dedicated session.

The present publication gathers the 179 abstracts selected for the conference, most of which are the result of a collaboration between different partners.

Vincent Gitz, FTA Director

*On behalf of the Scientific Steering Committee of the conference (SSC)*



# Acknowledgements

The conference was designed and managed by a Scientific Conference Committee, chaired by the program director Vincent Gitz and comprised of the reunion of the FTA management team and of the set of Stream Leaders: Ramni Jamnadass, Fergus Sinclair, Michael Brady, Peter Minang, Christopher Martius, Chris Kettle, Eduardo Somarriba, Plinio Sist, Yanxia Li, Rene Boot, Marlène Elias, Federica Coccia, Bas Louman, Anne Larson and Brian Belcher. The scientific committee and stream leaders set up the technical sessions, selected the abstracts, posters, and the invited keynote speakers. The design of the plenaries and the innovative “hot and controversial” sessions was elaborated by Vincent Gitz, FTA Director, and Alexandre Meybeck, senior technical advisor. The preparation of the parallel poster sessions was coordinated by Monika Kiczakajlo. Special thanks to Lucya Yamin for assisting the FTA management support unit.

The preparation and roll-out of the conference (online logistics, live technical support, interactive conference tools, daily digests, conference website and the present publication) was backed up by the FTA communication team: Santi Darmokusumo, Gusdiyanto, Vito Gama Kaparang and Dinny Saputri, with external support from Create Consulting (Justin Kiley, Melanie Kiley and Danielle Stephenson), under the coordination of Fabio Ricci and Michael Dougherty.

FTA thanks warmly all the scientists, keynote speakers and panelists for their participation.

All the material presented over the course of the 10 days is freely accessible on the FTA website:

<https://www.foreststreesagroforestry.org/fta-2020-science-conference-forests-trees-and-agroforestry-science-for-transformational-change/>

# Technical workstreams



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## **STREAM 1**

Inclusive value chains, finance  
and investments





## STREAM 1

### Inclusive value chains, finance and investments

The aim of this Stream was to support practitioners and policy makers in their efforts for more sustainable value chains and enhanced smallholder access to finance, and to identify areas for further action in research and capacity development.

The Stream explored innovations in public policy, business models and private investments and finance that stimulate the sustainable supply of timber from natural and planted forests and enhance the sustainable production of high-value tree crops, and reduce the impacts of agricultural expansion in forests through increased uptake of more sustainable and inclusive agricultural production and forest management systems.

Further to that, it looked at ways to facilitate innovations in public policy, finance and investments that help reduce the barriers encountered to scaling up finance for sustainable landscapes. Special attention has been placed on the importance of recognizing the role of gender in achieving sustainability, as well as on the rules and regulations that reign funds transfers and determine the funds applications.



#### STREAM 1 LEADERS

**Michael Allen Brady** - FTA Management Team Member, Flagship 3 Leader, CIFOR

**Bas Louman** - FTA Operational Priority 17 Leader, Tropenbos International

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# Sustainability of Participatory Guarantee System (PGS) for organic agriculture development: Evidence from Vietnam

Agriculture is one of the most basic of humankind's activities, but many agricultural practices put pressure on the environment such as through soil degradation, water shortages, pollution, and loss of biodiversity and natural habitat (Mercati 2016). In recent years, organic farming has increasingly been gaining traction and in many countries, the goal of agriculture has been shifted from merely increased productivity to sustainable and environmentally friendly production systems (Pokhrel and Pant 2009). According to the USDA National Organic Standards Board, organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. In other words, it is a farming system based on minimal use of external inputs and on management that restores, maintains and enhances ecological harmony (Vasile et al. 2015).

Participatory Guarantee Systems (PGS) are perceived as a democratic and independent way – based on the participation of all stakeholders – to guarantee the organic integrity of products (IFOAM 2008). The system aims to provide a credibility guarantee for organic products and production through a new approach that requires direct and active participation of farmers, consumers and other stakeholders in the verification process. In recent years, PGS have been successfully applied for the certification of organic products and to overcome previously introduced high-cost certification systems in Vietnam. Adopting a case study approach, this paper aims at assessing the sustainability of PGS and proposes solutions for improving PGS implementation and organic agriculture development in Vietnam.

It shows the ability of small-scale farmers to adopt standards and procedures of certifying organic products and receiving support from government and extension services for its adoption. Continual improvement in production practices is one of the dimensions for sustainability of PGS implementation in which three aspects of sustainability must be equally considered: increasing economic efficiency; improving social equality and cohesion; and strengthening environmental benefits and effects of organic production.

## KEYWORDS

Participatory guarantee systems, certification, organic agriculture, sustainability, Vietnam

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# Timber value chains and the development of innovative options for smallholders in San Martin, Peru

Peru has recently started experimenting with innovative policy mechanisms for smallholder farmers intended to slow agricultural expansion on forest frontiers and to create options allowing farmers to participate in forest restoration programs or sell timber legally. These mechanisms include agroforestry concessions that provide long-term usufruct rights to qualifying families living on forest frontiers that agree to adopt sustainable land use practices on deforested land (SERFOR 2015b; Robiglio and Reyes 2016) and commit to avoid deforestation. A second mechanism is a forest plantation registry system intended to facilitate the production and legal commercialization of timber and other tree products originating on registered plantations (SERFOR 2015a; Sears et al. 2018). While promising, the actual adoption of these mechanisms is at an initial stage. Analysis of localized market, policy and governance contexts could identify how smallholders are reacting to the opportunities provided by these mechanisms as well as potential strategies for facilitating greater adoption of viable options.

This paper analyzes forest value chains in the Peruvian Amazon around Moyobamba, San Martin, where the regional government is developing plans to promote agroforestry concessions and a forest plantation registry. This study was part of a broader project led by World Agroforestry (ICRAF) that is evaluating integrated technical assistance models based on an options by context approach (OXC) to assist the definition of a roadmap to support the implementation of these public policies. Results from value chain analysis identified multiple forest value chains that source trees from smallholder properties. These production systems are largely informal and smallholders generally play a passive role, selling standing timber opportunistically in markets dominated by other forest sector actors. Analysis identified continued demand for smallholder timber and a number of options for enhancing smallholder timber production. However, remaining obstacles include overly complex and costly administrative processes that discourage farmer participation as well as actors in the value chain with vested interests benefiting from the status quo. Recommendations include appropriate technical assistance to assist farmers to become more proactive managers by considering options based on farmer leadership.

## KEYWORDS

Timber, smallholder, policy, Peru, Amazon

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# Scaling up oil palm agroforestry in the Brazilian Amazon: Tailoring production systems and business models to the context of family farmers in Tomé Açu, Pará

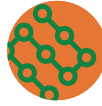
Depending on the viewpoint, *Elaeis guineensis* (oil palm) is the best of crops, worst of crops: transformer of smallholders' livelihoods, destroyer of rainforests. In the Brazilian Amazon, oil palm has expanded rapidly since 2010, largely driven by policy incentives that led major companies to invest heavily in the sector and establish agreements with smallholder farmers. Biodiverse agroforestry systems can reconcile oil palm production with more resilient livelihoods while also providing environmental functions. However, upscaling agroforestry oil palm will require tailoring the systems and agreements between outgrowers and companies to farmers' aspirations and capacities, which vary substantially at the local level, and on improving the enabling environment. This study aims to shed light on the key factors underlying the expansion of oil palm agroforestry in the context of Northeast Pará State, Brazilian Amazon, and point to paths forward for more socio-environmentally sustainable oil palm production. The methodology was comprised of: a comprehensive literature review; analysis of land use trajectories and socio-economic characteristics at the municipal level; a household survey of 200 farms with structured interviews focusing on livelihoods, value chains, and performance of different agroforestry types; and establishment of a network of 30 ha of demonstration sites, co-designed with family farmers, with different species and spatial arrangements. Preliminary findings show a wide array of agroforestry types practiced in the region and ample appetite for expansion of agroforestry systems, whereas adoption of monocrop oil palm in this sample so far has been extremely low. This technological pathway chosen predominantly by family farmers can be explained in part because of reduced risks of more diverse systems in coping with market fluctuations, disease, and constraints associated with inflexible, company-driven monocrop oil palm business models, in addition to the livelihoods benefits and resilience of agroforestry. Key motivations for adopting agroforestry systems in the region include their greater resilience to market risks and fluctuations, adaptation to climate change, and optimization of scarce labor and land. On the other hand, the main constraints for upscaling biodiverse oil palm agroforestry among family farmers generally are: low access to skilled labor, knowledge and capital required to establish and manage such complex production systems, as well as weak links in the value chain of some agroforestry products, including high dependence on intermediaries and low access to processing facilities. Since labor requirements for biodiverse systems are higher than for monocrop oil palm, the size of mixed agroforestry oil palm plots must not exceed available labor, which in the case of family farmers means establishing plots per year well below the minimum 6–10 ha imposed by companies for monocrop plantations. Additionally, expansion of mixed oil palm agroforestry will hinge on developing greater flexibility in integration agreements by including provisions in contracts between companies and outgrowers that take into account agroforestry species, particularly with regard to use of inputs, financial arrangements that reduce risks and increase benefits for farmers, and technical assistance geared towards agroforestry.

## KEYWORDS

Smallholder farmers, inclusive business models, Brazilian Amazon, oil palm business

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# Geographical approach to the bamboo value chain analysis: The case of the highlands and the eastern zone of Madagascar

Given the state of climate change, deforestation and extreme poverty in Madagascar, bamboo can represent a remedy while providing a significant part of the income of local populations and contribute to the protection of their environment for a better world. Thanks to its very rapid growth and its multifunctionality, all parts of the bamboo can be valued).

This research aims to demonstrate the operation and sustainability of the bamboo sector mainly in the Analamanga, Alaotra Mangoro and Antsinanana regions, involving all actors and stakeholders in various fields. This provides an analytical framework based on spatial interactions and on ecosystems in order to demonstrate the aspects of rational exploitation as well as the regional specificities of each valuation method.

In the Big Island, the bamboo value chain is traditionally developed and presents socio-economic and environmental challenges; here, the recovery system consists of the formal and informal sectors. The specificity of Madagascar is that it has a high endemism in bamboo biodiversity compared with continental Africa, with its 35 endemic species. Thus, it has a remarkable socio-economic and environmental influence. However, processing of bamboo still remains archaic with rudimentary techniques in use. In addition, it provides the population with a remunerative resource despite the overexploitation and excessive collection of bamboo poles.

With the aim of sustainable development and to promote this sector in Madagascar, the Intra-African International Bamboo and Rattan Organisation (INBAR) project, funded by International Fund for Agricultural Development (IFAD), in collaboration with the PROSPERER program, encourages the sustainable management of resources, the restoration of the landscape and the protection of biodiversity, and also improves the incomes of smallholder farmers. The project deploys an appropriate framework with different tools such as microfinance and business development services to develop bamboo resources and bring innovations for different types of processing. For example, nurseries and plantations were set up, gasifiers for electricity production were installed, and common production and training facilities were built. Recently, a national policy for the development of the sector has been put in place to meet these action research objectives.

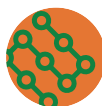
## KEYWORDS

Bamboo, value chain analysis, sustainable development, ecosystem, mapping

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# Towards a hybridization of the cocoa sector governance in Cameroon to meet economic and environmental sustainability

The cocoa sector is facing new demands, mainly from European markets, to demonstrate the legality of its production, its sustainability and the neutrality of its impact on tropical forest. In Cameroon, despite the importance of this sector for the national economy, the deregulation of the sector over the last 25 years has not allowed the state to face these three challenges. There is currently no precise definition of what legal cocoa is. A national standard for sustainable cocoa is being adopted, but it is not very binding. And the desire to reduce the footprint of cocoa production on the forest and to produce cocoa without deforestation is a more recent concern, which is not yet reflected in public policy.

In such a context, the certification of cocoa according to private standards can be a successful approach to facilitate the production of legal, sustainable and deforestation-free cocoa. We tested this hypothesis by studying the impact of cocoa certification (UTZ-Rainforest Alliance) on the livelihoods of small-scale farmers (owning a cocoa plantation of between 0.5 ha and 5 ha), who contribute to almost 90% of Cameroon's production. Three production systems for smallholder cocoa farmers were compared: (1) shaded cocoa without certification; (2) shaded cocoa with certification; (3) cocoa on grasslands with certification.

Data collection was done through a review of scientific and technical documentation as well as quantitative and qualitative interviews with 63 farmers in the Central, South, South-West and Coastal regions between March and May 2019. This information was used to develop the operating accounts of these agents, which were then synthesized for the three stereotypes of producers:

1. Non-certified small producers have a net profit rate of 4% and a value added of 471,984 CFA francs per tonne. This mode of cocoa production is a low-profit-making activity and weakened by an increase in production costs, which is not compensated by an improvement in turnover.
2. Producers in shaded agroforests and engaged in certification receive support of around 80,000 CFA francs per year, which improves their financial performance. Their net profit rate is 24%. The added value is estimated at 486,102 CFA francs/tonne.
3. The farmers on grasslands and involved in certification have production costs that are much higher than those of cocoa farmers in the forest. This type of cocoa production is more capitalist since access to certain factors of production such as land or labor is based on market relations. The monetarization of certain costs weighs on the rate of net profit, which rises to 15%, but reinforces the value added, which stands at 660,544 CFA francs per tonne.

Certification therefore presents an important advantage for smallholders by offering a higher purchase price for cocoa and above all by improving production through targeted support in terms of training, equipment and inputs. Overall, it has replaced the state in providing actual support to small producers. In the short term, the desire to commit the sector to legal and sustainable production requires progress towards private certification. However, this approach still has major shortcomings, in terms of traceability or creating a two-tier production system in Cameroon's rural economies. There is an opportunity to think about new forms of governance where the state focuses on certain sovereign functions while other private actors are delegated certain tasks for which they have demonstrated their effectiveness.

## KEYWORDS

Certification, value chain, deforestation

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# Improving smallholder inclusiveness in palm oil production: A global review

Much has been written over the past decades about the potential benefits of oil palm cultivation to smallholder farmers while minimizing negative social and environmental impacts. But coming to any consensus has been challenging. This paper reports the findings of a global review (Jezeer and Pasiecznik 2019) comprised of a collection of 25 articles and interviews. These present a range of approaches, dialogues and innovative tools and methods that are clearly and concretely enhancing smallholder inclusiveness in sustainable oil palm cultivation. In an analytical synthesis, Jezeer et al. (2019) showed that the topic is not as polarized as is often perceived, and that there are many middle ways, with the following key lessons being drawn.

1. 'Inclusiveness' is interpreted in different ways and a common understanding is needed.
2. Empowering smallholders is an essential prerequisite for increased inclusiveness.
3. Increased uptake of certification schemes is correlated with improved smallholder inclusiveness.
4. Smallholders benefit when they can take on more roles in the supply chain (e.g. co-owning mills).
5. Diversifying livelihood options through intercropping or other means is important for smallholders.
6. Companies must consider smallholder producers more as partners and co-investors.
7. Build trusting relationships with smallholders is crucial, and patience is paramount.
8. Inclusive palm oil production requires innovative technological and business models.
9. Policies at all levels have key roles in creating enabling conditions to stimulate inclusive businesses.

Expanding these approaches has great potential for improving smallholder inclusion in the palm oil value chain, as can emerging practices such as intercropping and agroforestry (e.g. Slingerland et al. 2019). The latter, for example, is now being promoted in Uganda as oil palm plantations are being expanded (Namanji et al. 2020), in response to proven concerns regarding reduced food security and farmer resilience and the need to maintain the diversity of crops produced, biodiversity and ecosystem services (Ssemmanda and Opige 2019).

The review does not, however, provide indisputable conclusions, but does allow for an improved understanding of the debate, and offers opinions and a range of possible pathways from a wide variety of perspectives. These voices show that there is a way to enhance smallholder inclusiveness – which is an essential component in working toward more sustainable supply chains. These articles can also serve as examples for similar efforts with other commodities, the production of which also threatens tropical forests. And if proposed solutions can be adapted and adopted in other situations and with other crops, these experiences will add significantly to global efforts to achieve the Sustainable Development Goals and climate agreements.

## KEYWORDS

Oil palm, smallholders, inclusiveness

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# Innovative finance for sustainable landscapes

Smallholders and communities produce more than half of all global food. However, in spite of major investments annually in the agri-food and forest sectors and of new forms of finance gaining momentum (e.g. blended finance, green bonds), these smallholders have problems accessing finance for their transformation to sustainable activities. This paper presents the results of a consultative process on the barriers and opportunities for inclusive finance for sustainable landscapes. The process consisted of a literature review; interviews with key stakeholders of international financial flows; and, in collaboration with the Global Landscapes Forum, discussion fora and an on-line dialogue. During this process, we identified two sets of barriers. One affects access to finance by smallholders and communities (appropriateness of financial instruments to local conditions, financial literacy, aggregation of recipients, one's role in social networks, appropriate policies and regulations and technological innovations). The other affects the sustainability of the financed activities (organization, risk management, knowledge and experience in particular land uses, climate, migration, land tenure security, and access to markets and natural resources). Of these, private and public investors and potential investees prioritized two factors: scale and risk. Investment needs in sustainable landscapes often are more diverse and much smaller than is of interest to potential investors. Risk is a factor that affects access to finance (many investors perceive the agri-food and forest sectors as containing unknown and too high risks, partially due to lack of local and market information to perform adequate financial analysis prior to investments). It also affects the sustainability of the activity once finance has been accessed (variability in weather, market prices or policies).

We have assessed the available information on innovative finance mechanisms against all these factors and our main conclusion is that current examples of innovative finance at scale (blended finance and green bonds) contribute to greater inclusion and sustainability in landscapes, but by themselves are not sufficient to overcome some of the main barriers to inclusiveness and sustainability. Examples assessed still had to overcome barriers such as achieving a greater understanding of the sector, finding investees at scale, and to develop suitable investment risk-reducing strategies. In addition, when access to finance for smallholders and small and medium enterprises (SMEs) is linked to existing agro-commodity-based value chains, it may increase local social conflicts and may make farmers more vulnerable to external shocks due to greater dependence on one single crop.

Similarly, current power dynamics in both development cooperation and trade hinder access by marginalized groups and favor business-as-usual finance rather than innovation. Some promising options, such as impact bonds or local community-based enterprises with potential for upscaling, need more research. Based on the results of this consultative process, we propose elements for a framework to assess innovative finance cases to increase the evidence needed for designing the scaling up of innovative finance for sustainable landscapes. Such studies can also be used to validate recommendations for action to address the major barriers found, further innovate financial mechanisms and contribute to greater inclusiveness and sustainability outcomes of investments.

## KEYWORDS

Innovative finance, barriers to finance, scale, risk, landscape

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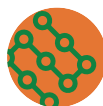
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# Do men and women speak with one voice? Gender preferences and challenges of tree-based value chains for land restoration in Africa

We investigated gender differences in prioritization of tree-based value chains and challenges encountered across eight countries in Africa. Considering the social, cultural and agro-ecological variability between East and West Africa, the data were differentiated into two subregions, East and West Africa. We used a combination of quantitative and qualitative approaches. A total of 246 focus group discussions were had by 123 male groups and 123 female groups. In total, 2,437 respondents were analyzed. We also analyzed household survey data from 4120 female and 4288 male respondents. The 10 prioritized tree-based values across the two subregions were analyzed. The findings indicate differences in gender preferences in tree products by country and by region. In West Africa, men and women had high interest in indigenous (domesticated) tree-based value chains such as shea and baobab, while the preferences in East Africa were mainly exotic tree-based value chains such as timber and charcoal. Reasons for prioritization reveal interesting gender dynamics of resource ownership and labor, whereas income and access to markets does not seem to vary between men and women. There were differences in the challenges that men and women encounter in the production/collection, processing and marketing of the various tree-based products. The paper contributes to the growing body of knowledge on gender-disaggregated priorities and challenges for tree products that are critical for ongoing large-scale restoration programs across the world.

## KEYWORDS

Gender, value chains, agroforestry, restoration, market, Africa



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# A feasibility study in sustainable financing for protected landscapes in Indonesia

Opportunities to improve the financial sustainability of protected landscapes are proliferating, yet there are also many challenges to overcome. Foremost among these challenges is to provide key enabling conditions for stakeholders in addressing commitments to biodiversity conservation and ecosystem services in an integrated landscape approach. Protected landscapes, in broad terms, covering the national parks and surrounding buffer zones under administrative areas of either province or district, are important for other significant reasons. These mosaics of landscapes ensure the continued flow of ecosystem services, contribute to economic benefits and provide spiritual, mental and physical well-being for surrounding communities. Each of these values of protected landscapes is important and should be considered in developing an effective management and financial plan at the landscape level. However, in the past, protected landscapes and land managers have been challenged in effectively applying landscape approaches by the unavailability of data at the appropriate spatial and temporal scales, which has restricted the role of protected landscape financing to conserve enough biodiversity and ecosystem services outcomes.

Financial sustainability requires close attention be paid to the benefits of protected landscapes and their distribution among different stakeholder groups. Protected landscape authorities are increasingly expected to justify their budgets in terms of benefits provided to local communities and the national economy. In addition to benefits shared by protected landscapes, covering the direct and indirect costs of protected landscapes is far from adequate. Different types of costs are distributed among multiple stakeholders. As a consequence, not only benefit-sharing schemes, but also cost-sharing ones must create tangible gains by encouraging all relevant stakeholders to collaboratively contribute to landscape management and biodiversity conservation. In short, cost-sharing is a joint responsibility rather than one party's deprivation of the other, therefore leading to fair and effective mechanisms (of conservation benefit- and cost-sharing).

Our feasibility study in sustainable financing of protected landscapes in Indonesia demonstrates that:

- (1) applying a landscape approach in designing management, financial and business plans of protected landscapes requires data and information covering both national parks and their surrounding buffer zones to ensure the continuity and integration of spatial, temporal and socioeconomic analysis towards desirable outcomes of landscape management in a broad sense;
- (2) instruments for innovative sustainable financing of protected landscapes are emerging, and the variety of available financing options is enormous – however, the recommendation, among others is that sustainable financing is not simply financing mechanisms and instruments, but rather, institutions with multiple roles, including:
  - (a) participating in the development of the application of a landscape approach in conservation strategies at national, subnational and national park levels,
  - (b) providing technical expertise and awareness raising to public and private agencies,
  - (c) promoting and implementing effective administration, which includes financial and in-kind resource mobilization, fund management and investment, and its distribution in supporting multiple conservation targets;
- (3) last but not least, such institutions must be characterized by multistakeholder collaboration and inclusivity principles, and are crucial to be established as an enabling condition for innovative sustainable financing mechanisms, i.e. fair and effective mechanisms of benefit- and cost-sharing for conservation and poverty alleviation purposes .

## KEYWORDS

Sustainable financing, protected landscape, multistakeholder, landscape governance, Indonesia

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# Mapping the gendered impact pathways of Fairtrade coffee: Case studies from Guatemala, Indonesia and Kenya

This research was commissioned by Fairtrade International to analyze the transformative potential of the Fairtrade Gender Strategy 2016–2020 for member organizations across three producer networks: Fairtrade Africa (FTA), Latin American and Caribbean Network of Fairtrade Small Producers and Workers (CLAC), and the Network of Asian Pacific Producers (NAPP). The gender strategy integrates the gender at work framework developed by Rao and Kelleher (2005) and was operationalized in the Fairtrade Foundation (2015) evaluation of gendered barriers to women's involvement in Fairtrade producer organizations. It aims to bring about gender transformative change in four overlapping spheres which align with the Fairtrade theory of change: individual and systemic spheres, together with formal and informal spheres. Fairtrade acts in the formal sphere to affect changes in the gendered economy that involve the production and trade of Fairtrade commodities. Fairtrade, however, also aims to impact the informal sphere to realize gender equality and the (social and economic) empowerment of women and girls. A persistent challenge to the Fairtrade system is that the Fairtrade vision aims for impact where it does not directly intervene, and must therefore also envision pathways of change that motivate transformations of gendered inequalities at the intersection of the formal and informal spheres.

This study examines how Fairtrade through its standards, strategies, programs and capacity-building work streams contributes to gendered outcomes, and whether Fairtrade further generates benefits for producers, workers and their communities regarding non-discrimination and the empowerment of women and girls. It was designed to support organizational learning; mapping the Fairtrade gender strategy against the Fairtrade theory of change to test the assumptions embedded in the proposed gender impact pathways.

Three signature gender-responsive interventions were selected for in-depth study by each of the producer networks: (1) Growing Women in Coffee Program (FTA, Kenya); (2) Women's Leadership School (CLAC, Guatemala); and the Gender Responsive Governance and Women's Leadership Program (NAPP, Indonesia). Two coffee producer organizations were selected in each country. This presentation shares the results of key informant and group interviews, intra-household surveys modified from the Project-level Women's Empowerment in Agriculture Index (Pro-WEAI) (Malapit et al. 2016), and validation and learning workshops which probed cultural and commodity-specific gender norms.

Findings from this study are intended to inform Fairtrade's key stakeholders about gender-related activities and outcomes; generate valuable learning on effective ways of supporting producers in deepening their impacts on gender-related dimensions; and provide recommendations for realizing the objectives articulated by the Fairtrade Gender Strategy 2016–2020.

## KEYWORDS

Gender, Fairtrade, smallholder producer organizations, coffee, empowerment

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# Continuity and change in the governance of the shea value chain in Burkina Faso, 1890–2019

This paper traces the governance of the shea value chain in Burkina Faso from the 1890s, when George Ekem Ferguson negotiated ‘treaties of friendship and free commerce’ in the hinterland of the (then) Gold Coast Colony, through to the emergence of an oligopolistic global value chain dominated by three leading foreign firms producing cocoa butter equivalents (CBEs) in the present day. Our intention is to question the common assumption of governments and development agencies that participation in global markets is a more viable alternative than reliance on local, domestic and regional markets. It adopts a broad periodization and global value chain (GVC) approach to understand the role and position of women shea producers and their associations at the intersection of global, regional and local value chains under present and previous waves of globalization.

Shea fruits, nuts and butter are non-timber forest products of the shea tree (*Vitellaria paradoxa*), the most widely-occurring arboreal species in West Africa’s parklands. The fruits and butter extracted from its kernels serve as important ingredients in the diet of rural communities, and surpluses of nuts and butter are sold to provide a critically important source of income to women. The parklands are also important sources of other subsistence foods and provide critical ecosystem services. Growing global demand for shea to produce CBEs and pressures to intensify local agricultural production systems to produce more food, and to meet firewood and charcoal needs, pose new threats to the sustainability of shea parklands and women’s livelihoods.

Historical evidence indicates a widespread and centuries-old exchange of shea kernels and shea butter by women in periodic local markets, and on a regional scale, with the densely populated West African littoral. Such exchanges were not only between producing and non-producing areas but also internally in producing areas due to seasonal variations in supply. In the early part of the 20th century, the French (and British) colonial administrations considered the possibilities of starting large-scale exports of shea kernels to Europe. Multiple initiatives to tax, extract (mechanically and chemically) and plant shea were not successful. In the post-Independence era, several state-led efforts to regulate and control the shea trade through stabilization funds and parastatal marketing boards were abandoned after 1984 when shea markets were liberalized. Increasingly since 2003, three leading foreign firms that manufacture CBEs are involved in sourcing shea to meet the growing demands of the multi-billion dollar confectionary and cosmetics industries. Burkina Faso is one of the main exporters.

The globalization of supply chains, consolidation of retail power and growing quality-based competition have transformed how the global agri-food system operates and the role of smallholders in the production of large-scale commodities such as palm oil, rubber, coffee and cocoa. Emphasis is frequently given to quality regulation, restructuring processes, standard-setting and upgrading. Governments and development agencies assume participation in global markets is a more remunerative alternative to reliance on local, domestic or regional markets. Hence, food security and the dynamics of local socio-economic systems are implicitly relegated to an inferior position. The paper also examines the roles that a national multistakeholder platform, the Table Filière Karité and the Stratégie Nationale de Développement Durable de la Filière Karité du Burkina Faso, 2015–2019, have played in setting the conditions for the inclusion of women shea producers and transformers in global shea value chains, and the gains that accrue to them.

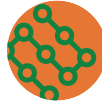
## KEYWORDS

**Burkina Faso, agroforestry parklands, global shea value chain, Table Filière Karité, women shea producers and transformers**

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# Increase oil palm inclusiveness for landless and women through agroforestry

Inclusive value chains intend to see smallholder producers as owners of land and labor. This is not always the case and has consequences for their terms of inclusion in value chains. In oil palm in Indonesia, many scheme smallholders established their plantation with full support from companies. The first years, when the palms do not yet yield, the land titles are kept by the companies, and the smallholders act as paid labor on the oil palm fields. When trees start to fruit, they formally become decision-makers on the use of labor for palm management, but they need to pay back investments and are therefore obliged to deliver the fruits to the company against conditions set by the mill. The land title is often only transferred to them after the debt has been repaid. Then they can renegotiate their terms of inclusion in the value chain. For independent smallholders, inclusiveness in value chains is more complicated. They are not preferential suppliers of a mill and have to negotiate uptake of their fruits and prices case by case. Due to a lack of technical support and self-establishment with inferior planting material, they produce lower volumes per hectare and lower quality of fruits. Their inclusion in value chains is therefore rather limited as is their negotiation power of the terms of inclusion. While oil palm has brought substantial income to some smallholders, oil palm has also led to several forms of exclusion. Transforming crop land into oil palm has for instance deprived women of access to land and excluded them from the value chains related to former crop production. Establishment of oil palm is only an option for those who have access to land and capital, and hence many others are excluded. When oil palm has replaced forest, the former uses of forest products have been excluded. A way for oil palm systems to become more inclusive is through agroforestry systems such as intercropping and through land sharing arrangements. We will present three examples. One is pineapple intercropping in Johor Malaysia, where landowners plant oil palm and allow landless people to cultivate pineapple on the oil palm fields. These landless people are included in very remunerative pineapple supply chains. In return, they keep the area weed free and they provide fertilizer to the trees. Therefore, financial benefits are free land for pineapple growers and decreased costs in maintenance for oil palm growers. Different modalities of pineapple intercropping by smallholders replanting oil palm themselves also occur and pineapple then helps them to overcome the income gap related to delays in oil palm revenues. Another example is banana intercropping in oil palm fields in Central Kalimantan, where women started processing banana into chips and set up a supply chain to sell these in cities. In both cases, the inclusion in the pineapple and banana supply chains was voluntary and at their own negotiated terms. These examples show that agroforestry with different forms of land sharing arrangements is a promising method to increase the inclusiveness of oil palm cultivation.

## KEYWORDS

Oil palm, agroforestry, land sharing, women, landless people

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# Addressing gender equity in agroforestry value chain: A case of Bengkulu, Indonesia

Women and men have an important role in managing agroforestry systems on their land to support household livelihood. Both actively participate in the value chain of agroforestry products, from production to marketing. This study examines gender equity in the agroforestry value chain in Bengkulu Province, Indonesia. Primary data were collected through field surveys and households interviews. Descriptive qualitative methods were employed to analyze the data. The research results proved that land management with an agroforestry system has been widely developed by farmers in Bengkulu, Indonesia. The agroforestry system provides opportunities for the communities to manage their land more intensively and in a more integrated way as regards agricultural production. The combination of plants that are most widely developed by people in Bengkulu, specifically in hilly and mountainous areas, is agroforestry of coffee with marrango trees. By developing this system, the community can support their livelihoods with coffee yields, while they also still have savings in the form of woody plants which they will usually sell when the plants are over 10 years old.

This method is quite profitable; Premono and Lestari (2018) showed that this agroforestry system was able to provide an Net Present Value, (NPV) of 76,250,582 IDR with benefit–cost ratio (BCR) value 2.28 and internal rate of return (IRR) 22% (level of discounted rate of 8%). Timber production from this agroforestry system has been able to support timber supplies for local and national demands. The role of women in land management, harvesting and product marketing is very important in Bengkulu Province. There are several types of work that require precision and perseverance so that the role of woman in this work is more dominant. But in many cases, the role of women is often considered less important and rarely gets attention. Only men are referred to as farmers, while women are only considered as assistants or even just housewives. The main decision-makers are men, both in determining the types of plants, harvest time, product selling prices and buyers. Meanwhile, women have a big role in increasing the value of the product, including harvesting coffee and processing it until it is ready to sell in the form of coffee beans, because when sold directly in the form of fresh fruit, the price is less profitable for farmers. The role of women in the agroforestry value chain is very important in this research location, because of the enormous potential that women have. Women need to be given voting rights and access rights to increase their abilities in various training opportunities, so that their roles can be more valued and recognized. The issue of gender equity still needs to be addressed and the role of women needs to be supported in this area by both men and other stakeholders.

## KEYWORDS

Agroforestry products, coffee, gender, marrango tree, value chain

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# Progress and persistent challenges of inclusive business models: Insights from the cocoa and oil palm value chains in Ghana and Peru

Inclusive business models (IBMs) connect smallholders and other low-income people with buyers, processors and traders in agricultural and forest product value chains. Value chain actors engage with each other through diverse institutional arrangements, relating to international (e.g. Global Compact, zero deforestation) and industry standards (e.g. Roundtable on Sustainable Palm Oil (RSPO), Cocoa and Forests Initiative), certifications (e.g. Fairtrade, organic), and contract farming.

Aiming at a better understanding of how IBMs perform both from a smallholder and company perspective, we studied IBMs in Ghana and Peru in two phases: 1) in-breadth study: scoping study on IBMs in three value chains each in Ghana (cocoa, oil palm, rubber) and Peru (cocoa, coffee, oil palm) through analysis of secondary information, key informant interviews (n=39) among aggregators and service providers, and focus group discussions (FGDs, n=3) for feedback and validation with value chain stakeholders; and 2) in-depth study: household survey among randomly selected households participating in IBMs (n=948) in the two targeted value chains per country (cocoa, oil palm), with two IBMs per chain, and FGDs (one per IBM) for feedback and validation with smallholder representatives. Analyses focused on household assets (human, social, natural, physical and financial capitals) for assessing the socio-economic performance of IBMs, and landscape-level indicators for their environmental performance.

Across the eight IBMs and the five types of capital, we found significant asset building at the level of smallholder households. Results varied widely though, across both IBM cases and households. We also found broad variation in terms of environmental performance, particularly as regards the IBMs' contributions to forest conservation and deforestation. Our analysis shows the extent to which given institutional arrangements contribute to measured or observed outcomes and identifies further drivers of change. We conclude with opportunities for designing and implementing IBMs in ways that enhance smallholder asset building commercial viability, and environmental performance.

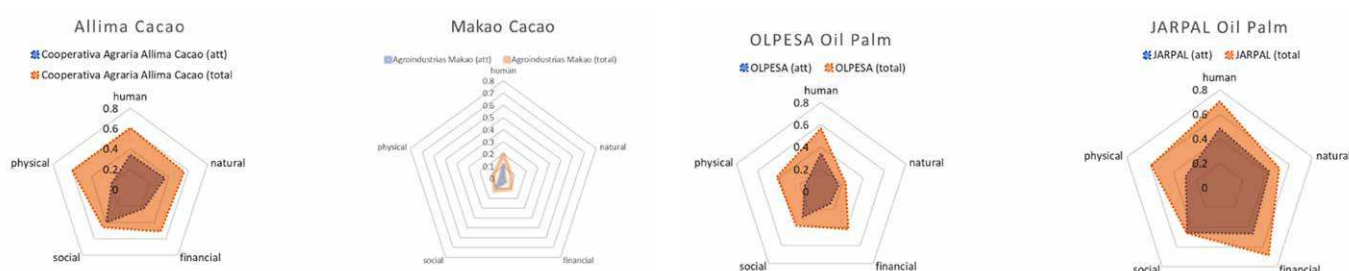


Figure 1.1 Asset building and attribution in four inclusive business models in Peru.

## KEYWORDS

Inclusive business models, smallholder livelihoods, asset building, cocoa, oil palm

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# De-risking investments in sustainable land use systems: Matching risk perspectives of smallholders and small and medium enterprises with that of investors

Smallholders (SH) and small and medium enterprises (SMEs) in the agri-food and forest sectors play important roles for local and global food security, and in strategies aimed at the conservation and sustainable use of forests and forested landscapes. In terms of agricultural practices, and under changing market and climate conditions, these stakeholders need to transform to resilient farming systems and sustainable operations along the value chain. The required transformations imply unknowns with regard to the processes toward sustainability and the resources and timeline needed for specific outcomes. As a result, associated investments are perceived to be of high risk and investors tend to opt for lower-risk and larger-scale investments that bypass the agri-food and forest sectors. New financial schemes (e.g. blended finance), instruments (e.g. alternative guarantees, first risk investments) and modalities (e.g. non-monetary returns, for example in the form of carbon credits) are aiming to address this finance gap, including specific arrangements for SH and SMEs in the agri-food and forest sectors. However, associated de-risking strategies are mainly designed from the investors' perspective.

In response, we propose a framework for assessing the risks associated with investments in the agri-food and forest sectors from the perspective of SH and SMEs, and for contrasting these to the risks perceived by investors. Based on matchmaking, we identify options for appropriate arrangements for de-risking such investments for both investors and investees. The framework draws on the findings of a literature review and was validated through case studies in Uganda, Ghana and Indonesia. Five types of key hazards were determined and for each of them we identified adaptation strategies at farm, landscape and national levels. The effectiveness of the strategies depends on allocation of resources, risk perception and risk preference by SH, SMEs and investors. In general, capacities of SH and SMEs to adapt to adverse production and market situations are underestimated by investors. The framework presented here offers opportunities for more realistic assessments of the risks facing investors, SH and SMEs by identifying the latter's adaptation capacities that directly affect the level of risk, and by laying out options for reconciling any differences in terms of perceived or real risks.

## KEYWORDS

Value chain finance, responsible investments, de-risking, smallholders, small and medium enterprises

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# Agroforestry can contribute to more sustainable cacao production and trade – But only if conditional on constitutional, corporate and consumer commitments

By December 2019, 85% of companies in cacao/cocoa industries had published deforestation-reduction action plans, following the 2014 New York Declaration on Forests and 2017 Cocoa and Forest Initiative. Cacao agroforestry was heralded for its ability to mitigate climate change and reduce deforestation, but related to findings from several reviews, this paper argues that as a practice it has enormous potential, but if based on voluntary agreements, can lead only to mixed outcomes at best, and at worst may even support allegations of corporate 'greenwashing' (e.g. Ruf and Varlet 2017). There is also no proof that cacao agroforestry has led to deforestation-free production anywhere, and attempts to guarantee this must first clearly define what is 'deforestation-free'. Certification schemes such as that by Rainforest Alliance try to overcome this by benchmarking production deemed deforestation-free if it does not displace primary forest after a specified cut-off date (2014 in this case). However, this is voluntary and not globally accepted, so there is a need for dialogue, especially between producer and consumer countries, that feeds into broader political and commercial discussions (e.g. Brack 2019; Tropenbos International 2019; Hoefsloot et al. 2020).

Agroforestry is also a broad concept with wide variations, making it difficult to define any single system that will halt deforestation. Some say that they are promoting cacao agroforestry, but what do they really mean by this? Low agroforestry standards are also very easy to realize in the field, so many plantations can be certified as such but their contribution to improved or at least maintained environmental services and resilience could be questioned, especially when they replace natural forests or complex agroforestry systems. The simple promotion of cacao agroforestry is thus not enough to meet the much needed commitments made towards forest preservation and smallholder resilience.

In addition, many initiatives are limited to plot scales (e.g. good agricultural practices, distribution of trees, and certification), but this alone has limited environmental benefits. Resilient agroforestry landscapes must also include natural forest remnants intermixed with farmed land, to ensure a diversity of land use, biodiversity corridors, and to limit the spread of pests and diseases. A landscape approach implies encouragement of more inclusive processes and integrated planning, assisted by mapping all remaining forests and high conservation value areas, and the creation of an enabling environment through collaborative responsibility, fair land and tree tenure, and ensuring that it is not the farmer who pays.

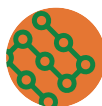
Promoting agroforestry through large-scale certification, distributing tree seedlings and top-down plot-scale intervention is not reaching corporate sustainability commitments, and this paper highlights the need to act at the landscape level and to adopt multistakeholder approaches to enhance the emergence of initiatives suited to contexts and that take into account farmers' preferences and needs. There is also a need to go beyond certification, and to participatively define what cacao sustainability should look like, and how agroforestry can help reach it at a landscape level, to ensure that trees are fully integrated within socio-political and economic contexts and survive beyond project timeframes and attain real farmer acceptance.

## KEYWORDS

Cacao, cocoa, agroforestry, West Africa

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# Landscape assessment of financial flows (LAFF): Does finance support achievement of locally relevant SDGs?

Collaborative landscape initiatives have demonstrated enormous potential to mobilize stakeholders across sectors, supporting them to work together toward shared objectives of landscape regeneration. This meets a wide range of human needs, economic goals and ecosystem objectives. However, implementing these partnerships is challenging. To support these landscape initiatives, Tropenbos International and EcoAgriculture Partners partnered to develop the landscape assessment of financial flows (LAFF) methodology. LAFF has been designed to facilitate the participatory identification and characterization of major flows of finance in the landscape and thereby to provide a better understanding of how a landscape's financial system does or does not support integrated landscape objectives. This practical two-phase approach helps stakeholders identify local sources of finance for new investment ideas, find the current financial flows that are most in need of transformation, and better understand those elements of a landscape's financial context that require support. This methodology has now been applied in two pilot landscapes, one in the Gunung Tarak landscape in West Kalimantan, Indonesia, and one in the Juabeso-Bia and Sefwi Wiawso landscape in the Western Region of Ghana. In both landscapes, stakeholders were convened for an initial training workshop to introduce them to the relevant financial concepts and methodology. During the workshop, landscape objectives were identified. Based on a summary of the available documentation on the economics of the landscape, workshop participants defined priority sectors. For each sector, discussion groups were formed, including sector experts. They identified existing financial flows and participants indicated their perception of the impacts of these flows on the previously defined landscape objectives. Discussions were supplemented by interviews with key actors engaged in some of the financial flows. In both landscapes, all identified financial flows contributed somehow to the economic well-being of the inhabitants. Most flows originating from public sources also support environmental and/or climate objectives. Financial flows originating in the private sector were generally perceived to have negative impacts on the environment, on water and food security, and on social cohesion between the stakeholders, except for several flows going to smallholder cacao farmers in Ghana, or rice farmers in Indonesia. Although our information regarding the size of money flows is not complete, the information gathered during our studies indicates that private investments are many times greater (>10×) than public ones and more often have negative impacts. Our data also suggest that banks or other financial institutions provide finance to many actors in different sectors and therefore have the potential to influence the impacts of private sector financial flows, for example by using sustainability standards when appraising loan applications. Illegal land uses also greatly influence the potential for achievement of landscape objectives. Greater control would reduce that negative influence but may not be sufficient for achievement of sustainability objectives. Based on these results, development programs in both landscapes are adjusting their strategies, trying to influence the main actors in the identified flows with negative impacts. The analysis of the results also brings forward suggestions to improve the efficiency and efficacy of the methodology.

## KEYWORDS

Finance flows, impacts, climate actions, food and water security, reduced emissions

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# Is there a perfect model to promote the integration of smallholders in agricultural value chains: Preliminary insights for the Brazilian Amazon

Integrating smallholder farmers in agricultural value chains has been a major strategy to reduce the impacts of large-scale plantations and to promote more inclusive rural development (WBCSD and SNV 2011). In order to achieve that, business models should be designed and implemented to assure that key factors such as technical assistance, access to markets and credit are broadly available. However, there is little consensus on what kinds of models are more suited to address the successful integration of smallholders in specific contexts, particularly in remote areas of developing regions (Vermeulen and Cotula 2010). In this paper, we compare three different models that aim to facilitate the inclusion of smallholders: (1) public/private partnership, (2) cooperative and (3) associative. Based on 200 household surveys held between October and December in the Brazilian Amazon municipality of Tomé Açu, this study assesses in detail seven agricultural value chains and their respective business models and production systems: oil palm (*Elaeis guineensis* Jacq.), cocoa (*Theobroma cacao* Aubl.), black pepper (*Piper nigrum* L.), açai (*Euterpe oleracea* Mart.), cassava (*Manihot esculenta* Crantz), passion fruit (*Passiflora edulis* Sims) and cupuaçu (*Theobroma grandiflorum* (Willd. ex Spreng.)). Preliminary analysis indicates that aspects such as price fluctuations, access to technical assistance, labor requirements, processing requirements and transportation are the main bottlenecks. According to a preliminary analysis, the support on technical assistance for oil palm is the most representative. This product also has fixed prices and buyers, and is characterized by contracts between companies and farmers. The analysis also suggests that none of the models is devoid of problems and risks and that the competition between them can create a favorable environment for smallholders by upgrading overall local conditions for smallholders' successful integration. This study seeks to understand the links presented by these value chains and to propose forms of intervention favorable to the farmer.

## KEYWORDS

Smallholder farming, inclusive business models, Brazilian Amazon, value chains

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# Governance of community forest enterprises: Insights for managing inclusivity and equity

Corporate governance involves a set of relationships between a company's management, its board, its shareholders and other stakeholders. The governance of community forest enterprises (CFEs) differs from that of corporate enterprises because decision-making is not based on majority shareholders, but on a collective dynamic of different stakeholders. Decisions also do not aim for shareholder wealth maximization but for community or stakeholder wealth maximization. Unlike corporate structures, non-profits are owned and managed by the community instead of shareholders. To explore and describe how CFEs in Cameroon currently function and could function in terms of social enterprises (SEs) governance, this research will explore possible governance tensions, mission drifts and relationships between four key stakeholder groups: (1) board of trustees, (2) managers and staff, (3) primary stakeholders (beneficiaries) and (4) stakeholder committees that are engaged in CFE management. This paper will explore critical issues related to managing diverse stakeholder interests, the role of trustees, and conflicting relations between different groups. It will equally explore possible governance challenges for joint management of CFEs with special interest in developing incentives for good governance. Different aspects of governance between the groups will further be explored, including aspects of accountability underscore the responsibility of each group and level of performance that each group member must uphold. Transparency captures how the organization openly discloses social accounts and information to stakeholders while democracy looks at the process of incorporating diverse views of different stakeholders in decision-making coupled with representation, and fair and honest processes of electing board members. Data will be collected through focus group discussions with CFE managers, staff, management committee members, and community members, and through key informant interviews and a review of CFE documents from 25 CFEs in Cameroon. Inductive content analysis will equally be used if necessary, to map the governance framework and how they relate with performance to deduce an appropriate governance framework. The results reveal that although communication, accountability and transparency improved significantly amongst many CFEs, misappropriation of funds, poor accountability and lack of communication abound amongst a few. These few have suffered significant community squabbles due to

- (i) poor understanding of enterprise communication
- (ii) mission drift by CFE managers
- (iii) overall lack of proper oversight by management committee members and community members on the running of the enterprise.

This paper proposes a generic CFE governance framework with obligations of different parties and options for resolution of potential conflicts due to mission drift.

## KEYWORDS

Community forest enterprise, governance, mission drift, management conflicts, tensions.

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# Sustaining palm oil: Social footprinting of informal and formal market value chains

Ghana is a major producer and consumer of palm oil, yet is unable to meet domestic demand (Rhebergen et al. 2018). Notwithstanding the emergence of large-scale plantations and industrial millers, smallholder farms account for approximately 80% of the land under oil palm cultivation while a similar share of crude palm oil (CPO, 76%) is processed by small-scale artisanal mills (MoFA 2010). The growth and expansion of smallholder and estate oil palm plantations in Kwaebibirem has witnessed a boom in informal mills operated by 'oil palm mamas'. Palm oil processing in Ghana has traditionally been perceived as a 'kitchen activity' in the domain of women, who have also historically dominated the midstream value chain nodes as farmgate buyers, artisanal millers and processors, and market traders (Sarku 2016).

Despite substantial representation of men as mill owners (80%), gender has remained central to the value chain function in the informal sphere (Barrientos 2010; Sarku 2016). Sarku (2016) has described how these so-called 'oil palm mamas' and 'market queens' perform highly structured and gender normative roles to construct social networks, safety nets, and a system of rewards and recognition (Jennische 2018; Sowatey et al. 2018). In addition, Ofosu-Budu and Sarpong (2013) reported that informal mills employ on average 22 laborers – predominantly women – in addition to the network of agents and transporters. While women's roles are more fixed and permanent, men's roles within the mills have been more transgressive; sometimes taking temporary 'women's' jobs in the absence of other decent work opportunities. This research addresses a critical gap in the gender value chain literature about the social, generative and sometimes gender transformative role that labor plays at these midstream nodes.

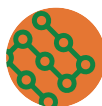
Despite the importance of the informal sector to localized oil palm economies, they are not without serious sustainability challenges in terms of extraction rates and waste; poor labor practices and toxic work environment; and environmental externalities. While registered companies are subject to environmental, labor and health regulations, informal artisanal mills operate outside of such standards. Workers in small-scale mills are often subjected to serious health hazards due to toxic smoke, while effluent disposed into streams and onto earthen floors pollute surface water (Osei-Amponsah et al. 2012). The formal sector maintains a critical role in Kwaebibirem and Atiwa West in terms of smallholder service provision and achieving sustainabilities at scale. Inflated fresh fruit bunch (FFB) prices and competition with the informal sector, however, have threatened the viability of medium-scale enterprises and undercut a large-scale outgrower scheme and service-delivery model through side-selling and default. Through deploying mixed methods to conduct a gendered value chain analysis, this research examines opportunities and challenges for upgrading at different points within the chain, and provides a gendered perspective about how men and women might differentially benefit from engaging at midstream nodes. We also develop and explore innovative participatory methodologies to measure the gender footprint in terms of livelihood impacts for the men and women within informal and formal oil palm value chains, as well as identifying gendered barriers to compliance experienced by small-scale actors.

## KEYWORDS

Gender, palm oil, Ghana, value chain

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# The changing bamboo value chains and effects on bamboo sector development in Kenya

The first comprehensive study of the bamboo value chain was done in Kenya in 2000 (Ongugo et al. 2000). The study revealed that the value chain was weak due to underdeveloped production and marketing links devoid of support from major players, mainly the government. In 2018, INBAR's Dutch-Sino East Africa Bamboo Development Programme conducted a value chain analysis and market assessment of bamboo products in Kenya (Gauli 2018). The main findings of the study were that even though cultivation of bamboo in Kenya started more than a decade ago, bamboo business was limited to the production and sale of seedlings, with minimal markets having been developed. A study carried out by the Kenya Forestry Research Institute and INBAR in 2019 as a precursor to developing a national policy on the development of the bamboo sector also emphasized the importance of processing and marketing of bamboo at both primary and secondary levels as a way of promoting the growth of the bamboo sector in Kenya. The National Forest Programme, 2016–2030 (MENR 2016) underscores the importance of bamboo in rehabilitating degraded forests and providing products for the wood market.

The objective of this paper is to provide an analysis of how the sector has changed since the first study done in 2000 and those of 2018 and 2019 and make suggestions on what needs to be done to spur the growth of the bamboo sector for the benefit of the national economy, improve livelihoods of the bamboo-growing farmers and communities, and environmental management in Kenya. This assessment also recognizes the importance of bamboo in the private sector given the dynamic nature of regulatory actions often taken to control harvesting of bamboo in public forests. The study takes an analytic approach involving a review of both secondary and primary ongoing work.

The results recommend the need to bring together stakeholders in the sector to refocus the development of the value chain based on a model aimed at mainly the private sector as vehicle to drive development of the bamboo sector. The paper also recommends the need for developing the market, first focusing on SME-based production, then moving to large-scale processing. This approach is necessary as the country increases growing stock from private bamboo growers and then releases stock in public forests for conservation of water towers in the country.

## KEYWORDS

Value chain, policy, bamboo, markets, cooperatives

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# Contests, prospects and strategies for enhancing performance of avocado value chain in Mt. Elgon region, Uganda

Over 500 million people in sub-Saharan Africa depend on forests and allied tree system products for a livelihood. A study was conducted in the Mt. Elgon region of Uganda to assess synergies for promoting selected agroforestry tree product value chains. The specific objectives were to characterize avocado fruit value chains and identify constraints, prospects and strategies for developing the avocado fruit product value chains in the region. A total of 91 participants were engaged in key informant interviews and focus group discussions to collect data. Results show that up to 80% of the actors operated on a small scale with 5 to 10 trees scattered on the farm. Avocado fruit production peaked during the wet season and reached consumers through five major paths. The market paths included: i) farmers to consumers, ii) farmers to large-scale consumers, iii) farmers to large-scale traders and small-scale consumers, iv) farmers to small-scale traders and consumers and v) large-scale traders to primary and secondary consumers. Generally, the farmers sourced potential consumers and the brokers engaged climbers. The buyers graded the fruit into piles of 'big', 'medium' and 'small' and physically assessed them in terms of health to determine the farm price. The farm price ranged between UGX 150 and 700 per fruit, depending on the fruit size and season. In gazetted markets, avocado fruits cost UGX 400–1500 per fruit and prices varied widely in ungazetted markets. The constraints for developing the avocado fruit product value chain included: low quality of fruit, lack of access to suitable markets, poor post-harvest technology, poor varieties and extreme weather. Opportunities included: progressiveness in commercial tree farming, advancement of credit infrastructure and availability of free or cheaper planting materials. The strategies consisted of: characterizing available varieties, involvement of stakeholders in market studies, certification of production systems, capacity building of key actors in value chain development, promoting networking, and intensifying research and policy formulation, and fruit tree germplasm production, distribution and management. These will help the avocado fruit value chain actors to build a robust horticultural system that will contribute to income and food security in the region.

## KEYWORDS

Tree products, smallholders, value addition, livelihoods, agroforestry systems

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# Effective business models for Latin America's forestry sector

The forest is the most important ecosystem in the world, and the population, in general, recognizes it. However, that ecosystem is threatened by agricultural frontier expansion, fires and unsustainable forest management. Moreover, the population living in forest landscapes is about 1.5 billion and they are mostly poor smallholders. However, they have multiple options for improving their livelihood with sustainable forest management, producing and extracting fuelwood, charcoal, timber and non-timber forest products (NTFPs).

Nevertheless, forest owners still have the same problems reaching markets and increasing welfare, to improve the well-being of their families and communities. The forest sector and specifically forest owners are crucial to promoting positive impacts in both the SDGs and NDCs, which reinforce the sustainable development and climate change strategies. To reach these goals and overcome the problems, we have to look for innovative approaches for designing business models and business cases.

A way to promote business in rural areas is through processes such as incubation. The aim of the incubation process is to produce effective business models that will become companies, cooperatives or other kinds of structures that will go into the market and become financially viable (NBIA 2007). To achieve these goals, many tools and ways to do it are available.

Latin American countries have the challenge in the forest sector to answer the question of how to improve forest conservation and promote well-being for their society. There is a lack of knowledge on the integration of key factors to produce a feasible business model for sustainable forest management. From 2016 to 2018, an evaluation of 42 forest firms in Central America was done to analyze the gaps and challenges of their business models.

The findings show several gaps between market requirements, investor expectations and forest owner needs. Based on that analysis, the Tropical Agricultural Research and Higher Education Center (CATIE) proposed the creation of a business lab for forest landscapes called Activa Business Lab. This is a virtual and face-to-face platform that looks for new business models created for forest owners. The way to achieve this is by using a method that combines a lean startup and CANVAS Business Model to guide forest owners to meet the consumers and other stakeholders in the sector.

## KEYWORDS

**Sustainable development, business innovation, forest landscape restoration, sustainable business model, sustainable business, the triple bottom line**

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# Rattan value chain analysis in Cameroon

Rattan is one of the major NTFPs and contributes to household economies, the conservation of biodiversity and the fight against climate change. However, despite their economic and ecological importance, it now appears that rattan resources are being depleted due to overexploitation. Indeed, the potential of this strategic resource is still neglected by the Cameroon Government and development agencies in their sustainable management strategies. Unquestionably, data on production, processing, market trends and the economic impact of rattan exploitation are still lacking in Cameroon. As a result, it becomes difficult to assess their contribution to the local and national economies. The overall objective of this study is to identify opportunities for the development of the rattan industry in Cameroon through an analysis of the rattan value chain.

The specific objectives are twofold:

- To carry out an analysis of the rattan value chain
- To identify interventions that make best use of rattan for socio-economic development and help achieve sustainable management of rattan resources.

To achieve these objectives, a total of 20 study sites were selected in the 6 representative regions of Cameroon: the center, south, northwest, east, southwest and littoral. Data collection was based on direct observations, informal discussions, interviews, literature review and questionnaires. In Cameroon, the key actors of the rattan value chain are harvesters, artisans, traders and consumers. Beside these direct actors, there are supporting actors, including ministries, local authorities, municipalities, technical and financial partners and forest owners. Harvesters are represented mostly by men (80%). The age class of 35–65 years represents 65% of the total number of age groups. In Cameroon, wild rattan canes are still harvested in natural forests; there exist no rattan plantations. The harvesters use empirical and traditional techniques for harvesting wild rattan. There are 19 species of rattan in Cameroon, but predominantly four commercial rattan species are harvested: *Laccosperma secundiflorum*, *L. robustum*, *Eremospatha macrocarpa* and *E. wendlandianna*. *Calamus deerratus* species is used sometimes for commercial purposes; however, the level of trade is low in comparison with the four other commercial species. The harvesting cycle in a given area can take 3–4 years. The frequency of cuts can be weekly, bi-monthly or monthly. Harvesting and selling is usually done on command, and from time to time on free sales. The cost of a rattan bundle varies from USD 3.54 in rural areas to USD 21.24 in urban areas.

The processing of rattan in Cameroon is predominantly a male activity (92%), compared with 8% of women, most notably in rural areas. Moreover, young people show little or no interest in basketry. The processing of rattan remains essentially artisanal. Manufacturers in urban areas produce a wide variety of products including chairs, tables, cupboards, beds, baby cots, wardrobes, trolleys, couches and house decorations. Those in rural areas are mostly involved in the weaving of cane baskets, sieves, fishing baskets, trays and other products used locally.

Concerning the trade of rattan products, there are two categories of traders: traders of raw canes/collectors and traders of rattan products (artisans).

Five major constraints that prevent the development of the rattan crafts sector in Cameroon are identified:

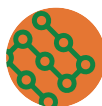
- Regulatory constraints, strategic, legal and institutional frameworks, unsuited for the development of NTFP sectors
- Lack of a framework for inter-sectorial concertation and dialogue, including local communities for the sustainable management of rattan
- Unsustainable exploitation and management of rattan characterized by lack of land-use plans
- Insufficiency of appropriate funding mechanisms
- Unsatisfactory scientific and technical knowledge of the rattan sector.

## KEYWORDS

Rattan, value chain, livelihood, market, artisans

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# Fine flavor native Peruvian cacao market segmentation based on matchmaking between buyer and farmer typologies

Cacao (*Theobroma cacao* L.) is one of the most important cash crops in many tropical countries. According to the International Cocoa Organization (ICCO), 75% of the cocoa exported from Peru can be classified as fine flavor cocoa (FFC), which fetches a premium price. However, most of this production is based on non-native cacao genotypes. This undermines the country's ambition of leading the FFC market segment based on the increasingly recognized unique quality of its native cocoa diversity.

The objectives of this study were to assess opportunities for smallholders to access FFC value chains through an evaluation of critical success factors on the demand side and locally available capacities and resources to meet these on the supply side. To this aim, we surveyed 60+ Peruvian and international FFC buyers to understand their requirements in terms of volume, quality and contractual requirements. On the supply side we interviewed 400+ farmers and cocoa associations and cooperatives to analyze the capacities and resources available at cooperative and household levels to satisfy buyer requirements.

We developed typologies of both FFC buyers and producers to explore options for matchmaking of different types of buyers and producers. Our results suggest the existence of distinct bottlenecks. Although the cacao grain quality, story and flavor were expected to serve as a catalyzer of future sales, there is a wide gap on the FFC supplier side that needs to be overcome regarding management capacities, and inclusion of women and youth to enhance sustainability. More work is needed to assess the true potential of enhancing inclusion of women and youth in the cacao value chain.

## KEYWORDS

Market access, cocoa value chain, fine flavor cacao, Peru

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## **STREAM 2**

Towards resilient and diverse landscapes  
and food systems



## STREAM 2

### Towards resilient and diverse landscapes and food systems

The global food system drives unsustainable agriculture and land use change leading to a planetary biodiversity crisis. Paradoxically, biodiversity is the foundation of resilient landscapes and sustainable food systems that nourish people and planet. This Stream highlighted the latest science innovations using tree biodiversity from genes to ecosystems at landscape scales to support food systems for a sustainable future.

A first focus was placed on exploring the challenges and opportunities to scale delivery of biodiversity to deliver sustainable development goals, especially related to cost-effective tree-based restoration to promote resilient and diverse landscapes and food systems. The outcomes are all wildly relevant for many other tree-based biodiversity-related initiatives, such as the Bonn Challenge, the Forest Ecosystem Restoration Initiative and the United Nation's Reducing Emissions from Deforestation and Forest Degradation (REDD) programmes.

Secondly, the most important FTA innovations to enhance delivery of biodiversity based solutions were showcased and discussed: maps, databases, advanced genomic methods, smartphone apps, participatory domestication methods, etc. These tools help promote tree species' biodiversity effectively, plan agricultural diversification with trees across multiple settings in a context-specific manner, accounting for agroecological differences and cultural preferences. They provide the correct information on what trees to plant where and for what purpose, with information on the nutritional contribution of different species as well as their role in restoration.



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# Use of direct seeding technique for enhancing parkland tree density and species diversity in Mali agroforestry parkland systems

Woodland and agroforestry parkland systems are critical habitats for biodiversity, providing food, fodder, fiber, fuel and other regulatory ecosystem services in the Sahel region. Overharvesting of existing woody vegetation coupled with extreme climate variability are leading to a lack of regeneration, decreased tree density and lowered species diversity. On the other hand, tree planting using nursery-propagated plants in the Sahel is costly and fraught with problems of low field survival rate and productivity. Previous trials conducted on station by ICRAF have shown that direct seeding using deep planting holes is a promising low-cost alternative for establishing four key indigenous tree species: *Adansonia digitata*, *Faidherbia albida*, *Vitellaria paradoxa* and *Ziziphus mauritiana*. Field experience in rural Mali has shown that trees' performances in rural settings are affected not only by seedling-related traits and environmental conditions, but also by management practices used by farmers to plant, own and manage trees for expected benefits. In order to better understand farmer tree establishment practices, a multi-environment trial was established by 100 volunteer farmers in four districts of Mali – Koutiala, Yorosso, Tominia and San – to assess the success of direct seeding compared with tree planting. Preliminary results after three months of field establishment revealed that tree survival rate involving deep planting holes (0.6 m × 0.6 m) of plants (73±3%) was comparable to that of tree planting (81±3%), and growth rate performance for direct sowing was greater for some species such as *Z. mauritiana* and *F. albida*. Further analysis of farmers' appreciation of the use of direct seeding as a novel technique for enhancing tree density and diversity on their farms will be conducted. Findings from this study supported by the Regreening Africa project are expected to largely inform large-scale tree-based land restoration projects focused on the fragile Sahelian landscapes.

## KEYWORDS

Agroforestry parkland degradation, biodiversity, farmers' opinions, West Africa



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# Forests sustaining agriculture: A new development paradigm for conservation and food production?

Ensuring food security while conserving biodiversity remains a pervasive global challenge. Forests and agriculture, although often considered as separate or conflicting entities, are mutually interlinked in a myriad ways. Therefore, it is vital to manage landscapes in an integrated and inclusive way to achieve both biodiversity conservation and food security. This paper will share a recent review and ongoing body of work on forest- and tree-based ecosystem services for their relative contribution to agricultural production with a focus on one or more forest-derived services and their links to agriculture. The research includes an emphasis on ecosystem services from trees across the landscape, and hence incorporates both forest formations and trees on farms. Based on this critical evidence base, we propose a series of entry points for engagement with the broader policy/development nexus to bring integrated landscape approaches further into the development arena with a focus on both agricultural production and sustainable forest management.

Forest ecosystems are crucial to agricultural production through their direct and indirect contribution of provisioning and regulating services. Tree-based agricultural systems and forests in agricultural landscapes directly complement agriculture by providing food, fodder and cash income from wild harvest. These systems also contribute indirectly by providing various provisioning and regulating ecosystem services such as pollination services, nutrient cycling, climate regulation, resilience to climate events, soil stabilization and watershed protection. For instance, forests and trees increase crop production by reducing soil erosion and nutrient leaching and by improving soil fertility. Similarly, wild pollinators such as bees, butterflies, birds and bats directly affect the productivity of 75% of globally important crops. Incorporating forests and trees within agricultural landscapes also creates heterogeneity in the habitat and supports diverse natural predators of crop pests, especially in perennial crops. Moreover, trees improve microclimate conditions in agricultural landscapes and buffer extreme climatic fluctuations such as temperature increase that has negative impacts on crop growth.

Current discourses on agricultural intensification appear to overlook the contribution of ecosystem services to crop productivity. Although some work has been undertaken on enhancing on-farm provisioning of ecosystems services, the ecological and socio-economic value of forests and trees in terms of their contribution to agricultural production has rarely been integrated into land use planning and other sustainable management processes. Similarly, the roles of forests and tree-based systems in delivering multiple ecosystem services and the impact of their interaction on different crop systems is not well known.

Moreover, comparative analysis across different crop systems, climatic zones and geographic locations are required to better understand the impacts of trees in agricultural landscapes. Further research is also required to assess the complementarity and resilience of different crops and trees in agroforestry systems to climatic fluctuations and how to better manage these systems in different socio-ecological contexts. Addressing these key knowledge gaps will be critical in managing landscapes to meet biodiversity, production and livelihood goals.

## KEYWORDS

**Agroforestry, ecosystem services, integrated landscape approach, food security, livelihoods**

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# DiversityForRestoration: A climate-smart and scalable decision support tool for species selection and seed sourcing contributing to long-term restoration success

At the dawn of the UN Decade of Restoration, tree-based restoration of degraded areas has become a global priority. An important, but often overlooked, aspect of ensuring the long-term success of restoration projects relates to the selection of appropriate species and seed sources, at least for active restoration activities that involve tree planting. As a minimum condition, the selected planting material should (i) correspond to the restoration objectives, (ii) be well adapted to survive and thrive under the degraded site conditions, and (iii) have sufficient genetic diversity to ensure the potential to adapt to changing conditions in the future. Here we present a scalable map-based online tool available at [www.diversityforrestoration.org](http://www.diversityforrestoration.org),

which is intended to assist restoration practitioners with the identification of appropriate tree species and seed sources. Originally developed for the tropical dry forests of Colombia, the tool has now been outscaled to the tropical dry forests of northwestern Peru and southern Ecuador, and further outscaling to Burkina Faso and Cameroon is underway. Decision making combines information on (i) suitability modeling under current and future climate conditions; (ii) restoration objectives, including agroforestry and commercial uses; (iii) locally prevailing stress conditions; (iv) functional trait diversity of tree species; and (v) the genetic quality of seed sources. Acknowledging that restoration has different, audience-specific meanings and interpretations, our tool is intended to support the decision making of anyone interested in planting trees for whichever purpose.

## KEYWORDS

Forest restoration, decision support, functional traits, seed sources, climate change

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# Within-species variability in nutrient composition of *Parkia biglobosa* pulp and seeds from three agro-ecological zones in Burkina Faso

There is increasing evidence that differences in nutrient content within crop varieties and animal breeds of the same species are sometimes greater than those found between species. *Parkia biglobosa* is a hugely valued tree that provides edible products and income for rural households in West Africa. The vast literature on this species' nutritional properties was synthesized with special attention to how within-species variation in nutrients was captured in published research. In addition, new data were collected and analyzed to explore nutrient variation across *P. biglobosa* populations from distinct locations in Burkina Faso.

We reviewed all published data between 1980 and June 2018 on nutrients in pulp and seeds of *P. biglobosa*. In addition, 75 *P. biglobosa* trees were selected from three provenances in Burkina Faso, and soil and tree characteristics were recorded. Immature and mature pods were collected from the selected trees in 2017 and 2018. Seed and pulp samples from *P. biglobosa* pods were analyzed for proximate composition, minerals, amino acids (seeds) and carotene (pulp). Variability in nutrients according to provenance, maturity stage, year and soil characteristics, and correlations with tree characteristics (e.g. grain weight and size, bark color, tree age, etc.) were explored.

The quality of published nutritional data on *P. biglobosa* is very poor and published articles rarely include information on environmental and biological factors, which are necessary to understand intra-species variability in nutrient content. Our nutritional analyses revealed significant differences in key nutrients, particularly in seeds, across the three populations studied.

This knowledge could assist in selecting nutritionally '+' trees for multiplication and/or domestication. Consuming micronutrient-dense foods or not, can make a difference in being nutrient deficient or not.

## KEYWORDS

Forest food, nutrition, *Parkia biglobosa*, seed, pulp

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# Lifting the buzz out of provisioning pollination services

Globally, most flowering plants including wild species and many food crops require pollination by animals to set fruit. Both managed and wild pollinators play an important role in forest landscapes, providing pollination services to cultivated plants, wild plants and forest trees; thus, they are vital in the maintenance of biodiversity and associated ecosystem functions globally. Reliance on pollinator-dependent cultivated plants is higher in tropical countries than anywhere else. Pollinators benefit from diverse natural habitats for forage and nesting requirements, especially when limited within cropping systems where floral resources can be highly seasonal or short lived. Management of forests can thus play an important role in maintaining and providing a continuous supply of pollinators that are important for resilient forests and surrounding land use. We reviewed and synthesized the current knowledge on how forest management practices strengthen pollination services, highlighting identified knowledge gaps. In addition to the literature review, two expert workshops and a questionnaire survey of global experts provided us further insights.

In summary, forest management practices, management of adjoining lands and climate change are important factors affecting pollinator abundance and diversity within forests. Most studies have concentrated on the impact of land use change, landscape composition, logging and fire on pollinator abundance and diversity, especially from the temperate region. Other studies have explored resource availability (nesting and forage), invasive species, grazing and mowing, dead wood retention, urbanization, management of riparian forests and plantation forestry as important influences on pollinator abundance. Recently, studies have begun to investigate impacts of climate change on pollination services and pollinators. Climate change will alter the time, quality and duration of phenological events such as flowering and shifts in plant species' geographical distribution having direct consequences for pollinators. A mismatch in phenological events in plants and pollinators may have significant impact on the survival of both communities. A decline in pollinators due to habitat degradation and climate change together will have severe consequences for the natural regeneration of forests, for maintaining genetic diversity of forest trees and for their adaptive potential regarding future climate change and resilience to pests and diseases.

Significant knowledge gaps were identified for tropical landscapes, in comparison with temperate systems. There is a lack of translation and dissemination of scientific knowledge into practical management guidelines that are accessible to diverse stakeholders. Since pollinators encompass a wide range of taxa and because responses to management practices are often taxa specific, management measures are not simple and need to be administered by considering the larger context. Given the critical ecological role of pollination for landscape resilience, understanding how forest management practices can benefit pollinator communities and be effectively implemented is imperative to sustainable landscape management.

## KEYWORDS

Pollination services, forest management, landscape, review, knowledge gaps

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# Empower smallholders to increase sustainability and productivity of agroforestry landscapes in Africa

Agroforestry practice – the planting and utilization of trees on farmland – is a blend of agriculture, forestry and horticulture, mainly, but not exclusively, practiced by smallholder farmers in the tropics. Globally, agroforestry represents over 1 billion hectares of land and involves more than 900 million people. The practice of agroforestry is increasingly being recognized as an important contributor to sustainable development in the tropics, but is severely constrained (among other things) by the limited access to good genetic-quality planting material of relevant trees. The uncertainty posed by climate change further stresses the importance of the germplasm used, with a focus not only on present performance but also on resilience.

Agroforestry as a scientific concept dates back some 40 years, when ICRAF (now World Agroforestry) was established and the supply of quality germplasm for smallholder farmers was recognized as a key constraint from the very beginning. We posit that this constraint is not a unique agroforestry problem, but rather a general constraint for smallholder farmers; it is also exacerbated by the biology of trees as compared with agricultural crops.

Input supply constraints have been the subject of a vigorous and fruitful scientific discussion in agriculture and have led to major initiatives intending to improve smallholders' access to a wider variety of high genetic-quality annual crops. A similar discussion for agroforestry has been strangely absent. The discourse in agroforestry is on the social processes of promoting agroforestry practices on farms, with limited (or no) discussion on how germplasm can be made available to smallholders. The agroforestry discourse overemphasizes the dichotomy between the two views – 'the Green Revolution' and 'Agroecological intensification'. Advocates of 'Agroecological intensification' unnecessarily disregard an aspect of germplasm quality, which is particularly important for trees – that quality of tree planting material is not only about productivity increases, but also about avoiding using inferior material, that may lead to complete failure of plantings.

The evidence from smallholder input supply systems clearly demonstrates the absence of genetic quality as a driver in agroforestry value chains. The value chain breaks between (lack of) investments in domestication/breeding and the growers of agroforestry trees in tropical tree value chains.

We discuss how available knowledge could be utilized in practice for mending the broken value chain in agroforestry and provide for climatic adaptation (environmental and economic). We argue that agroforestry value chains can only be fully understood and improved in an interdisciplinary context. We propose to develop and utilize a package of tools – using a 'precautionary principle' – for determining the potential adaptation of tropical trees across their distribution areas that would decrease the risk of failure of plantings and ensure productivity (natural potential distribution is undocumented for probably at least 59,000 of the planet's 60,000 tree species). The tools will make knowledge available for producers and users of tropical tree germplasms and empower smallholders to increase productivity of agroforestry in Africa.

## KEYWORDS

Quality germplasm, input supply, agroforestry discourse, tropical tree adaptation, interdisciplinary

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# Contributions of biodiversity to the sustainable intensification of food production

Biodiversity is crucial for environmentally and nutritionally sustainable food supply. Yet often its roles in food systems have been under-recognized, with rich local resources of biodiversity – including the diversity of tree species and the genetic variation within them – being consequently neglected and lost. Published meta-analyses and systematic reviews reveal that biodiversity's beneficial roles are context specific, depending on the particular production system and environment. This, considered along with the trajectory of global food systems toward homogenization, presents challenges for biodiversity in supporting future food supply. Further understanding of the drivers behind trends in food systems, at a cross-sectoral level, is essential. In addition, actual implementation of biodiversity-based food production options requires not only that these options are productive from an agronomic perspective, but that many additional factors are addressed, such as the transaction costs of knowledge acquisition for practice adoption. In this talk, we will set the scene for further biodiversity-based interventions to support sustainable food production within the context of human nutritional needs. We will summarize some of the major interactions that exist between the different biological components (crops, trees, pollinators, microorganisms, etc.) that can be found in food production systems. We will then discuss the interventions that can be made to enhance biodiversity's many potential roles in future food supply, along with the knowledge gaps that are targets for further research. We will end by discussing the practical implementation of biodiversity-based food production options.

The talk will be based on a thematic study submitted to the Food and Agriculture Organization of the United Nations (FAO) to support the development of the landmark first State of the World's Biodiversity for Food and Agriculture report, and published in 2019.

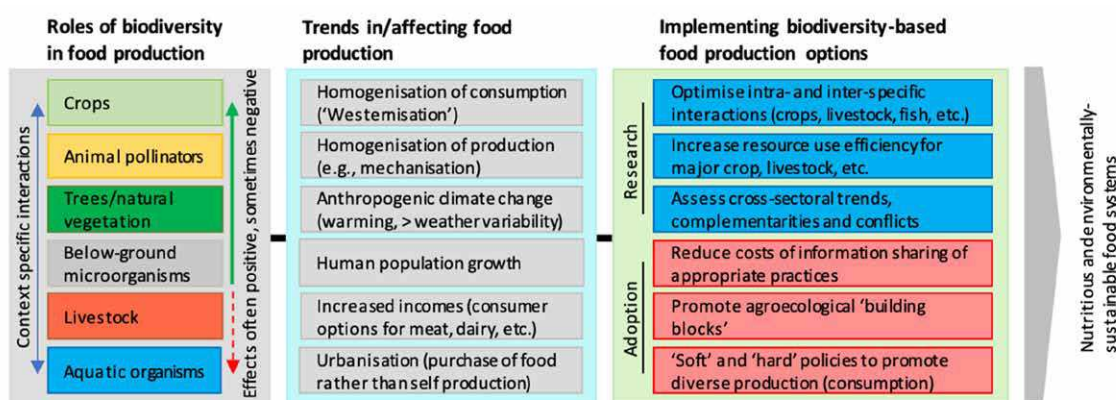


Figure 2.1 Schematic summarizing major issues in the roles of biodiversity. Left: the context-specific roles of biodiversity in food production are often, but not always, positive. Centre: trends connected with food systems relevant to a discussion of the roles of biodiversity. Right: the implementation of biodiversity-based food production options, for more nutritious and environmentally sustainable food systems.

## KEYWORDS

Agrobiodiversity, biotic interactions, cross-sectoral food system interactions, dietary sustainability, food system trajectories

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# Exploring genetic effects of forest degradation on the Brazil nut socio-ecological system in Madre di Dios, Peru

Non-timber forest products offer a critical opportunity for supporting the sustainable development of rural communities and the conservation of natural ecosystems. The Brazil nut, a hyperdominant carbon-rich tree species, is an exceptionally successful conservation model in this context, since its products are globally traded and economically important for a vast number of people in rural areas in the Amazon Basin. This species has the potential to contribute to resilient stewardship of forest landscapes, while giving economic benefits to local communities and improving their livelihood, as well as playing a role in carbon sequestration and climate change mitigation. Although it is a protected species, the habitat where Brazil nuts occur is being fragmented by human impact due to logging of other tree species and land conversion from forest to agricultural systems and pastures using unsustainable practices, e.g. burning.

In this project, we explored the consequences that forest degradation has on the long-term viability of Brazil nut populations and on their genetic resources, which are the foundation of resilient production and a vital source of material for forest enrichment and Brazil nut-based restoration. We analyze associations between genetic diversity and fitness attributes (heterozygosity–fitness correlations), using a combination of microsatellites and single-nucleotide polymorphism (SNP)-based genotype data, linked to data from adult fruit production, germination and seedling establishment in planting experiments. We place these findings in the context of patterns of fine-scale genetic structure, both within our study sites, and compare with other tropical tree species with similar restricted gene flows. We assessed contemporary patterns of gene flow by pollen dispersal, and signals of inbreeding compared with adult trees across study sites following a forest-degradation gradient. Finally, we explore the implications of these results for restoration practices including seed collection and plantations and relative investment costs for quality genetic material for restoration.

## KEYWORDS

Non-timber forest products, genetic diversity, fine-scale genetic structure, heterozygosity–fitness correlations, inbreeding

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# Mapping tree species' vulnerability to multiple threats as a guide to restoration and conservation of tropical dry forests

Understanding the vulnerability of tree species to anthropogenic threats is important for the efficient planning of restoration and conservation efforts. We quantified and compared the effects of future climate change and four current threats (fire, habitat conversion, overgrazing and overexploitation) on the 50 most common tree species of the tropical dry forests of northwestern Peru and southern Ecuador. We used an ensemble modeling approach to predict species distribution ranges, employed freely accessible spatial datasets to map threat exposures and developed a trait-based scoring approach to estimate species-specific sensitivities, using differentiated trait weights in accordance with their expected importance in determining species sensitivities to specific threats. Species-specific vulnerability maps were constructed from the product of the exposure maps and the sensitivity estimates. We found that all 50 species face considerable threats, with an average of 46% of species' distribution ranges displaying high or very high vulnerability to at least one of the five threats. Our results suggest that current levels of habitat conversion, overexploitation and overgrazing pose larger threats to most of the studied species than does climate change. We present a spatially explicit planning strategy for species-specific restoration and conservation actions, proposing management interventions to focus on (i) in situ conservation of tree populations and seed collection for tree planting activities in areas with low vulnerability to climate change and current threats, (ii) ex situ conservation or translocation of populations in areas with high climate change vulnerability, and (iii) active planting or assisted regeneration in areas under high current threat vulnerability but low climate change vulnerability, provided that interventions are in place to lower threat pressure. We provide an online, user-friendly tool to visualize both the vulnerability maps and the maps indicating priority restoration and conservation actions.

## KEYWORDS

Multi-threat vulnerability assessment, functional traits, planning for restoration and conservation, climate change

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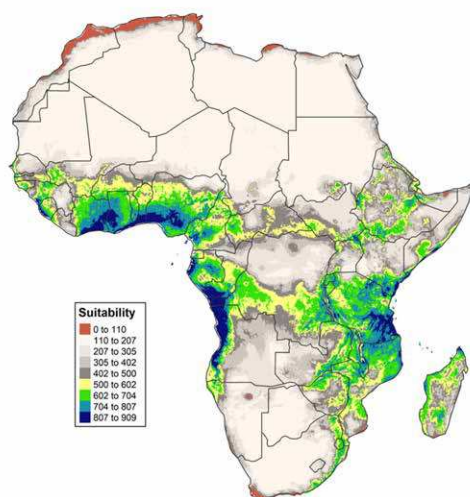
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# High-resolution species distribution modeling across Africa: Atlases and decision-support tools to select suitable species and their seed sources for 150+ priority tree species

World Agroforestry, collaborating with Bioversity International, CATIE and Hivos, recently published habitat suitability maps for 100 tree species that are widely used in Central America for shade in coffee or cocoa agroforestry systems (de Sousa et al. 2019). Using similar methods of species distribution modeling, including ensemble methods whereby consensus habitat suitabilities are either weighted average probabilities from different algorithms or counts of the number of algorithms that predict the presence of a species (Kindt 2018), habitat suitability maps were prepared for 150 tree species native or exotic to Africa. These maps are already available from ICRAF's landscape portal and include KML layers that can be uploaded in Google Earth. Maps are currently being prepared for a species atlas and an interactive portal documenting 'what to plant where'. Applying the likelihood scale recommended by the IPCC, habitat change maps are based on the middle of the 21<sup>st</sup> century for two representative concentration pathways. Calibration methods applied were further augmented using filtering approaches of species occurrence datasets in geographical and environmental space, spatial blocking techniques to reduce spatial correlation during model evaluations (Valavi et al. 2019), and circular background point-selection masks. These methods were also integrated into the BiodiversityR software package to facilitate wider application (Kindt 2019). Models were calibrated with a subset of bioclimatic and topographic variables obtained from WorldClim, AFRICLIM and ENVIREM (where future data had to be pre-processed). To reduce potential overestimation of the effects of climate change, species distribution data were obtained from across Africa.



Selected species were priorities in different projects and countries, including for a large forest landscape restoration project in Ethiopia (PATSPPO), the African Orphan Crops Consortium, and priority food tree species identified in Burkina Faso, Ethiopia, Gambia and Kenya. Maps will allow future climate planning to support tree-based livelihoods and environmental services.

Figure 2.2 Consensus habitat suitability map of *Adansonia digitata* L. with suitability values above 500 indicating the predicted presence of the species by using the threshold that maximizes the sum of specificity and sensitivity. Suitability values below 110 reflect polygons that were completely outside the convex hull surrounding known presence observations. Suitability values are probabilities rescaled from 0 to 1000.

## KEYWORDS

Species suitability modeling, seed sources, species selection, forest landscape restoration

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# Development of novel field and genomics resources for diversifying food systems

A food systems approach deals with understanding the dependency and interaction of various aspects of food production and utilization such as growth and cultivation, harvesting and processing, logistics and transport, markets and value chains, and consumption and waste disposal. Due to the overarching nature of the approach, it offers various options for food and nutritional security and livelihood, achievable through diversification of farming landscapes by planting multipurpose crops and trees, building sustainable multi-crop–tree production systems, and diverse food offerings/choices.

Orphan or neglected fruit trees are traditional but nonconventional delivery vehicles for productive and diversified agricultural landscapes. Promoting and mainstreaming locally adapted indigenous or naturalized fruit trees have an immense capacity to provide options for diversified land use, nutritious and diverse food choices, and broad ecological services but need modern interventions for enhanced preferential uptake by farmers. African Orphan Crops Consortium (AOCC) and World Agroforestry (ICRAF) have prioritized ~50 neglected trees of African importance (Hendre et al. 2019), to develop novel field and genomics resources to be used in modern breeding and improvement programs as follows.

1. Building informed and structured field resources: A successful improvement program is built on promising material and various types of populations such as random mating populations, structured populations, bi-parental progenies, multi-parental progenies, and advanced inbred lines suitable for modern breeding programs can be developed using this (Hickey et al. 2017).
2. Novel traits for improvement: Apart from farm productivity, a varietal product profile should be defined using novel traits such as tree architecture, nutrition and compatibility for mixed cropping, and smallholder preferences such as easy harvesting, processing, storage, etc., and other farmer and consumer preferences (Dawson et al. 2020).
3. Development of genomic resources: This includes sequencing genomes, diversity sequencing, and gene/transcriptome sequencing that gets routed into germplasm management plans, population improvement, pre-breeding programs, and bi-parental and bulked breeding efforts. The consortium has published five tree genomes till now (Chang et al. 2019; Sahu et al. 2020).
4. Genomics for genebank: Genomic characterization of germplasm allows us to select the most diverse material to form a core collection of genebanks. This is important for trees, where phenotypic data are very scarce.
5. Genomics to maintain genetic diversity for population improvement and pre-breeding: Genomics tools can ensure the maintenance of sufficient productive genetic diversity among the selected trees in breeding orchards for sustained clonal or varietal release program.
6. Genomics-based modern breeding programs: Genomic diversity can be associated with phenotypic diversity using various genomic-driven approaches such as quantitative trait locus (QTL)/trait mapping, genome-wide association studies (GWAS) and genomic selection (GS), which can increase genetic gains and shorten the varietal release cycle (Hickey et al. 2017). Inclusion of diversity and participatory approaches can offset genetic erosion to a large extent.
7. Ecological genomics: This is a relatively new application where genomics can help in understanding the genetic basis of ecological adaptation at the population level to guide conservation and utilization strategies of natural forest stands.

Through these tools, methods and approaches, sustainable and integrated food systems can be built on a profitable agricultural ecosystem driven by smallholder and larger farming landscapes.

## KEYWORDS

Genomics, orphan trees, nutrition, tree breeding, livelihood

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# Unexplored potential for the conservation of tree genetic diversity in large African cities

Increasing and maintaining agroforestry systems in urban settings is largely advocated, as trees in the city provide many ecosystem services. In Africa, one of the world's fastest urbanizing regions of the world, they contribute particularly to food production and to maintaining the quality of the environment. Nevertheless, little is known on the levels of genetic diversity of urban trees. Our model species, *Dacryodes edulis* (G. Don) H.J. Lam, is a widespread indigenous fruit tree in Central Africa. In Cameroon, it is commonly found in different agroforestry systems (home gardens, agroforests), from the capital Yaoundé to production zones in rural areas. In order to test the contribution of urban trees to species genetic diversity conservation, we adopted a joint genetic/ethnoecological approach. We compared for the first time the genetic diversity of an urban *D. edulis* population (in a district of Yaoundé, 250 ha) and a rural population (one large cultivation area of this species, 200,000 ha). Surprisingly, we found that the genetic diversity is as high in Yaoundé as in the rural population. We demonstrated that this pattern results from an extensive seed exchange network by which the planting material available in the city comes from different regions of the country, as new urban in-migrants settle down in Yaoundé. Our finding of a significant intra-specific diversity of *D. edulis* in Yaoundé, associated with the considerable circulation of planting material typical of a highly populated urban environment, is a compelling result that encourages us to explore further the potential untapped role of cities in biodiversity conservation.

## KEYWORDS

Genetic diversity, indigenous fruit tree species, seed exchange network, urban trees, conservation and sustainable use of forest genetic resources

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# How important are wild fruits for healthy diets in Zambia?

The dietary importance of wild foods in most countries is not well understood. Most of the information that we have on wild foods and diets is qualitative and the little quantitative data that exist tends to be from very specific small case studies. We know from qualitative data that many wild foods are valued in Zambia and that some of these are widely consumed. We do not, however, know how much of these foods are consumed, how important they are for peoples' diets, and how this consumption varies through the country. We present findings from a CIFOR–FAO collaborative project entitled Zambia Wild Food Statistics.

We selected one site in each of the four agro-ecological zones across Zambia. In each site, we first carried out a focus group discussion to identify the most important wild foods commonly collected in several food group categories as well as their seasonality. This was followed by an individual seven-day food frequency survey of the female head of household, as well as a household survey with questions about which products were collected by the household, where the products were gathered, how much was gathered, and how much was consumed. Because most products are only available seasonally, we used a one-year recall period for collection. We surveyed 209 households across all agro-ecological zones of the country.

All but one household surveyed collected products from the forest and most collected multiple types of products from forest areas. We collected data on several food groups but, in this presentation, we report results only for fruit. The WHO recommends a minimum of 200 g of fruit per day for healthy diets and most national guidelines recommend at least two servings of fruit per day. In our seven-day food frequency survey, we found that only 58% of women consumed any fruit in the week preceding the survey and only 11% ate at least one piece of fruit per day. For the 42% of women who did consume fruit, the contribution of wild fruit was enormous: wild fruit was consumed more than twice as frequently as domestic fruit (3.4 times vs 1.6 times per week). There was significant regional variation, with the sites in the north, south, and west consuming a higher proportion of wild fruit and those in the center consuming a higher proportion of domestic fruit. Quantities of fruit consumed were also substantial. Preliminary results suggest that an average of approximately 7 kg of wild fruit was consumed in the previous year per person across the four agro-ecological zones. This means that households could meet dietary guidelines for fruit consumption for over one month by just consuming wild fruits.

Recent attempts to quantify national contributions of forests to food and nutrition have struggled due to a lack of data. There have been claims that collecting such data would be prohibitively expensive and extremely difficult. This small pilot project shows that it is neither very difficult nor expensive to collect meaningful representative data on the consumption of wild foods from forests.

## KEYWORDS

Wild food, Zambia, fruit, consumption, nutrition

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# What indicators to assess the contributions of forests, trees, and agroforestry to food security and nutrition at national level?

Forest, trees and agroforestry provide multiple contributions to food security and nutrition (FSN) in its four dimensions of availability, accessibility, utilization and stability, as shown by the GFEP report (2015) and the High Level Panel of Experts on food security and nutrition report (HLPE 2017). These two major reports have played a considerable role in describing the contributions of forests, trees and agroforestry to FSN and have raised awareness on their importance in both the forestry and food security and nutrition communities. However, there is currently no quantitative indicator to assess these contributions at national level.

We consider the four main contributions of forests, trees and agroforestry identified by the HLPE to FSN and link them to the four dimensions of FSN:

- direct provision of food and feed (availability, utilization)
- provision of wood energy used for cooking food and boiling water in developing countries, which is critical for assimilation of nutrients and reduction of risks of diarrhea (utilization)
- formal and informal employment and sources of income in the forestry sector and through sales of wood and non-wood forest products (NWFP) (accessibility)
- provision of ecosystem services that sustain all food production through water regulation, soil formation and protection, nutrient cycling, pest control and pollination (availability).

These four contributions are also particularly important to buffer the impacts of shocks and crisis (stability).

They have effect at various scales, from local to global. As no single indicator can track at national level these four contributions, we propose to use a set of sub-indicators, using data already available for all countries:

- employment provided by forests and trees, covering forestry, wood transformation and related sectors
- consumption of woodfuel per capita
- consumption of fruits (or only of fruits from trees) per capita in kg
- consumption of nuts per capita in kg.

This set of sub-indicators would need to be complemented by an indicator of the ecosystem services that support agricultural production. It also does not cover the specific contribution of wild foods to the FSN of people living in or close to forests. Several options have been mentioned, such as the number or percentage of rural households deriving benefits from forests and trees, that could be informed by a qualitative question in agricultural census and comparable surveys, or indicators linked to forest proximity indexes and/or to riparian strip tree coverage indexes. These proposals have been discussed during the expert workshop in support of the Collaborative Partnership on Forests (CPF) Joint Initiative on streamlining forest-related reporting. It was decided to create a specific work stream that would finalize the first set of sub-indicators in a concrete and practical way, for quick use and to further explore options to better cover ecosystem services that support agricultural production as well as the specific contribution of wild foods to the FSN of people living close to forests (CPF 2019).

## KEYWORDS

Indicator, food security, forests

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# Proximate and mineral composition of indigenous bamboo shoots of Ethiopia

Demand for natural and organic foods, including bamboo shoots, has greatly increased. In Ethiopia, bamboo shoots of the two indigenous species is traditionally used for food. However, information on the nutritional profile of the two indigenous bamboo species and bioavailability of important mineral elements is limited in the country. This paper describes the proximate and mineral composition of bamboo shoots of the two indigenous bamboo species of Ethiopia (*Arundinaria alpina* and *Oxytenanthera abyssinica*). Shoot samples, height 10–30 cm, were collected from Northwestern Ethiopia and analyzed for their nutrient and mineral contents following the methods developed by the Association of Official Analytical Chemists. The results indicated that *A. alpina* shoots have higher protein, calcium, phosphorus and crude fiber and low hydrocyanic acid contents. On a dry weight basis, *A. alpina* contains 31.33% protein, 12.17% crude fiber and 13.67% ash. The mineral content, in mg/100 gm of bamboo shoots, was found to be: potassium 1661.17, calcium 369.5, phosphorus 887 and sodium 17.33. *O. abyssinica* shoots have almost the same nutrient contents as *A. alpina* shoots except for differences in a very few mineral elements. *O. abyssinica* shoots have higher potassium. On a dry weight basis, it contains 27% protein, 8.67% crude fiber and 11.33% ash. Its mineral contents in mg/100 gm, dry weight basis, were potassium 4737, calcium 203.8, phosphorus 704 and sodium 16.67. The values for tannin and phytate are higher for *A. alpina*, but with very low (below detection level) hydrocyanic acid. The results indicated that mineral and proximate contents also vary depending on location and species. Shoot size has no significant effect on proximate and mineral contents except that tannin increased with shoot size. Generally, the two indigenous bamboos have a good nutrient profile. Thus, with further adoption of improved processing techniques that enhance the bioavailability of iron, bamboo shoots of indigenous species can be promoted to enhance food and nutrition security in the country.

## KEYWORDS

Highland bamboo, lowland bamboo, *Oxytenanthera abyssinica*, *Arundinaria alpina*, *Yushania alpina*

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# Clonal and seasonal variation in fruit yield of *Uapaca kirkiana* in Malawi

*Uapaca kirkiana* or wild loquat is an important indigenous tree of the Miombo woodlands, with a huge potential to improve the nutrition and livelihoods of millions of smallholder farm families in southern Africa. Domestication of wild loquat was identified as key to enhancing fruit production and reducing reliance on the forests. As part of the domestication process, grafted trees from superior phenotypic trees were used to establish a clonal test at Makoka research station (altitude 1029 m asl; latitude 15°32'S; longitude 35°11'E), with the objective of identifying superior clones for on-farm cultivation. The trial comprised 37 clones each with between 1 and 13 ramets. Fruit yield data were collected to determine the fruit yield potential of the clones and also to assess whether the clones exhibit mast seeding behavior as observed in other forest trees. Mast seeding is a phenomenon in forest trees and refers to the intermittent production of large seed crops, where seasons with high fruit production are followed by one or more seasons with very low fruiting. We report on the performance of these 37 clones across 6 seasons and also the correlation of climatic variables (rainfall and temperature) with fruit yield.

## KEYWORDS

Clone, fruit yield, seasonal, mast seeding, *Uapaca kirkiana*

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# Minimal descriptors for *Dacryodes edulis* (G. Don) H. J. Lam in Mbalmayo ICRAF genebank

*Dacryodes edulis* (safou), a tree species with considerable economic and nutritional value for people in West and Central Africa, is one of the priority species for tree domestication in the region. In view of conserving the resource for future use and improvement purposes, a genebank consisting of 190 accessions was established by the World Agroforestry (ICRAF) at Mbalmayo in the Centre Region of Cameroon in 2002. An assessment of descriptors of the species in the genebank was conducted as a preliminary step for breeding. Fifty-one (51) morphological parameters (25 qualitative and 26 quantitative) were assessed. The results indicated diversity in most of the studied parameters of *D. edulis* in the genebank (41/51). Ten traits however did not show diversity, i.e. trunk shape (StS), leaflet apex shape (IAS), leaflet base shape (IBS), leaflet margin (IM), young leaf color (YLC), seed number per fruit (SNF), cotyledon number per seed (CNS), flowering period, fruiting period and regularity in fruiting. Among the traits that showed significant diversity were pulp weight and anthracnose attack. Pulp weight (PuW) ranged between 11 g and 109 g, with accession Bum/DE/34M displaying the highest value. During the period of observation, more than 90% of the accessions showed severe anthracnose attacks (100% severity), three accessions (Tree116, Tree2-105, Tree2-61) had low levels of attack (1% severity), and four were healthy (Bum/DE/34M, Bum/DE/34S, Bum/DE/37M and Tree2-92). Interestingly, principal component analysis (PCA) /Pearson correlation studies highlighted positive correlations between the following parameters: fruit weight (FrW), pulp weight (PuW), fruit length (FL) and fruit diameter (FD). In addition, we have information in our database about other trees with superior traits that meet farmers' needs, that were identified during prospection in natural populations, but not collected for conservation in the genebank. A good example is DE/EN/205 and DE/MA/130 with higher fruit pulp weight (200 g) and off-season fruiting, respectively. Previous studies on the economic value of safou revealed that off-season safou can fetch double the price compared with that during the main production period, thus offering producers the opportunity to increase their income significantly. Selection of accessions with desirable traits for propagation and integration in farmers' fields could improve farmer revenues, assuming that characters are genetically controlled. In conclusion, the *D. edulis* genebank in Mbalmayo is highly diversified and hosts accessions with interesting traits. Also, there are accessions that were registered in our database but not collected for conservation in the genebank. Such trees could be brought into the genebank to improve its utility. The assessment results can guide future selection of targeted *D. edulis* trees for domestication purposes, especially in breeding programs.

## KEYWORDS

Accessions, anthracnose, breeding, off-season and pulp weight

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# Estimation of heritability and genetic gain in height growth of superior clones of *Dacryodes edulis* (G. Don) H. J. Lam

To improve their livelihoods, farmers in West and Central Africa have long been domesticating wild and virtually wild tree species such as *Dacryodes edulis*, locally known in Cameroon as safou. More recently, the species has attracted interest from international agroforestry research because of its commercial and nutritional importance. Since the beginning of the tree domestication program by ICRAF and partners in the mid-1990s, research on the species has covered several topics, including assessing different propagation options. Propagation studies demonstrated that safou can be multiplied through seed germination, as well as by rooting of cuttings and marcots. Despite efforts to disseminate these propagation techniques, wide-spread cultivation of the species has not yet happened. Producers are still expecting scientists to produce cultivars that optimize benefits. To address this issue, ICRAF has orientated its research towards the development of cultivars with desired fruit characteristics. Hence, in 2015, the five top accessions with the largest fruit mesocarp identified from ICRAF's genebank in Mbalmayo (Cameroon) were cloned and planted in three locations with different agroecological characteristics (Mbalmayo, Bangangte and Kribi).

While waiting for the fruiting, trees have been monitored each year for growth parameters. However, heritability and genetic gain in safou growth traits are not yet known. Therefore, we estimated narrow-sense heritability ( $h^2$ ) and genetic gain in height growth in *D. edulis* using five accessions from ICRAF's genebank. No significant difference ( $p = 0.08$ ) was observed between locations, whereas accessions showed significantly different results ( $p = 0.03$ ). Overall, narrow-sense heritability amounted to 0.64 and genetic gain in height ranged from -27.62 to 35.02 cm. One clone (DE/MA/41) had a mean height increment above the overall mean performance and was recommended for future selection. Including growth parameters on top of desirable fruit/nut traits in tree selection is important because tree domestication has been identified as an economic incentive for farmers to plant trees, thus offering an efficient option to restore degraded and deforested landscapes. Results of the present study can be used for future selection of targeted *D. edulis* trees for land restoration.

## KEYWORDS

Accession, breeding, cultivar, land restoration and selection

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# To shift or not to shift? What are rural households' preferences for livestock breeding as alternatives to reduce pressure on wild fauna in the Yangambi Man and biosphere reserve – DR Congo?

Using a unique dataset from our multi-attribute choice experiment with 700 households in 40 villages within and around the Yangambi Man and Biosphere Reserve (Y-MaB) in July and August 2018, this research investigates possible adaptive strategies for food security while preserving biodiversity and the multi-functionality of the Y-MaB. More precisely, it investigates the willingness to accept (WTA) of rural households to adopt livestock keeping as a partial or total substitute to current ongoing activities; it quantifies trade-offs between various levels of the attributes characterizing substitution options; and it identifies key policy options or adaptive strategies using a final mixture or latent class model (LCM). It finally identifies the membership of the classes as well as their localization across the four main axes surrounding the Y-MaB reserve. Choice experiment outcome shows that only 13.4% of respondent have chosen to keep current practices versus 86.6% who are inclined to shift from current practices and to take a position across the substitution path. This supposes a low level of inertia for the status quo. Based on the alternative specific constant of the RPLM, \$151.35 on average is required as a baseline subsidy to compensate for the disutility of the respondents when accepting to allocate a certain amount of time spent in the current activity to livestock breeding without compensation. In addition to the subsidy, partial and total substitution of the principal activity is feasible as adaptive strategies for a sustainable food system, conditional to capacity building on breeding and small farm management, and to an appropriate accompaniment and follow-up. Marginal rate of substitution leads to the result that engagement for adaptive strategies will require an average additional compensation of \$423.27 for an average poultry farm of 41.95 individuals. The engagement for pig, sheep, duck, guinea pigs, rabbit and turkey will require on average a compensation of \$806.83, \$650.69, \$227.97, \$40.72, \$36.32, \$37.51, respectively. Among the 5 classes of individuals with different substitution patterns sharing common characteristics identified using the final mixture analysis, Classes 1 and 5, located along the Yangambi–Lilanda axis (Class 1) and the Kisangani–Yangambi axis (Class 5), representing 62.7% of the population within and around the Y-MaB (38.7% for Class 1 and 24% for Class 2), are in favor of adopting adaptive policy options based on livestock raising as a partial or total substitute for current practices compared with Classes 2, 3 and 4. Further analyses identifying membership reveal significant differences in gender, age, education and main activities across classes. As a result of the final mixture analysis, substitution patterns behind Classes 1 and 5 can stand for main adaptive policy options derived from rural households' preferences to be supported by policy makers, and technical and financial partners in the Y-MaB and surroundings.

## KEYWORDS

Biodiversity conservation, food security, Yangambi Man and Biosphere Reserve, field experiment, adaptive policy options

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# Rural resource centers as extension support for diversified food systems

Improving dietary diversity has recently been recognized as a critical component of food security in developing countries especially for Sub-Saharan Africa. Reduced investment in formal extension services, however, negatively affects the ability of farmers to adopt novel food production practices that often require knowledge and input. Rural resource centers (RRCs), locally designed as dissemination hubs, have been applied to promote agroforestry technology adoption in East Africa by accelerating farmers' access to knowledge and diverse planting materials. RRCs are supported by projects but owned by target communities, and provide farming communities with peer learning opportunities and access to inputs to improve and diversify food production. This analysis has reviewed successes and challenges around RRC implementation under the Trees for Food Security Project East Africa. Findings have recorded the role of RRCs in: diversifying current germplasm input systems; rapid multiplication of planting material; and farmers' innovation and engagement with formal extension services. Lessons documented are being shared with development project designers to help in scaling up work involving the adoption of novel, diversified food production approaches such as fruit tree portfolios. It is anticipated that this study's findings will provide knowledge about investment in more innovative extension services to rapidly help diversify monocropping systems and mitigate hunger problems in affected developing countries.

## KEYWORDS

Rural resource center

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# Domestication of dioecious *Allanblackia stuhlmannii* and *Daemonorops* spp. in Tanzania and Indonesia

Domestication of dioecious animal-pollinated wild fruit tree species in agroforestry systems impose problems of maintaining adequate numbers of males in the population and hence maintain adequate levels of pollination. Transition to farmland modifies the flowering habit and possible environment for pollinators.

The project looked at the challenges of two very different species with mixed extractivism and initial cultivation, viz. *Allanblackia stuhlmannii* in the Usambara Highlands in Tanzania and *Daemonorops* spp. in southern Sumatra, Indonesia. The former is a large canopy tree with a 15–20-year long juvenile stage and used for extraction of oil-rich seed. The latter is a climbing ‘rattan’, yielding a reddish fruit resin used for medicine and cosmetics. It has a juvenile stage of <6 years.

We studied the ratio of males and females in forest and farmland. In *Allanblackia*, male trees typically flower some years younger than females, making young populations male biased. In natural forests, there tends to be a male bias of up to 1.5 males per female. Farmers’ removal of non-fruiting male trees inverts the sex ratio to female biased with less than one male per four females. Although the distance between females and nearest males increases, the prolific flowering in farmland seemed to compensate for the reduction of males. Supplementary hand pollination had no visible effect on fruit production of female trees within 40 meters of a male tree. Correlation between distance to males and fruit set was weak and only visible beyond 40–50 meters. In planted *Daemonorops* stands, the sex ratio on population level was approximately 1:1. Number of flowering stems, age of flowering, and number of inflorescences was strongly influenced by light exposure, i.e. support tree. Farmers occasionally reduced the number of male stems but maintained the plants. There were usually three *Daemonorops* plants per one rubber tree.

Several remnant forest trees of *Allanblackia* had been maintained for a long time after forest clearance, and most farmers in the project area sold seeds. However, the planting rate was very slow. Constraints to adoptability by planting was partly reasoned in the extremely long non-productive juvenile stage, the high number of non-fruiting male trees, and the competition with other tree crops, clove and cinnamon, with more secure and profitable markets. Also, short-rotation timber such as *Grevillea* was generally preferred over *Allanblackia*.

*Daemonorops* was primarily procured by extraction from natural forests, and the activity had a strong cultural affiliation, primarily to the local Batin Sembilan tribe. Farmers in southern Sumatra had recently started intercropping with rubber as support tree, and there was no immediate cultivated competitive species to *Daemonorops*. However, as many farmers shifted to palm oil, which is more profitable, the rubber–*Daemonorops* combination had become less popular.

## KEYWORDS

Dioecious, domestication, *Allanblackia*, jernang, adoptability



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# Developing a participatory theory of change for integrated landscape management in Zambia

Integrated landscape approaches that engage diverse stakeholder groups are increasingly promoted to address linked social–environmental challenges in tropical landscapes. Recent research proposes that a transdisciplinary approach to landscape management can help identify common research needs, enhance knowledge co-production, guide evidence-based policy development and harmonize cross-sector action. Meanwhile, guiding principles for landscape approaches suggest that identifying common concerns and negotiating a process of change are fundamental to implementation and evaluation efforts. As such, the use of decision support tools such as theory of change models that build ordered sequences of actions towards a desired future state are increasingly advocated. Here we apply landscape approach and knowledge co-production principles to develop a theory of change for dealing with current unsustainable landscape management and associated conflicts in the Kalomo Hills Forest reserve of Zambia. The participatory process engaged a diverse range of stakeholders, including village head people, local and international researchers, district councilors, and civil society representatives amongst others. Several potential pathways for action were developed around the themes of deforestation, biodiversity and wildlife conservation, socio-economic development, enforcement, distribution, process, and recognition. To make the pathways actionable, participants identified a need for enhanced capacity building and improved governance, while a lack of commitment towards coordinated knowledge exchange and access to information along with poor policy formulation and weak enforcement of rules were among potential impediments to action. Developing a theory of change for integrated landscape management is inherently context-specific, but the process and outcomes of this study should hold relevance across a range of contexts faced with governance challenges related to reconciling conservation and development objectives.

## KEYWORDS

Transdisciplinary science, sustainability, complex systems, landscape approaches, knowledge co-production

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# The cacao pollination process: Flower visitors, pollen deposition and fruit set

*Theobroma cacao* L. (Malvaceae), the source of chocolate, is a cash crop native to the Amazon Basin, with a longstanding cultivation history in the tropics worldwide. It produces fruits or pods that contain about 30 seeds that are processed to be sold as cacao beans, from which chocolate is manufactured. Despite the economic importance of cacao and the relevance of pollination for production of fruits and seeds, many questions about the entire pollination process remain unresolved. Although it is known that cacao depends on insects for successful pollination of its flowers, ambiguity remains about which taxa effectively contribute to pollen transfer. Our recent flower visitor observations in Peru do not provide evidence that backs up the long-held view that dipteran midges are the main pollinators. Because cacao trees produce thousands of tiny blossoms that remain receptive for pollination for about 36 hours, chances are low that a single flower is visited by an insect, and chances are even lower that those visitors are caught or observed. Of those many flowers a tree produces, usually only a very small fraction are pollinated and set fruit, i.e. receive enough pollen and are successfully fertilized. Further, not all flowers that are fertilized yield harvestable fruits, as developing fruits are often aborted in the first three months after fertilization. This phenomenon might be contributing to the observed yield gap, as numbers of fruits produced are often lower than the yield potential. It is recognized that fruit set of cacao is limited by pollen deposition under optimal field conditions, but recent studies that assess pollen amounts deposited in the field are scarce. From our experiments, it is apparent that hundreds of pollen grains are necessary to form mature fruits. Fruit set happens infrequently, suggesting that the yield gap could be partly due to insufficient amounts of pollen grains deposited. Not only the quantity, but also the origin of the deposited pollen can have an influence on successful fruit development, as our hand pollination experiments with several genotypes demonstrate. Across its native range, non-domesticated cacao is believed to be predominantly outcrossing: fruits usually do not develop after pollen is transferred to female flower parts from the same tree. We used a native Peruvian cacao variety to address some of the unresolved questions about the cacao pollination process by linking visitation frequencies, pollen quantities and hand pollination to fruit set rates. We suggest that the complex interplay of low visitation rates, poor pollen deposition, compatibility issues and seasonality are partially driving low fruit set rates in our study area. We further highlight the need for studies that focus on the entire cacao pollination process, from flower visitors to pollen deposition and integrating early fruit set, because together, they are critical for determining cacao yields.

## KEYWORDS

Cacao, pollination, yield gap, pollen deposition, compatibility

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# Structure and composition of two areas of *Pinus caribaea* Morelet pine forests and their relationship with the diversity of associated birds

This research was carried out at the Viñales Agroforestry Experimental Station, with the objective of determining the relationship between the diversity of birds associated with two areas of pine forest and the composition and structure of the vegetation. For this purpose, a natural area of *Pinus caribaea* and a plantation of the same species were chosen in order to compare both; 4 circular plots were established in each, with a fixed radius of 15 m. The plant species present in each plot were inventoried, the height and diameter of the trees were measured, and the birds present in each plot were inventoried, in the months of January and February 2018. For both vegetation and birds, the alpha diversity ( $\alpha$ ) and vertical stratification were performed. The Kruskal–Wallis means comparison test was performed to determine if there were differences between the wealth and abundance values of the birds detected, between the strata and the sampled months. A Spearman correlation matrix was performed to determine the relationship between the birds and the measured vegetation variables. A total of 18 bird species were identified, which were grouped into 5 orders, 11 families and 16 genera. The majority of the species were permanent residents, consuming insects and grains, there being no significant differences in relation to the richness and abundance of species between months and plots, existing between the high stratum and the middle and low strata. There is little relationship between the vegetation variables and the bird species detected.

## KEYWORDS

Birds, diversity, abundance, wealth, vegetation

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# Assessment of the different landscapes in the Guanahacabibes National Park. Case study: Cabo de SanAntonio

Advanced techniques in the field of geoprocessing have become very effective in landscape studies. In the present work we intend to make a landscape study of Cabo de San Antonio, an area inserted in the Guanahacabibes National Park, based on a characterization of the combination of two landscape valuation methodologies ('in situ' method and cartographic method) with the delimitation of landscape units, considering the natural and anthropic factors that affect the study area in order to correspondingly develop a comparison of the results of both methodologies. The landscape assessment was carried out using a satellite image of the Sentinel-2, with a resolution of 10 m, which allowed us to determine the different types of landscapes and demonstrating their conditions in the study area. The objective was to show if the study area has a satisfactory landscape quality.

## KEYWORDS

Image, landscape, classification, valuation, methodology

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# Diversifying diets and filling micronutrient gaps through customized food tree and crop portfolios: Case studies from East Africa

As a result of predominantly staple-based food production by smallholder farmers in sub-Saharan Africa, consumption of a diverse range of nutritious foods is a challenge, with a lack of seasonal availability among the reasons for low intake. Using participatory research, World Agroforestry (ICRAF) developed a food tree and crop portfolio approach to enhance seasonal availability of nutritious foods in local food systems. These nutritious food portfolios are customized towards location-specific recommendations for cultivating a greater diversity of indigenous and exotic food tree species with complementary vegetables, pulses and staple crops that could address month-on-month harvest and micronutrient gaps in local households' diets. In addition to filling harvest 'gaps', certain nutrient 'gaps' are addressed by mapping the nutritional value of selected species using food composition data, following international standards and guidelines. For the portfolios, the micronutrients vitamin A, vitamin C, iron and folate were chosen due to public health concerns related to them, their supportive functions, and their natural high quantity in tree foods. To simplify nutrient content information, a rating has been applied as to whether the species are a high source, source, or low source of the selected micronutrients. This informs decision-making in the selection of species. As information on the nutrient composition was lacking for several indigenous species that were included in the portfolios, we have collated food composition data for these species where possible. These data are available through the ICRAF Priority Food Tree and Crop Food Composition Database, a database that is regularly updated as new portfolios are developed. The database is further linked to additional information on ecological suitability, and agronomic characteristics. The portfolio approach promotes greater diversity and seasonal availability of food species and can support the mainstreaming of food trees and crops rich in micronutrients in local food systems.

## KEYWORDS

Nutrition, healthy diets, diversity, seasonality, local food systems

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# Forest and food security in West Papua: Recommendation for future research

The province of West Papua in Indonesia has vast expanses of intact natural forest, with more than 80% forest cover. The provincial government is committed to preserving this important resource and is one of the signatories of the Manokwari Declaration, which commits to the conservation of at least 70% of the province's forests. Despite its rich natural assets, the population of West Papua has been ranked as one of the lowest in Indonesia for food security and has high rates of both under- and overnutrition. It is important to understand the implications of the commitment to forest conservation for the food and nutrition security of West Papuans.

On the one hand, forests make an important contribution to food security and nutrition for the many West Papuans who live inside and near the forest, directly depending on forests for hunting, fishing, collecting wild plant foods and wood fuel provisioning. On the other hand, restricted access to land could mean less land available for local agriculture and slower growth in employment for West Papuans, giving less income for food purchases.

The objective of this study is to explore available data on what is known about different aspects of food security (dietary changes, sufficiency and quality) in West Papua, and to what extent stakeholders link these issues to forests and land use in the province. We use quantitative data from the National Socio-Economic Survey for 2008 and 2017 on food consumption and qualitative data collected from four focus group discussions on food and land use with key stakeholders in the city of Manokwari and with community members in two villages.

We find that at the provincial level, West Papua had adequate energy and protein consumption in 2008 and 2017. However, areas with large indigenous populations consumed less than the recommended amounts. We also find that diets in West Papua have been changing dramatically over the period studied: traditional sago consumption has been replaced by rice and consumption of wild meat has declined, while consumption of broiler chickens and layer's eggs has increased. Consumption of fresh legumes decreased, and processed legumes increased, fruits and vegetables decreased, while edible fats increased. Consumption of ready-to-consume beverages and caloric snacks increased. Consumption of fresh foods decreased, and food consumed outside home increased. Diets in West Papua seem to be following the pattern found all over the world towards more caloric, ready-to-eat foods and away from nutrient-rich high-fiber plant-based foods.

Results from the qualitative research support the quantitative results; focus group participants perceived the changes away from traditional and locally available foods as bad for sustainability, food security, land use, health and culture. Stakeholders believed that a return to traditional diets, combined with good land use management, would result in greater food security. However, there were concerns about how these processes would occur. We conclude our study with a summary of key issues that need to be addressed in order to reconcile future food and nutrition security with conservation of West Papua's forests.

## KEYWORDS

Food security, conservation, West Papua, Manokwari Declaration

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## Farmers' resilient decision-making on agroforestry diversification

In the context of farming in Indonesia, farmers have been typically characterized as price-takers and passive decision-makers. Farmers are also observed to become more dependent on providers, such as NGOs, who provide facilitation and aids, and policy-makers who provide financial subsidies, to the extent that farmers would have these providers decide for their well-being. However, in periods of farm income struggles, farmers intuitively diversify their on-farm activities. It is basically a practice of producing a variety of products, which has been a favored economic strategy. Different forms of diversification represent essential strategies of farmers to either cope with the changing economic conditions or to continue to submit and obtain aid or subsidies. From the farmers' perspective, income-seeking may be the only element being considered. The need to make extra money represents the primary motivation for diversification.

The decision-making process, which presumably rests in the hands of farmers, associates heavily with entrepreneurial choices. It could be argued that farmers are not entrepreneurs because of the continual aid and subsidies obtained and not needing to make competitive efforts. But farmers who decide to diversify may pursue resource-based entrepreneurial strategies to widen the range of farm-based opportunity-seeking activity. Besides farmers' entrepreneurial capacity, there is increasing acknowledgment that the spatial scale of the farm's location accounts for a substantial influence on farmers' decision to diversify. It is expected that the geographical location may have an influence on decisions. Landscape attractiveness has been argued to be a driver of diversification.

Landscapes are also where social, economic and environmental objectives compete. While farmers are economically challenged to produce more on less land, they compete with environmental and biodiversity goals. This challenge also hints at farmers' resilience with regards to their ability to cope with, and adapt to, economic and environmental adversity. The psychological resilience resources approach argues that a person's resilience depends on their ability to access and use key resources that facilitate effective adaptation to adversities. These include psychological, social and community resources. In the social-ecological system approach, resilience is considered a function of the extent to which people are (i) exposed to change, for example, climatic or economic variability, (ii) sensitive to that change, and (iii) have the adaptive capacity to cope with the change.

In the context of agroforestry, where trees in agricultural systems buffer climate variability and provide income options, diversifying farming systems both ecologically and economically increases the resilience of landscapes and livelihoods. Is it a faulty decision when farmers decide to diversify in isolation? By not considering the diversification activities of multiple stakeholders involved and their adaptive capacity, including land multifunctionality, decisions to diversify may lead to conflicting objectives, distrust, higher transaction costs and unmanageable trade-offs. Thus, I propose that by understanding how farmers make decisions, landscape values and resilience will take on roles as a vital overlay on farmers' decision-making on diversification. This would be a good fit with the research gap in resilient decision-making and for providers (i.e. NGOs and governments) to acknowledge the importance of understanding decision-making processes at farm level.

**KEYWORDS****Resilient, farmer, decision-making, diversification, landscape****REFERENCES**

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# Dryland restoration = more climate-resilient landscapes: Scaling up successes from the Sahel and Greater Horn of Africa

Drylands occupy some 40–45% of the world's land surface area, and are home to an equivalent percentage of all humanity. But they also contain large areas of woodland and have soils with significant sequestered carbon, although both are today much reduced after centuries of over-exploitation. Dry forests also tend to get less attention compared with rainforests, at least in the public eye, and drylands tend to attract much less inward investment than more humid regions or irrigable areas due to their lower levels of productivity – and thus potential profit. However, there is now a growing momentum for dryland restoration and programs that support and complement national initiatives and commitments made by governments to meet international goals agreed through diverse conventions and declarations.

This review summarizes a selection of successful dryland restoration initiatives, focusing on those in the Sahel and the Greater Horn of Africa regions. These are drawn from some 25 papers and associated interviews in the latest edition of the ETFRN News compilation 'Restoring African Drylands' (Pasiecznik and Reij, 2020, in preparation). This builds on many previous editions of ETFRN News (e.g. Chavez and Tafur 2014) and associated publications (Zagt et al. 2014) that have analyzed such issues at a landscape level. This ETFRN News also draws in expertise from across the target regions in its editorial board, and the detailed analytical review that summarizes the findings (Reij et al. 2020, in preparation).

This paper offers a critical analysis of the role of government policies, current and potential roles of the private sector and non-governmental organizations, and how different relationships with local communities and associations affected the eventual impacts. The environmental impacts of landscape-level restoration appear to be clear, social impacts less so, and these will be further analyzed in the light of the above contexts. Examples of diverse experiences related to dryland restoration are detailed, including reforestation, agroforestry, and soil and water conservation and improvement to grasslands and rainfed agriculture whether led by the state, NGOs, donor or smallholders themselves, such as farmer-managed natural regeneration (Reij and Garrity 2016). This paper acknowledges the roles of more inclusive land governance, changing climates and markets, and improving efficiencies in rainfed agriculture, pastoralism, and dryland product processing and utilization. It also looks at the practice of forest landscape restoration, how to ensure local participation of smallholders and local communities, attract inward investment, and reconcile global and local expectations with an emphasis on gender and youth aspects.

This review adds to the growing body of knowledge on dryland restoration, highlighting commonalities to the observed successes across countries and the use of different mechanisms, as well as identifying continuing gaps in knowledge and policy and technical challenges. It indicates best practices and bad practices, and presents a list of recommendations to improve the implementation of the current momentum for landscape restoration in Africa through the commitments of governments to international goals, conventions and declarations, and how these are realized in impacts at community level.

## KEYWORDS

Drylands, landscape restoration, Sahel, Horn of Africa, East Africa

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# Survey of diseases on *Dacryodes edulis* (G. Don) H. J. Lam in Mbalmayo ICRAF genebank

*Dacryodes edulis* (G. Don) H. J. Lam, commonly known as African pear tree, is a local fruit tree species from central Africa. It grows in the countries along the Gulf of Guinea, including Cameroon, where the tree is cultivated in home gardens and in other tree crop-based systems. The selling of this fruit in local and international markets provides incomes to traders including farmers. During its production period, the trade of fruits can contribute about 50% of the revenue of households dealing with it, and roasted fruit mixed with plantain is part of the daily meal for several households. Its fruit has high nutritional value and is thus important in human diet. Therapeutic values of leaf, bark and root are relevant for social development. This high contribution of the species could be not sustained due to the threats that it is facing. The main drivers are numerous, including intensive agriculture and urbanization. With a view to conserving the species, the World Agroforestry (ICRAF), in the framework of its tree genetic resources conservation program, set up its genebank in 1998 in Mbalmayo, Cameroon. Currently, more than 190 accessions from Cameroon, Nigeria and the Democratic Republic of Congo (DRC) are found there. Unfortunately, since 2014, it has been noticed that these collections are attacked by different kinds of pests and diseases that have to be controlled. But nothing can be done if the characterization of diseases is not successfully implemented. It is to this effect that a survey was conducted from March to July 2018 to determine their causes. The results show that anthracnose (*Colletotrichum* spp) with an incidence of 98.4% and dieback (*Lasiodiplodia* spp) with an incidence of 5.85%, were the major diseases observed in the collection. Stocktaking revealed a loss of around 24% of the initial trees. Fungal isolation and morphological characterization on Potato Dextrose Agar (PDA) displayed 23 groups among which were species of genera *Lasiodiplodia*, *Colletotrichum*, *Chrysosporium*, *Geotrichum*, *Oidiodendron*, *Trichoderma*, and *Penicillium*. Fungal species in some of these genera have previously been reported to be pathogenic to *Dacryodes* leaves and fruits, whereas others are associated to die-back in perennial crops. In addition, two inoculation methods (with scarification and without scarification on leaf discs) of *Lasiodiplodia* were tested in vitro among five accessions (RDC3, RDC11, Mbyo5, Mbyo3, Mbyo10). The results showed that inoculation without scarification induced no symptom (lesions) on Mbyo10, whereas the highest lesion area ( $5.34 \pm 2.9 \text{ cm}^2$ ) was obtained on scarified Mbyo5. Further study will be focused on several areas including fine-tuning the identification of fungal pathogens using a molecular approach, monitoring disease incidence in the field on a monthly basis and exploring various components of a sustainable management strategy (in vitro testing of a potential biocontrol agent (*Trichoderma asperellum*)).

## KEYWORDS

*Dacryodes edulis*, anthracnose, dieback, *Lasiodiplodia*, *Colletotrichum*

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# Restoration concessions: A second lease of life for beleaguered tropical forests?

Logging has depleted timber resources across a huge area of tropical forests, leaving them vulnerable to conversion. Is management for restoration an economically viable alternative? We review more than 10 years of experience with restoration concessions in Indonesia and find that, although a diversity of activities is being explored, business models remain aspirational. Costs – including taxes and reporting, forest protection, community development and restoration interventions – are high, while developing revenues at sufficient scale from carbon, non-timber forest products and ecosystem services is challenging. Solutions lie in developing restoration-compatible revenue streams and value-added processing to generate income, investing in communities to make them partners in restoration enterprises, and creating a supportive regulatory environment by reducing statutory costs and removing perverse regulations. Restoration concessions are a scalable policy option for promoting private investment in restoration that could be replicated internationally to help meet ambitious global restoration targets.

## KEYWORDS

Conservation, deforestation, ecosystem services, multi-use forest management, forest policy

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# Contrasting patterns of bird and bat diversity in cacao agroforests inside tropical dry forests

The benefits of cacao agroforests for bird and bat biodiversity and ecosystem services offered by them in tropical areas have been shown, but there is no information on the relationship between cacao agroforests and the fauna of dry tropical forests. We focused on native cacao agroforestry systems in the region of Piura, Peru, known for their origin in the dry environments of the northwestern coast of the country. In 2018 and 2019, we studied bird diversity with 25-minute point counts, and bat diversity with mist-netting surveys in 12 cacao agroforests and at 4 points in remaining seasonally dry tropical forests around La Quemazón, Peru. We modeled bird and bat species richness and abundance in response to distance to forest and seasonality, using generalized linear mixed effects models. Bird species richness decreased with distance to forest and was higher in the rainy than in the dry season. However, bird abundance increased with forest distance during the dry season, which highlights the value of cacao agroforests for avifauna when resources are scarce. The overall abundance of omnivorous birds increased with distance to forest during the dry season and decreased during the rainy season, whereas insectivorous birds decreased. There were more bat species with increasing distance to forest, but bat abundance remained comparable along this gradient and between seasons. Whereas insectivorous bats were more abundant with increasing forest distance, the abundance of bat species with other diets decreased. Our results point to the importance of cacao agroecosystems as habitats with permanent food resources for birds and bats in tropical dry forests, and show the relevance of studying the effect of seasonality on the structure of these communities. The high number of vertebrate insectivores inside cacao agroforests found in this study highlights the importance of maintaining cacao well connected with adjacent forests, if we aim to ensure pest-control services for cacao producers.

## KEYWORDS

Tropical dry forests, cacao agroforests, functional diversity, vertebrates, seasonality

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# Cadmium in cacao in Peru: A country baseline and mitigation options

An increasing number of countries are regulating the level of cadmium in chocolate and cacao derivatives. This has resulted in the loss of export markets for many farmers. To help Peru develop a plan for managing this problem, as well as potential mitigation solutions, we present results from a nationwide baseline assessment of levels of cadmium in soil and cacao grains of >1000 trees growing in the 12 cacao regions in Peru, and preliminary results from 10 field trials aimed at testing the effectiveness of different soil amendments in lowering cadmium accumulation in cacao beans. Even though cadmium levels in the soil rarely surpass the national regulatory limit for agricultural use, levels of cadmium in cacao grains from the regions of Tumbes, Piura and Amazonas in the north of Peru, as well as parts of Huánuco were found to surpass the EU limits frequently. Initial results from field trials being carried out in 4 regions of Peru and testing up to 14 different soil amendments reveal that it is possible to reduce cadmium uptake by 50% on average after 6 months of application. Low-accumulating genotypes have also been identified that are being tested under field conditions to understand their ability to reduce cadmium levels in cacao beans.

## KEYWORDS

Cadmium, cacao, Peru, field trials

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# Breeding seedling orchard (BSO) in the context of the national tree seed project in Ethiopia

Deforestation and land degradation in Ethiopia are limiting the capacity of forests and land to contribute to food and water security and to provide other benefits such as timber, fuel wood, fodder and environmental services. To counteract this situation Ethiopia has embarked on one of the globally most ambitious programs of forest landscape restoration with the recent commitment to restore 20–25 million ha of degraded forest landscapes within the next 20–25 years.

A major challenge of landscape restoration based on tree planting is that it generally requires the use of many diverse tree species. The supply of a broad spectrum of genetically diverse, healthy and productive tree seedlings is mostly not easily available. Traditional seedling supply programs (including tree seed supply) focus on relatively few species, most of them of unknown genetic quality and often with insufficient knowledge on adaptation to site conditions and adaptability to climate change.

A huge amount of seeds is procured and distributed in Ethiopia, with the majority of seeds used in nurseries (supported by government offices and NGOs) to produce seedlings for planting in small woodlots and other farmland niches. Additionally, a large number of seedlings are distributed and planted to restore natural vegetation and for watershed protection.

Most of the tree seeds are supplied through an informal seed system where there is no legal certification. This includes retained seeds by farmers, farmer-to-farmer seed exchange and cooperative or NGO-based seed multiplication and distribution. The formal seed system, on the other hand, is a system that involves the production and distribution of basic quality seeds, mainly by the research system or certified seed traders. In general, matching of planting material to planting sites is inadequate, leading to huge loss of higher productivity opportunities. Most seeds procured by traders are collected from trees in farmlands, urban areas and other compounds, implying that the genetic quality and origin of the seeds is not known and performance is suboptimal compared with seeds deliberately chosen to match a planting site.

In response to the challenges outlined above, the Government of Ethiopia embarked on a national tree seed project (Provision of Adequate Tree Seed Portfolios, PATSPO) supported by the Norwegian government to provide a multiple tree species program including the building up of the tree genetic resources of the country, i.e. through establishment of BSOs for selected priority species.

## KEYWORDS

Landscape restoration, tree seed, BSOs, Ethiopia

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# Agroforestry and its contribution to food and nutrition security in smallholder farms in rural Kenya

Agroforestry systems provide a wide variety of foods and can contribute to food and nutrition security in multiple ways, either directly through consumption, or indirectly through income generation. To understand the potential contribution of food trees and crops on farms to food and nutrition security, our project looked at the relationship between several on-farm food production diversity indicators, socio-economic indicators such as ownership of tropical livestock units (TLU) and the progress out of poverty index (PPI), and food security and nutrition indicators. For food security, we assessed months of adequate household food provisioning (MAHFP), food consumption scores (FCS), and household dietary diversity scores (HDDS). For nutritional adequacy of diets, we assessed minimum dietary diversity scores for women (MDD-W), as well as quantitative food intake using 24-hour food recalls. Four hundred and fifteen households were interviewed across three counties in Kenya: Tharaka Nithi, Kitui and Kwale. Descriptive and inferential analyses were undertaken, with correlations and generalized linear regressions used to assess any present relationships between socio-economic status and food tree and crop richness and abundance variables, with the various food security and nutrition indicators. Our study found the average farm size to be 0.8 hectares (median 0.5), the average food tree species richness on farms to be 2.7 (median 2, min 0, max 20), and an average abundance on farms of 19 individual trees (median 5, min 0, max 1044). For vegetables and staple crops, this was an average of 1.4 (median 1, min 0, max 9), and 2.6 (median 3, min 0, max 10), respectively. Using a generalized linear model, staple crop richness, farm size, TLU ownership and PPI had a significant influence on the FCS ( $p < 0.000$ ). TLU ownership and PPI also had a positive significant influence on MAHFP ( $p < 0.000$ ), with PPI being the only variable to show significant influence on HDDS ( $p < 0.000$ ). For nutrition indicators, only the PPI was found to significantly influence women's dietary diversity scores ( $p$ -values  $< 0.000$ ). Our data show that women/caregivers who achieved their recommended daily allowance (RDA) for vitamin C had significantly higher fruit intake (291 g) than those who did not (26 g). However, this was not found to be significant for those who achieved their RDA for vitamin A. This could be due to consumption of other, non-fruit, vitamin A-rich foods. Our study found that higher fruit intake was associated with an increased likelihood of meeting the daily vitamin C dietary recommendation. Additionally, our study found that wealth indicators such as infrastructure and assets based on the PPI, and livestock ownership based on the TLU, positively influenced several food security indicators, and MDD-W. Therefore, agricultural development interventions should promote food tree cultivation for direct production–consumption benefits for improving diet quality, while continuing to prioritize production- and income-generating opportunities for rural smallholder farmers to increase food security.

## KEYWORDS

Food trees, species diversity, assets, diets, livelihoods

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# Using species life-history traits to improve the management of tropical tree genetic resources

The number of tropical tree species in the Indo-Pacific region was recently estimated to be over 19,000 species. Information on the genetic variation at any level is only known for a tiny fraction of these species, mainly those that are important for plantation forestry. Understanding genetic variation is critical for improved forest management, conservation and restoration, especially under progressive climate change that requires unprecedented adaptive capacity. Continued expansion of agriculture and urban areas creates degraded and fragmented landscapes, where remaining tree populations are often small and isolated. Reduced population size and isolation can reduce gene flow and increase inbreeding, which affects individual fitness, seed viability and seedling performance.

Due to the high species diversity in tropical forests it is not possible to study them all, as genetic studies can be costly and time consuming. Species in the same family or genus may be differently vulnerable (for example, dipterocarp species pollinated by thrips, or small pollinators, might be more vulnerable to genetic erosion than those species pollinated by larger pollinators such as bees), so there is a need for other ways to design management practices for less studied species.

Furthermore, understanding tropical species' long-term viability can be very important for rural communities in Asia, which are dependent on forests to generate livelihood benefits, as people collect non-timber forest products for food and to supplement their income. In Asia and the Pacific region, more than a thousand tree species are actively managed for different purpose (such as non-timber forest products), yet tree species in this region are among the most threatened in the world; losing tree species' genetic diversity could ultimately undermine the food security of millions of people in the region.

We reviewed studies on the reproductive traits of 63 tropical Asian tree species and their genetic diversity across more than 350 populations, to analyze the role of species life-history traits in influencing variation in genetic diversity and vulnerability to genetic erosion. We identify traits or groups of traits that are associated with genetic diversity and that can be used to refine genetic conservation and management practices for lesser known tree species for the resilience of species' populations in the face of environmental change.

## KEYWORDS

Genetic diversity, inbreeding, forest management, life-history traits

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# Influence of socio-technological factors on smallholder farmers' choices of agroforestry technologies in the eastern highlands, Uganda

Agroforestry has been identified as the most sustainable remedy to counter the declining agricultural productivity in Sub-Saharan Africa. Over the last decades, several agroforestry practices have been promoted from which smallholder farmers have chosen to implement in an effort to improve their farm productivity. However, the influence of socio-technological factors on smallholder farmers' choices of specific agroforestry technologies to practice on their farms is not clearly known. Knowledge of these factors will help us to refine extension messages to specific smallholder farmer contexts and enhance uptake of agroforestry technologies. This study, anchored in the decomposed theory of planned behavior, unveils the socio-technological factors that influence smallholder farmers' choice of agroforestry technologies in the densely populated eastern highlands of Uganda. Data were collected through a cross-sectional survey in which 277 randomly selected farming households were interviewed using a semi-structured questionnaire. In addition, focus group discussions were used to explore some of the quantitative findings in more detail.

An alternative-specific conditional logit (ASCLOGIT) model was used to examine the socio-technological factors influencing smallholder farmers' choices of agroforestry technologies. Results indicate that number of tree species desired by the farmer, sex, number of training sessions received, total land owned, perceived value, subjective norms and perceived behavior control had a significant influence on smallholder farmers' choice of agroforestry technologies. While some of these factors cut across agroforestry technologies, others are technology specific, suggesting the need to tailor agroforestry interventions to specific farmer categories.

## KEYWORDS

Choice decisions, farm productivity, conditional logit, highlands, smallholder farmers

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# Climate change impact on cultivated and wild cacao in Peru and the search of climate tolerant genotypes

Cacao (*Theobroma cacao* L.), one of the most important cash crops in many tropical countries, is expected to be severely impacted by climate change. Higher temperature and lower precipitations are already affecting cacao cultivation across the world, with negative effects on survival, yield quality and quantity, and increased diffusion of fungal diseases. Breeding for climate change tolerant genotypes represents one of the most promising adaptation options to climate change. Peru has a great potential for cacao genotype selection because it presents high levels of genetic diversity of cacao and is located within the centre of origin of this species. The objectives of this study were to (i) assess the future impact of climate change and (ii) identify areas where climate change tolerant genotypes are potentially present in Peru. To this aim, we characterized the spatial distribution of suitable habitat of cultivated and wild cacao under present and future climatic conditions in Peru. The suitability analysis was performed using ensemble modelling algorithms with a dataset of 19,687 presence points for cultivated cacao and 1,183 for wild cacao. In order to select the best model, we compared several models for both cultivated and wild cacao using two calibration approaches and four resolutions of spatial filtering. Future projections were predicted for three time horizons (2030s, 2050s, 2070s) and two emission scenarios (RCP 4.5 and RCP 8.5). To estimate the uncertainty of future predictions, we generated future projections for all the ensemble models and built consensus maps for the models with sufficient predictive accuracy. Further, we investigated the potential emergence of novel climates within the cacao suitable area, determined how ecogeographical zones (i.e. zones representative for particular sets of growth conditions) are expected to change, and carried out an outlier analysis based on the environmental variables most relevant for climate change adaptation to identify areas where climate change tolerant genotypes are potentially present. Our models presented a distinct distribution for wild and cultivated cacao, with cultivated cacao extending from the North to the South of Peru along the Andean premontane zone and wild cacao covering Peruvian Amazon from Loreto to Madre de Dios. Our future projections foresee a contraction of suitable area of cultivated cacao and a moderate shift towards higher elevations, while for wild cacao, most of the current distribution range is likely to remain suitable and expected to further expand. However, in most areas predicted to remain suitable for cacao cultivation in the future, growth conditions (i.e. ecogeographical zones) are expected to change drastically. As such, local genotypes may be not adapted to the predicted shifts in ecogeographical zones and may require to be replaced with tolerant genotypes. We identified areas where climate change tolerant species are present in Peru, which will be the target of collection missions led by Bioversity International. Next steps include climate chamber experiments and genetic analysis to verify the potential of these genotypes for climate change tolerance. These results can inform a breeding program to develop climate change tolerant genotypes for Peru and Latin America.

## KEYWORDS

Ensemble modeling, breeding for climate change, climate change, cacao, cacao genotypes

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# Investing in genetic and species diversity during landscape restoration reduces overall costs

Genetic and species diversity of seeds and planting stock is crucial for the short- and long-term success of forest landscape restoration (FLR) projects. Moreover, diversity is an essential prerequisite for a resilient functionality of ecosystems and therefore for sustainable livelihoods. Nevertheless, genetic and species diversity is widely neglected in both the planning and implementation of FLR, for which there are a number of potential reasons. One of them is that some decisions within FLR initiatives are dominated by economic considerations, in which short-term personal or community well-being considerations prevail over long-term benefits for society. In this session, we would like to share the results of our research, in which we have analyzed how the inclusion of genetic and species diversity affects project costs. Based on the insights gained by this analysis, we provide some perspective on how this influences involved actors in their decision-making process.

First results indicate that integration of genetic diversity and species diversity in a landscape restoration project significantly increases the costs incurred at the beginning of a FLR initiative, specifically during seed sourcing and species selection. These additional costs include increased search and collection efforts to effectively capture greater diversity in seed lots. However, we demonstrate that the overall costs of the entire restoration process drop substantially despite these added costs, due to the savings in expenses related to post-planting maintenance and mortality. In conclusion, our analysis highlights that investment in FLR and consideration of genetic diversity and quality into restoration represented a highly efficient use of resources, based on economic grounds alone. However, this resource efficiency applies only to the project as a whole and not necessarily to individual actors involved in the project, as the costs of integrating diversity are not incurred where the benefits accrue. Accordingly, there is a lack of economic incentives, especially at the beginning of a project, for actors to strive for high diversity. We believe that these findings can help stakeholders to take better-informed decisions and to create appropriate incentives, which ultimately improve the economic, social and environmental sustainability of FLR projects.

## KEYWORDS

Genetic diversity, cost model, forest landscape restoration (FLR), decision-making

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# Species choice in ecological restoration: Are we getting it right?

Large-scale restoration projects have been initiated to impart resilience in several fragile landscapes through various programs such as the Bonn Challenge, the Great Green Wall, the Pan-African Action Agenda on ecosystem restoration for increased resilience, the UN Decade on Ecosystem Restoration among others. There are pledges by these initiatives to plant billions of trees by 2030 and these initiatives have even been adopted at national levels, with countries committing to achieve certain restoration targets. For instance, Ethiopia has targeted to plant more than 21 billion seedlings by 2030. Ecosystem restoration using trees remains among the most effective strategies for climate change mitigation. There have been divergent approaches on the goal of restoration from different disciplines, for example, ecologists seek to increase biodiversity and hence they champion the use of a broad range of species; sustainable-development advocates focus on species that contribute to improved rural livelihoods; and researchers focusing on climate change push for fast-growing tree species, which may promote planting of a single species. It is important to bring all these approaches together and pay special consideration to the species choice in restoration projects. Bearing in mind that ecological degradation resulted in loss of biodiversity that includes indigenous tree species, ecological restoration can also play a significant role in ensuring reintroduction and conservation of indigenous species for specific habitats. This paper reviews some of Africa's restoration projects and draws attention to the impact that tree species choices can have on the long-term goal of restoration projects.

## KEYWORDS

Ecological restoration, tree diversity, germplasm sources, climate change, resilient landscapes

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# Ecosystems services from bamboo and other land uses in the Colombian coffee region

Natural forests dominated by the bamboo species *Guadua angustifolia* (guadua bamboo) in the coffee region of Colombia are important natural ecosystems along the elevation gradient from 900 m up to 2000 m. In this region, coffee plantations have been important as a support of livelihood of farmers over several years. However, conditions associated with global dynamics of markets and coffee diseases have encouraged farmers to make land use changes, mainly in two ways: first, by establishing cattle systems, and second through the conversion of traditional coffee farming systems to more intensive monocrops and highly depending on external incomes. Ecosystems services (ES) are an important way of describing land use conditions. However, assessment of them should be adjusted according to scale, landscape conditions and availability of data or information. In this study, we used two approaches for assessing and comparing the ES provided by different land uses. An approach was focused on the construction of indicators with available data associated with ES of nutrient cycling, soil protection, water regulation, climate regulation and habitat provisioning, called the quantitative approach (QA). Farmers' perceptions of ES were also assessed by interviews and defined as the qualitative approach (QL). ES indicators of the QA were compared among land uses by using a nonparametric test and then a principal component analysis (PCA) was performed in order to reduce data dimensionality. Also, it was useful to find relations between groups of indicators associated with ES and land uses. Data obtained from interviews were averaged by land use and then plotted in radar figures. In the QA approach, significantly ( $p < 0.05$ ) better conditions for most ES assessed were associated with guadua bamboo forest and natural forest, followed by those land uses with more complexity in structure as agroforestry. Multivariate analysis of PCA permitted us also to elucidate associations between land uses and the level of ES provision and to confirm the results obtained in the previous analyses. Given the conditions of this region and the predominant landscape, the presence of bamboo gave remarkable results because of its contribution to ES associated with ecological functions that represent the proper maintenance of ecological quality within farming systems, but additionally, farmers considered the possibility of obtaining from them ES of provision. The QL approach shows that farmers perceived the guadua bamboo forest as important for providing ecological benefits as natural forest, but additionally because they can obtain from them the provision of raw materials and other possibilities for improving livelihood conditions. Thus, in spite of the transformation of land uses to those with more limited possibilities of providing ES, the presence of the guadua bamboo forest is highly relevant for keeping proper conditions at the landscape level, and each bamboo forest fragment integrated into a farming system fulfils important functions to make agriculture in this region still possible.

## KEYWORDS

**Guadua, assessment, perception, farmers**

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# National target or local needs? Exploring development strategies in the South Sumatra landscape

The agriculture development strategy of a landscape must abide by the national development target while embracing local context and local needs. Pagar Alam, a city in South Sumatra, has been one of the highest producers of coffee and rubber since late 1800. During the period 2005–2015, the area of tree-based systems is unchanged at 55% of the total Pagar Alam area. However, during this period, the area of coffee systems has increased by 16% which is roughly similar to the decrease in rubber systems. In 2015, the Government of Indonesia launched a national program to increase the production and productivity of rice, maize and soya bean. The implementation of this policy in Pagar Alam is through the development of reservoirs for irrigation to allow the establishment of rice fields in 2021. The effectivity of the program is in question considering the potential areas for rice field establishment are currently managed as coffee systems. Exploration through FGDs in the villages potentially affected by the irrigation program revealed that coffee contributes to 50–80% of their income as opposed to rice, which only contributes about 20%. The returns for land growing coffee in its productive years is 1024 USD/ha/year, roughly twice the return for rice. Based on household surveys conducted in 23 villages with 416 respondents, out of 672 coffee plots owned, none of the plots are planned to be converted to rice in the next 3 years and 92.5% of farmers are interested in keeping them as coffee systems. Using ex ante analysis through simulation modeling (Lusiana et al. 2012; Mulia et al. 2019), the study explores the consequences of the existence of the irrigation systems to the socioecological landscape of Pagar Alam. The ecological consequences include changes in carbon sequestration and erosion risks, and the socioeconomic consequence is the level of farmers' income due to the change in farming practices. The latter will inform the landscape managers at what level of economic incentives farmers will be interested in converting to rice.

## KEYWORDS

Agricultural development policy, coffee systems, ex ante analysis, South Sumatra

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# Outcomes and impact of applying diverse productive tree portfolios for different functional uses in landscape restoration

The FTA Flagship Project on Tree Genetic Resources to bridge production gaps and promote resilience (FPTGR) is based on a portfolio of individual projects across the tropics with a total value of about 40 million USD over the 4-year period 2017–2020 considered in this study. The combined project portfolio of FPTGR is contributing to three major outcomes: 1) safeguarding diversity, 2) tree domestication-enhancing products and services, and 3) delivery systems providing productive and adaptive tree-planting material for restoration of degraded lands and diversification of agricultural landscapes. Sixteen indicator targets were identified to monitor and assess progress towards the achievement of the stipulated outcomes, with a pathway to provide impacts in terms of reaching end users (no. of farm holdings, area covered, and economic value of interventions). The indicator targets are linked to the Strategic Results Framework of the CGIAR as well as to other global agenda targets, such as, e.g. the SDGs, the Aichi targets, the NDCs, and the Bonn Challenge. The fulfilment of the 16 indicator targets of FPTGR have been assessed through an evaluation of the FPTGR outputs, including the individual projects of which FPTGR is composed, and how they contribute to the outcomes. Initial results covering 4 of the 16 target indicators show an apparent 'overperformance' with respect to all 4 targets covering adoption of decision support tools by national research partners, development and use of genomic data in applied breeding for important tree crops, testing by development partners of tree crop varieties across agroecological zones, and uptake of incipient cultivars by public and private partners engaged in applied domestication. The full study will present results for all 16 target indicators and provide an interpretation of their potential impact value for end-users. The potential impact value is based on an ex ante impact assessment of the largest bilateral restoration project in the FPTGR portfolio of projects, Provision of Adequate Tree Seed Portfolios (PATSPPO) in support of Forest Landscape Restoration in Ethiopia; and on a series of species-specific potential socio-economic and environmental impact studies in Kenya and Ethiopia for tree species in different categories (timber, fruit, oil, local commodity, global commodity). The species-specific assessments consider mitigation (including environmental values such as carbon sequestration, and soil and water conservation), as well as adaptation-related impacts (including (bio)diversification and climate suitability) and social and economic returns. The potential values show very significant returns with respect to both the environment and the economy. The methodology used for the assessment could be relevant for wider application across landscape restoration initiatives.

## KEYWORDS

Tree genetic resources, economic and ecological value

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# The role of school gardens as conservation networks for tree genetic resources

In addition to linking children closely to the nutritional benefits of a diverse diet, school gardens offer a huge opportunity to engage children in the wide area of plant identification, conservation and sustainable use of plant genetic resources for sustainable development. This paper discusses the role that schools and children can play in documenting the diversity of socioeconomically important tree species around their school and community, the role that trees can play in their diet and the multiple co-benefits of trees for delivery of sustainable food systems. In particular, the study will highlight the critical role schools can play in the ex situ conservation of genetic resources through school arboreta, seed orchards and school nurseries. Engaging children and youth through school gardens offers a unique educational opportunity to introduce restoration and plant diversity as a solution to multiple environmental and social challenges. We will present case studies and a framework for building a novel component into school curricula.

## KEYWORDS

Tree biodiversity, school gardens, ex situ conservation, sustainable food systems, youth engagement

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# Enhancing Vietnam's NDC with mitigation targets for agroforestry

Despite its potential for climate change mitigation and adaptation, nationally determined contributions (NDCs) of non-Annex I developing countries rarely include agroforestry. Technical complexity and absence of reliable data for setting up targets partially constrain the inclusion. In this study, we estimated the mitigation potential of agroforestry in Viet Nam, represented by its capacity for sequestering carbon for greenhouse gas removal. Both sequestered carbon in the existing and potential expansion areas of agroforestry in the country were estimated. The total area of eight key existing agroforestry systems in the country namely, those based on *Melaleuca cajuputi*, *Rhizophora apiculata*, acacia, tea, arabica coffee, robusta coffee, rubber, and cashew agroforestry, reaches about 830,000 ha, estimated to store  $1346 \pm 92$  million ton CO<sub>2</sub> equivalent as the total for aboveground, belowground and soil carbon. Apart from these areas, 930–2400 thousand ha across the country are suitable for expansion of the systems with about 10% of the areas being highly suitable for the expansion. The C sequestered in the highly suitable areas ranges from 2.3 to 44 million ton CO<sub>2</sub> equivalent as the total for aboveground, belowground and soil, depending on which system is expanded, for a 10-year expansion over the period 2021–2030. Climate change, analyzed using Representative Concentration Pathway 4.5 and 8.5 for the period 2040–2060, can however reduce the highly suitable area and associated C by 34–48%. Due to this potential, agroforestry can help to offset greenhouse gas emissions, for example from the agriculture sector of Viet Nam, projected to reach 109 million ton CO<sub>2</sub> equivalent by 2030. However, the crop species selected for the agroforestry expansion must be adaptive to a warming climate.

## KEYWORDS

Agroforestry, carbon sequestration, expansion, nationally determined contribution, Vietnam

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# What is the sacrificial lamb in using economic incentives for restoration?

Economic incentives, specifically offering premium prices or new income opportunities, have been premised as an approach to incentivize farming communities to support the implementation of large landscape restoration projects in Africa. Nature-based enterprises largely relying on biodiversity have been identified to serve this role even though trade-offs linked to social, livelihood and environmental impacts are poorly understood. Along the livelihoods concept, we analyze drivers of household behavior within the context of restoration efforts and conceptualize potential trade-offs along the assumed impact pathway of restoration projects. This will then be embedded into a landscape-level view as the ultimate target of restoration. There are concerns of negative feedback due to over-extraction of certain products such as charcoal, firewood and shea given the current state of degraded resources and institutional policy challenges. The main groups of potentially adverse effects are classified around environmental factors as well as socio-economic disruptions. The analysis considers the setting within which the projects are typically implemented and draws on literature to outline the stumbling blocks which – when left unchecked – lead to unintended consequences which undermine other important global targets such as the SDGs. Findings from the current study are expected to help land restorationists to design and implement more nuanced land restoration projects with reduced reliance on external support and risk of failure. Recommendations will provide important knowledge and a guide for donors and policy makers to plan projects with mechanisms to better integrate value-chain development approaches and mitigate negative feedback and risks involving community participation in value chains.

## KEYWORDS

Land restoration, tree value chains, regreening, restoration

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## **STREAM 3**

Transforming livelihoods through  
agroecological approaches with trees





## STREAM 3

# Transforming livelihoods through agroecological approaches with trees

This Stream focused on the role of trees and forests in agroecological approaches to transforming livelihoods. It comprised contributions addressing how agroecological principles are being operationalized to improve the productivity and resilience of livelihoods in contexts that involve trees or forests. The scope covered field; farm or forest; landscape or community; and, whole food system; scales.

Agroecological transitions have been classified as incremental or transformational, depending on the extent to which they represent a systemic change to the agricultural and food systems involved (Gliessman, S.R. 2016. Transforming food systems with agroecology. *Agroecology and Sustainable Food Systems*, 40 (3): 187-189 <https://doi.org/10.1080/21683565.2015.1130765>) and agroecological principles have been associated with each of these types of transition (HLPE 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome <http://www.fao.org/3/ca5602en/ca5602en.pdf>).

An initial focus was put on incremental transitions, mainly involving agroecological principles of input reduction, recycling, animal and soil health, biodiversity, economic diversification and synergy but also considering the nature of principles and their utility in shaping research on how trees and forests can contribute to transforming livelihoods. Secondly, transformation was analyzed, mainly involving agroecological principles of social values and diets, fairness, connectivity, governance, and, participation with a view to exploring the role of trees and forests in helping humanity stay within a safe operating space reconciling human wellbeing and planetary health (Raworth, K 2017. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Random House, London.).



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# Principles for R and D supporting forests, trees and agriculture

The current work of CIFOR–ICRAF is diverse on almost any criteria assessed – geography, the science, positions along the R–D continuum, partners involved, source of funding and others. Opportunities and pressures to further diversify arise continually and are conventionally managed by setting out a strategy even though challenges to its content typically arise immediately. An alternative approach is to set out principles. Here, a principle is defined as “...a statement that provides guidance on how to think and behave towards some desired result...” (Patton 2018) and recent examples from related fields can be found, such as those for agroecology (HLPE 2019). Principles that can effectively guide CIFOR–ICRAF work are of four types:

1. Principles that underly our vision of how the world needs to function
2. Principles describing the role of trees and forests in this vision of the world and the trajectories for reaching it
3. Principles guiding the way research and development is done to support #1 and #2
4. Principles for organizations engaged in #3.

We propose principles for each group, drawing from and connecting to those already proved of value in related domains.

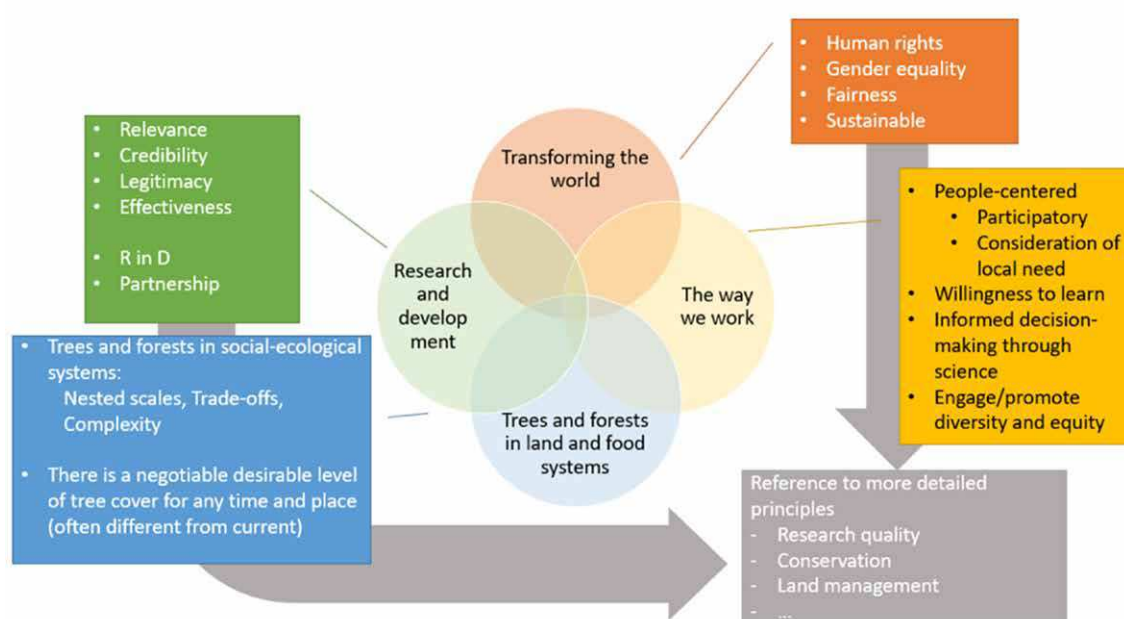


Figure 3.1 Categories of principles to guide R and D work on forests, trees and agriculture.

## KEYWORDS

Principles, trees, forests, research, development

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# Employing a farmer-centered approach to scale land restoration in East Africa and the Sahel: Understanding what works where and for whom using planned comparisons

Farmer-led land restoration innovations in Niger, Mali, Ethiopia and Kenya are turning out to be key pathways to addressing severe land degradation affecting the livelihoods of the most vulnerable people living in Africa's drylands. Successful restoration efforts must be taken to scale, both by reaching a large number of farmers and by covering large areas, if we are to achieve the Sustainable Development Goals of the UN and contribute to the latest declaration – The UN Decade on Ecosystem Restoration. This FTA-mapped project, “Restoration of degraded land for food security and poverty reduction in East Africa and the Sahel: taking successes in land restoration to scale”, highlights advances toward achieving transformative outcomes by placing farmers at the center of land restoration efforts. Specifically, we employed the research ‘in’ development approach by partnering with large development programs to influence the way they interact with farmers and implement options on the ground. The research in development approach is a transition from traditional research methods, which often work on a small number of sites with limited farmer engagement, to an approach based on high levels of farmer participation while generating robust evidence across a high number of sites and multiple contexts. We used planned comparisons to implement, test and scale restoration options with farmers. Planned comparisons allow for rigorous comparisons of various options implemented on farmers’ fields across different conditions and locations, while also encouraging farmers to innovate what works best for their context. Within the project, over 10,000 farming households evaluated land restoration options on their farms, including options for soil and water conservation, tree establishment on farms, and farmer-managed natural regeneration (FMNR) (ICRAF 2018). The evaluations were done using electronic data entry. This paper focuses on key lessons learned employing these approaches across East Africa and the Sahel as well as results of the performance of restoration options in Kenya. In Kenya, over 1800 households were profiled and we implemented planned comparisons on tree planting and planting basins for cereal and legume production. We report impacts and performance of restoration options across contexts, revealing how appropriate, locally adapted options can impact food security and farm incomes and how different options are suitable for different farmers. We also report on the development of tools and approaches to facilitate the scaling of land restoration options as well as the utility of the nested communities of practice to promote learning and knowledge sharing across stakeholders.

## KEYWORDS

Farmer-centered, land restoration, evidence-based

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# Innovations in agroforestry extension for scaling-up the adoption of non-timber forest products (NTFPs) domestication in Indonesia

NTFPs have become sources of local livelihoods in Indonesia, particularly for farmers who live near forested areas. Currently, most of the NTFPs are still extracted from nature, with limited efforts invested in their domestication. Technologies for the domestication of NTFPs are now available; however, the technology dissemination process is still low due to the ineffective extension systems used to deliver the information to the farmers who use the NTFPs as their source of livelihood. In the case of Indonesia, the current public agricultural extension systems are mostly focusing on food crops, while the public forestry extension services focus more on timber products. Thus, innovations in agroforestry extension need to be explored for scaling up the adoption of the domestication of NTFPs in Indonesia. This study focuses on the NTFPs for which more developed domestication technologies have been tested by farmers, i.e. trigona honey bees and bamboo, with cases in Yogyakarta and Lombok. A survey was conducted by collecting information on: the type of extension approaches used to deliver the information on trigona honey bees and bamboo domestication; stakeholder analysis in each extension approach; and potential partnerships between multi-actors to deliver agroforestry extension on the domestication of NTFPs. Analysis from the study reveals that innovations around agroforestry extension approaches in public extension systems are (a) strengthening the farmer-to-farmer extension approach, (b) developing agroforestry learning centers, and (c) promoting market-driven agroforestry extension through multi-stakeholder partnerships. Detailed descriptions of each innovation are provided.

## KEYWORDS

Trigona honey bee, bamboo, market-driven extension

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# What can doughnuts tell us about the value of forests and trees?

Recent fires in the Amazon Basin, California, Indonesia, and Australia have reignited society's attention to the costs of the loss of trees, critical to society. Trees in forests and on farms, ranches and in cities conserve biodiversity, regulate climate, drive hydrological cycles and provide a wealth of other services. Often overlooked, however, is their importance for meeting basic human needs: food, shelter and health. Using available data, we benchmark trees' contribution to human well-being while keeping society within planetary boundaries. Here, we adapt Raworth's conceptual framework of 'doughnut economics' (Raworth et al. 2017) and quantify the contribution of forests and trees to the established planetary boundaries (e.g. climate change, biodiversity, biogeochemical cycles, etc.) and human well-being (e.g. nutrition, income, energy security, etc.) (Figure 1). We found that forests and trees have significant leverage for half of the planetary boundaries. For example, historical management of forests and trees is responsible for a nearly 125 ppm increase in atmospheric carbon dioxide (one-third of the planetary boundary), which is responsible for ocean acidification as well as climate change. Tree cover is such a critical driver of Earth system change that some of the

selected indicators and thresholds for the planetary boundaries are directly tied to them (e.g. land system change). But forests and trees deliver multiple benefits for people too. For example, about 2.4 billion people, more than one-third of the global population, depend on wood for cooking fuels sourced from trees and woody biomass; about 20% of smallholder income was found to come from forests in one large study of tropical rural communities; and trees also produce 52% of fruit consumed, which has important effects on nutritional security. Our compilation benchmarks the importance of forests and trees to the environment and society, forms the basis to inform sectoral and cross-sectoral action, and defines what is known and less known about the value of forests and trees. The doughnut framework also highlights the interconnectedness of both human needs and planetary boundaries. Our hypothesis is that a world that keeps humanity in a 'safe operating space' is one in which trees are a core element of land use systems and need to be considered in every development policy and action.

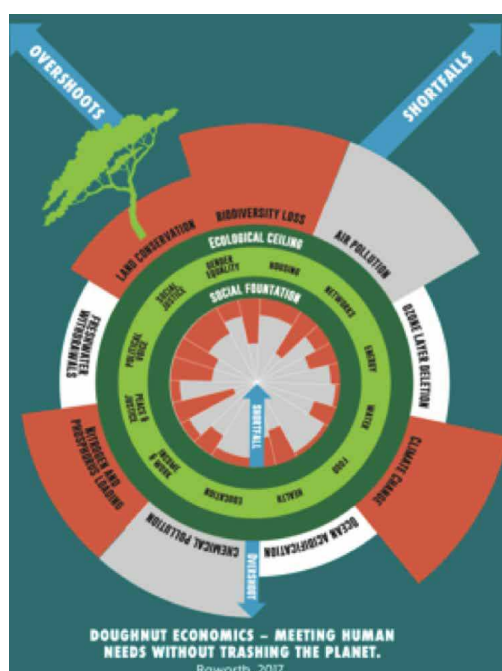


Figure 3.2 Conceptual framework of doughnut economics that illustrates that the safe operating space for humanity (green) sits between the planetary boundaries (outside) and the social foundation (inside). Planetary boundary size and color represent the degree that society is operating within or beyond the threshold of what has been set to avert Earth system change. Social foundation shortfalls show the degree to which society is not meeting basic needs of the global population. Our analysis adapts this framework and specifically highlights forests' and trees' contribution to the relevant factors.

## KEYWORDS

Planetary boundaries, human well-being, doughnut economics, green growth

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# Green Growth Plan and strategies for the pristine and indigenous landscape of Papua, Indonesia

Indonesia has submitted its Nationally Determined Contribution (NDC) to UNFCCC, which details the country's plan to reduce emissions in line with the Paris Agreement. At the same time, the country must maintain its economic growth and improve the livelihoods of 255 million people. It was against this backdrop that in 2013, the leading national government launched the Green Growth national strategy that targets: (1) sustainable economic growth, (2) inclusive and equitable growth, (3) economic, social and environmental resilience, (4) healthy and productive ecosystems in producing ecosystem services, and (5) reduction of greenhouse gas emissions.

Papua Province is rich in forests, as well as in huge precious mineral reserves, is home to hundreds of thousands of indigenous people and has a high level of biodiversity. Ninety percent of terrestrial Papua is covered by forest (26 million hectares). Papua's forest constitutes one-fourth of the total forest area in Indonesia. Papua has dual tenurial systems; one is the customary law and the other is state law. The annual growth rate of Papua's gross domestic product (GDP) is 4.89%, and ranked low amongst all 34 provinces in Indonesia. Therefore, a robust and holistic plan to guide Papua in utilizing the natural resources sustainably for improving economic performance, while conserving the environment are urgently needed. The Green Growth Plan (GGP) can be a suitable approach to fulfil the goals of economic productivity and environmental sustainability in Papua Province.

In order to maintain the development of the Green Growth Plan (GGP), local wisdom practices in the context of land utilization need to be considered as one of the essential factors. Most of the indigenous people in Papua are very dependent on natural resources, including commercial wood products and non-timber forest products (NTFPs) such as honey, nypa and sago. It is also known that Papua is the largest producer of sago in Indonesia (66,593 tons/year). Accordingly, by considering Papua's local context, agroforestry is one of the most prevailing practices in the GGP to maintain land use management while providing livelihoods for local communities.

This research attempts to assess the performance of the GGP in increasing the economy and preserving the environment by comparing it with the business-as-usual (BAU) scenario with time-series projections (2018–2048). An input–output (IO) analysis was used to quantify the contribution or production of each sector in all economic activities. The Land-Use Planning for Multiple Environmental Services (LUMENS) tool was used to project the land use change based on historical data, and to analyze the trade-offs between economic benefits and ecosystem functions in various scenarios. Specifically, this research only focuses on diagnosing regional economic, land use and land cover change, and emissions levels for both BAU and GGP scenarios. The results showed that, on average, when compared with the BAU scenario, the GGP scenario can increase forest cover by 6.77%, GDP by 4.6%, and GGP can also reduce the deforestation rate of 46% and the emissions level of 14%.

## KEYWORDS

Land use planning, sustainable development, Green Growth Plan (GGP), Papua, Indonesia

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## Agroforestry concessions in Peru – Effective compliance comparisons

Agroforestry concessions, introduced by the government of Peru in 2011, comprise a potentially innovative policy mechanism to engage thousands of smallholders in sustainable land use and management. By allocating usufruct rights over state forest land for 40 years, eligible farmers are expected to refrain from deforestation and implement agroforestry and small-scale forestry on their farms. Research has highlighted that agroforestry concessions are more likely to be successful if the government supports a nested-scale process, one that builds a strong connection between field-level innovation, markets, policies and institutions while embracing farmers' heterogeneity in both circumstance and practice. A major barrier to be overcome is an institutional culture among concerned government departments, NGOs and private sector entities that promotes top-down, pre-defined/prescriptive interventions for agroforestry and small-scale forestry, overlooking locally devised strategies and contextual opportunities and constraints. This paper presents advancements of a pilot study spearheaded by ICRAF–CIFOR that is testing a potentially improved way of promoting effective compliance with the agroforestry concessions mechanism, while maximizing benefits for participating farmers. In particular, we are comparing the performance of three rural advisory service (RAS) approaches assigned to 45 villages in two sub-watersheds of the San Martin Region: 1) options × context-based RAS that is centered on the engagement of farmers in identifying sustainable land management practices that enable compliance with agroforestry concessions; 2) pre-defined practices based on RAS, in which farmer groups select facilitators who are trained and backstopped by partner NGOs' extension staff and follow a prescriptive intervention model; and 3) information-based AC registration that involves conducting agroforestry concession registration campaigns based almost solely on informing farmers about the opportunity. The paper focuses on the insights and challenges the project team has experienced thus far in the piloting process.

**KEYWORDS**

Technical assistance, agroforestry design, agro-ecological principles, governance, scaling



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# Phenotypic variation in tree traits from five provenances of akpi (*Ricinodendron heudelotii*) in Côte d'Ivoire

The forest supplies among other things large quantities of non-timber forest products (NTFPs) to local populations. They are often considered as secondary products so that their potential contribution to the market economy or to self-consumption is marginalized and ignored. NTFPs are currently receiving special attention because of their contribution to the survival of many populations and especially those of the least developed countries (Marshall et al. 2003). For Côte d'Ivoire, seeds collected from akpi (*Ricinodendron heudelotii*) are traded nationally, thereby contributing to poverty reduction and improving the income of local populations (Ndoye 2008; Bonnet et al. 2011).

To contribute to the sustainable use of these genetic resources, the implementation of a policy of tree management disseminated throughout the plantations and fallows and the establishment of plantation of these species would be appropriate. However, the lack of good quality planting material and knowledge about the forestry management of trees, and the long phase of juvenile growth before fruiting are constraints to planting these species for fruit production. Thus, participatory domestication – an approach developed by the World Agroforestry Centre (ICRAF) that combines endogenous knowledge with scientific advances, and which could help improve the cultivation, yields and quality of fruit production of these local species in a short time – is very important. To do this, a better understanding of the genetic diversity and distribution of these species is essential for their conservation and use.

This study aims to assess the diversity of the populations of akpi (*Ricinodendron heudelotii*), in the different cocoa agroecological zones of Côte d'Ivoire in order to develop clones through grafting. This study is carried out on trees spaced at least 50 m apart from each other in each zone. Data collection includes traits such as height, chest height diameter, and crown diameter of each tree. The GPS details of each tree were also collected. A sampling of 24 fallen tree fruits was collected. For each of these fruits, the mass of the fruit, the number of kernels per fruit, the mass of each core, the mass of each kernel, the length and the two widths (perpendicular directions) of the fruit were collected. An ANOVA was performed and a comparison of averages was done using the Duncan method at 5%. Preliminary results show 220 trees of *R. heudelotii* bearing fruits have been identified and geo-referenced in 33 localities of the five different agroecological zones of Côte d'Ivoire. Sampling of the fruits of these trees was done. Preliminary analysis revealed that a significant difference was observed among accessions and among the five agroecological zones sampled. Accessions from Soubré possessed a high weight of fruits and seeds, while those of Aboisso and Man showed the smallest fruits. However, accessions from Aboisso showed high length, width 1 and width 2 of fruit compared with those from Daloa, which registered the lowest value of these variables.

## KEYWORDS

*Ricinodendron heudelotii*, accession, performance, characterization, domestication

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# Soil and groundwater recharge or surface runoff? Landscape-scale assessments of soil infiltrability across the global tropics

Infiltration is a key hydrological process driving the partitioning of water at the soil surface into surface runoff and subsurface water recharge, thereby affecting water security, plant water availability and the risk of soil erosion and flooding, which in turn impact livelihood opportunities. Systematic measurements of soil infiltrability at the landscape scale are rare, which makes it difficult to draw sound conclusions on the main variables affecting infiltrability beyond the plot level. Here, we present and analyze data on soil infiltrability and other indicators of land health collected systematically across the global tropics using the Land Degradation Surveillance Framework (LDSF). These data were collected across a number of projects, including FTA-supported projects, in over 20 countries. The main objective of the analysis was to explore what variables best explain the variation in topsoil field-saturated hydraulic conductivity (Kfs) at the landscape scale. Infiltration data from over 5000 plots were used in the study. Kfs was estimated using a single ring model for falling head conditions. The estimated Kfs values ranged from 0 to 800 mm h<sup>-1</sup>.

The analysis will focus on the role of land cover – with particular emphasis on woody vegetation cover – land use, soil organic carbon (SOC) and soil inherent properties such as texture. Finally, we will discuss the potential of these data, which constitute the most comprehensive database of systematic soil infiltrability measurements globally, to address other research questions related to FTA.

## KEYWORDS

Infiltration, tree cover, water security, land health, systematic landscape-scale assessments

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# Strategies and standards for production and distribution of tree germplasm in Mt. Elgon region of Uganda

Shifts in global strategies for management and conservation of forests and allied tree resources have increased consideration for the needs and opinions of local investors. A study was conducted in five districts within the Mt. Elgon region of Uganda. The purpose was to assess the robustness of structures and mechanisms for effective production and distribution of tree germplasm.

The specific objectives were to:

- i) assess the socio-economic traits of actors
- ii) profile stakeholder typologies and interests in new tree-based enterprises
- iii) assess the standards for producing fruit tree germplasm.

A total of 126 tree farmers and nursery operators were engaged in interviews and focus group discussions to collect data. Data were summarized in Excel and analyzed in MINITAB 19. Results show that the tree germplasm sector was dominated by men (84%) of whom 40% were youths between 15 and 35 years old. The local investors were interested in five major tree-based enterprises including fruit growing (86%), beekeeping (80%), eco-tourism (70%), woodwork (56%) and carbon farming (40%). Gender had a positive effect on the choice of businesses carried out ( $X^2=27.432$ ,  $DF=4$ ,  $P<0.001$ ). Although the standards were different among the untrained actors, education did not seem to be very important during seed sourcing and pre-treatment practices ( $X^2=9.53846$ ,  $DF=4$ ,  $P=0.049$ ). Fruit seeds were gathered from trees on farms (45%), in market places (38%) and in the wild (22%). We recommend a policy formulation to regulate tree germplasm production and distribution in the region. The policy will help to establish a high-quality, well-coordinated and harmonized tree germplasm system.

## KEYWORDS

Tree seed, seedling production, tree farming, nursery standards

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# Agroforestry enrichment options in tobacco farms in the Dominican Republic

Several assessments have shown that agroforestry systems benefit producers' livelihoods through the provision of ecosystem services, especially provisioning services. The integration of timber trees is an option for the diversification of both farm activities and income generation. This work lays the ground for opting for an agroforestry enrichment plan with timber trees on tobacco farms, through linear planting and pure plantations. Using a reference chain approach, of focus groups and farm visits, we collected information from 44 producers who own their farms (producer selection criterion, since this is a determining factor for the adoption of forest interventions). Focus groups were divided into two phases: a diagnostic phase (phase 1) and a design phase (phase 2). In phase 1, all producers identified in the reference chain were surveyed to find out which timber species and in what quantities were present on their farms. According to the tobacco farmers, 11 wood species were grown on their farms (i.e. *Acacia mangium* Willd., *Prosopis juliflora* (Sw.) D.C., *Swietenia mahogany*, *Rochefortia acanthophora* (DC.) Griseb, *Eucalyptus* spp.), with a total of 368 individuals in an area of 62 ha. In phase 2 we identified that almost half of the interviewees are willing to plant timber trees in their agricultural fields. Six wood species were listed as the most desired, with *Eucalyptus camaldulensis* being the most accepted with 28% having that preference, and the species with the lowest acceptance was *Prosopis juliflora* (Sw.) D.C. (0%). As mentioned by farmers, one of the factors affecting the potential integration of timber trees on their tobacco farms is the reduction of light needed by the main crop, by the effect of the shade of the companion trees. We performed shade simulations using ShadeMotion 5.0 software to forecast the expected shade level of selected species in proposed spatial arrangements (linear plantations and block plantations) and orientations. This is the first attempt to integrate trees on tobacco farms in the Dominican Republic.

## KEYWORDS

Agroforestry enrichment, timber trees, tobacco, linear planting, ShadeMotion

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# Factors affecting adoption and diffusion of agroforestry by smallholders in the Mt. Elgon region of Uganda

Forests and trees on farms are fundamental to the physical and economic survival of every human being. A study was conducted in the Mt. Elgon region of Uganda to assess the dynamics of agroforestry in the context of smallholders. The specific objectives were to: i) assess the socio-economic qualities of farmers, ii) assess the suitability and benefits of agroforestry technologies and iii) identify the challenges, incentives and strategies to support agroforestry among women and young smallholders. A total of 250 farmers were engaged in semi-structured interviews, key informant interviews and focus group discussions to collect data. Results show that smallholders were generally keen and actively involved in agroforestry practices. The majority (82%) were illiterate and used indigenous methods and tools to farm. Up to 70% of the participants depended on farming as a business, earning about USD 250 per annum. Commonly, land scarcity (65.9%), seed shortage (45.9%), inadequate markets (27.1%) and restricted technology (22.9%) were among the major challenges highlighted. The incentives included farmer training (32.4%), growing demand for tree products (18.8%) and access to free seedlings (18.8%). The strategies involved: strengthening farmer capacity building programs (71.2%), sensitization on climate change (48%), accurate timing for planting (48%), supporting community nurseries (30%) and promoting fast-growing tree species (28%). There is a need to re-organize and reinforce farmer capacity building programs on tree species, site and context matching, climate-smart agroforestry and tree product value chain development. These will arouse a deeper smallholders' interest in agroforestry interventions for food and income security.

## KEYWORDS

Tree seed, seedling production, tree farming, nursery standards

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# Assessing land and soil health in Son La Vietnam for prioritizing and tracking restoration activities within the AFLI project

Annual crop cultivation provides the most significant source of food and income for smallholder farmers living in the mountainous areas of Northwestern Vietnam. The recent decades witnessed the remarkable increase in annual crop areas on sloping land which covers 75% of the total area of the region. This has led to severe land degradation threatening multiple ecosystem services of the landscape. In an attempt to assess land degradation and understand drivers of degradation, this study was conducted with the aim to identify and measure key indicators of land and soil health using the Land Degradation Surveillance Framework (LDSF) methodology. The LDSF provides a field protocol for measuring indicators of the 'health' of an ecosystem such as vegetation cover and structure, land use, soil erosion prevalence, tree and shrub biodiversity, and soil health, including soil organic carbon content and infiltration capacity. In total, 160–1000 m<sup>2</sup> plots were randomly sampled across a site of 10 km × 10 km. The majority land cover of the plots was annual crops (85%) with the remaining plots classified as shrubland (8%) and bushland (7%). Visible erosion was recorded for 70% of sampled plots; all of them were annual crops on steep or medium slopes. Only 32% of the sampled plots had soil water conservation measures, indicating an opportunity for improved on-farm soil management interventions. As a key indicator of land degradation, soil erosion prevalence was mapped using a prediction model based on Landsat satellite imagery and LDSF data for seven districts of the Northwest region. Initial results reveal that 2% of the project site (16,500 ha) is under the highest threat of soil erosion (75%–100%), while 27% of the area (215,500 ha) falls into the medium level of soil erosion prevalence (50%–74%). The study benefited from existing data in the LDSF database while contributing to global datasets, demonstrating the importance of global data-driven datasets. Changes of soil and land health over time can be monitored using historical Landsat imagery. The map has implications for land use planning and interventions to reduce soil erosion and restore the capacity of ecosystem services.

## KEYWORDS

LDSF, land degradation, soil erosion prevalence, ecosystem services, remote sensing

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# The *Prosopis juliflora* invasion in drylands presents multiple challenges and benefits: The case of charcoal for improved livelihoods in Kenya

In Kenya, *Prosopis juliflora* was introduced between mid-1970 and 1980s into dryland areas to minimize deforestation, desertification and fuelwood shortages. However, this aggressive species invades about 500–1300 ha per year causing land use and land cover (LULC) losses of grasslands, woodlands, cropland and settlements (Ng et al. 2017; Mbaabu et al. 2019;). On the other hand, *Prosopis* presents an opportunity for sustainable charcoal from the estimated 40 million tonnes of utilizable biomass that would fill the 55% deficit faced in the country (MEWNR 2013).

A study was conducted in Baringo County under the Governing Multifunctional Landscapes (GML) project implemented by ICRAF and CIFOR and supported by the EU. This write-up presents part of project work that aimed at establishing the evolution of people's perceptions around *Prosopis*, gender roles in its management, and associated benefits and challenges. The study used focus group discussions (FGDs), seasonal and livelihood calendars, participatory visioning and mapping, and training of trainers delivered in partnership with Kenya Forestry Research Institute (KEFRI). A total of 32 participants took part, drawn from charcoal producer associations in Baringo, Ministry of Agriculture, Schools and Local artisans. The perceptions have shifted from positive when it was first introduced in 1975 to negative after facing a myriad of challenges attributed to the species. Some of these challenges include loss of crop and pastureland, human physical injuries caused by *Prosopis* thorns, loss of native tree species, flooding, human settlement displacements, increased malaria cases and loss of wildlife habitat. In the last decade, the community started to appreciate the value of *Prosopis* mainly because of its provisioning of wood for charcoal, firewood, timber and fencing materials for household use and income generation, employment opportunities along the charcoal value chain and ecosystem services such as reduced soil erosion, shade and wind breaking.

Men are the main decision-makers as regards trees to be cut, where to locate the kiln for charcoal processing and how the income from the sale of charcoal is spent. Cutting of trees, arranging the wood in the kiln, harvesting and loading charcoal into trucks and marketing are mainly carried out by men. Women are more involved in pruning fallen trees, lighting the kiln, and sorting and packaging the charcoal. Participatory visioning and mapping identified the intervention to improve the landscape and a future map for 2030 indicated an improved landscape where some portions of the *Prosopis* stands are cleared and enrichment with native species will be carried out. The participants were trained as trainers (TOT) on sustainable wood harvesting, improved charcoal processing, use of charcoal waste as biochar for soil amendment and for fuel briquette production, charcoal regulations and marketing (Njenga et al. 2019). The graduates of the ToT will be backstopped to scale out improved charcoal production targeting all the charcoal producers, who number about 150 in the study area.

The study recommends management of *Prosopis* through sustainable production of charcoal and other wood and non-wood products which should be integrated with clearing of some areas and enriching them with other multipurpose trees for improved multifunctional landscapes and resilient livelihood systems.

## KEYWORDS

Invasive, *Prosopis juliflora*, sustainable charcoal livelihoods, local communities

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# Agroforestry for sustainable cocoa production in the forest–savannah transition zone in the north of the Congo Basin including Cameroon

Past studies showed a gradual expansion of tree cover over savannah in the forest–savannah boundary zone of Cameroon (Gillet et al. 2001). While the encroachment of savannah by forest is more and more impeded by human activities, farmers have proven that afforestation at the border of the forest is achievable using cocoa and specific techniques to build up an associated tree canopy (Jagoret et al. 2012). Furthermore, mature cocoa agroforestry systems created on savannah (S-cAFS) and in forest (F-cAFS) seem to exhibit comparable multi-strata structure linked to a multi-purpose objective of farmers in terms of livelihoods and long-term sustainable management of cocoa. By combining measurements of cocoa production, litterfall and cycling, soil quality, carbon storage and tree species diversity along an age gradient (1 to 70 years), we showed that those variables in S- and F-cAFS generally tended to comparable levels after several decades. Results also emphasized the ability of S-cAFS to increase most of the ecosystem services (ES) although the time needed to reach levels found in F-cAFS varied strongly amongst variables (Nijmeijer et al. 2019a,b).

We also compared the impact of five shade tree species (*Canarium schweinfurthii*, *Dacryodes edulis*, *Milicia excelsa*, *Ceiba pentandra*, *Albizia adianthifolia*) and unshaded conditions on soil functions and cocoa yield in relation to plant functional traits and leaf litterfall within 8 cocoa farms 20 to 60 years old (Sauvadet et al. 2020). While no difference in cocoa yields could be detected between the different tree species and unshaded conditions because of high variability of data, the effects on soil functions varied largely among species. Shade tree species with the most dissimilar litter traits to cocoa (cocoa showing the lowest leaf litter quality) showed the largest improvement of soil functions. Low litter recalcitrance was strongly associated with increases in soil fertility indicators such as N and P availability, while pH, soil C and N contents increased with litter Ca restitution. Improvements of soil functions were low under the two fruit trees (*Canarium* and *Dacryodes*), medium under the legume tree *Albizia*, and high under the two timber trees (*Milicia* and *Ceiba*). According to the tree species and nutrient, nutrient recycling through litterfall could barely to largely offset the nutrient removal by cocoa beans and husks. This study corroborates that the two tall timber trees (*Milicia* and *Ceiba*) are some of the most appreciated companion species for cocoa production by farmers, alleging desirable light shade, higher soil fertility and cocoa yield.

In order to better assess the role of shade trees in these cocoa systems, future research will need to extend these approaches, especially to understand how plant diversity can help to adapt to climate change, including higher temperature and longer dry seasons.

## KEYWORDS

Cocoa agroforestry, ecosystem services, forest–savannah transition, plant functional traits, soil fertility

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# Factors influencing on-farm tree seedling survival across various contexts in the eastern drylands of Kenya

The role that trees on farm play in enhancing both ecosystem and livelihood resilience in drylands is well documented. For example, trees provide ecosystem goods and services such as food, fodder, fuel, reducing soil erosion and enhancing soil health, and provide opportunities for generating additional income. They also contribute to answer the household food demand and nutritional requirements. Despite this, tree planting in the eastern drylands of Kenya is largely characterized by low tree seedling survival. This is partly due to unreliable rainfall, high levels of land degradation resulting in low soil productivity, planting of ecologically unsuitable tree species, and poor tree seedling management practices.

To explore how different tree planting and management practices influence seedling survival, over 2000 farmers in Kitui, Machakos and Makueni counties in Kenya conducted on-farm planned comparisons around survival across different planting and management options. This included tree species, hole size, manure application, mulch application, watering and, across varying contexts, such as farm size, planting niche, soil health status. Seedlings of six tree species were distributed and planted in November 2016 and seven species in November 2017. Farmers planted between 7 and 21 seedlings on their farms, and survival was monitored six months after planting using electronic data entry. Data were analyzed using R statistical software.

Results show a 20% increase in survival in Kitui, 4% in Makueni, and similar in Machakos for seedlings planted in 2017 compared with 2016. Farmers reported that this was partly due to increased rainfall during the 2017 planting as well as improved farmer management of the seedlings due to practices learned during training. Farmers also reported a change in perception of the ownership of the tree seedlings. Of the seven tree species planted in November 2017, *Moringa oleifera* seedlings had the highest survival rate in Kitui County while *Carica papaya* and *Senna siamea* had the highest survival rate in Machakos and Makueni counties, respectively. Tree seedlings planted with manure had a higher survival rate compared with those planted without manure, with variation within species, and across counties and planting years. Mulching resulted in increased seedling survival in Kitui and Makueni counties while in Machakos, there was no variation in the survival with or without mulching. Statistical analysis on what leads to successful tree seedling survival showed that watering, manure application and seedling protection by fencing positively influenced tree seedling survival. The size of the planting hole did not significantly influence tree survival. However, differences were observed within species and counties. The planting niche and farm size did not have an influence on the survival, with variation observed within the species and across the counties. The gender, age and education level of the household head had a significant influence on seedling survival, with variation across the planting years.

## KEYWORDS

Trees on farm, options by context, on-farm planned comparison, tree seedling survival

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# From analytic geometry to shade canopy design in coffee/cocoa agroforestry systems: The mathematical and computational basis of ShadeMotion 5.0, software that simulates the shade patterns of trees

A wealth of knowledge is available and technology is applied at the farm level on good agricultural practices, including improved genetics, better crop protection measures, soil fertility management, optimal spacing/pruning configurations, and so on. Unlike crop management, the optimal design and management of the shade canopy of the coffee or cocoa plantation is still an aspiration despite the ample evidence of the important supply of valuable products for both family/farm consumption/use and sale that shade canopy plants make to rural households. Trees on farms (timber, but also fruit trees) are valuable assets that can be harvested at times of hardship or to cope with unexpected needs. Trees reduce the financial vulnerability of the household.

Surprisingly, and disappointingly, most shade canopies are sub-optimal in terms of botanical composition (species' uses not matching farmers' expectations), spatial heterogeneity of tree cover and shade levels. Why do farmers neglect the opportunity to optimally design the shade canopy of their coffee/cocoa plantation to achieve their goals? A study in Bolivia showed that farmers 'flunk' most shade-management-related questions. Lack of knowledge on how to manage trees in cocoa agroforestry systems was posited as a proximate reason for farmers having flunked the exam. Shade design and tree management are usually absent or only superficially treated in extension messages to farmers. There is clearly a need for user-friendly tools to help extension services teach local promoters and teach farmers how to think about their shade canopies, and how to optimally design them in terms of botanical composition (value and use, ecology), density and temporal/spatial patterns and management.

We developed internet-based software to graphically, quickly and easily design and test tree shade canopies in terms of the number of hours of shade received by each point on a plot with trees. ShadeMotion handles large plots, anywhere on Earth, horizontal or tilted planes, any number of trees in any spatial configuration on the plot, tree features (monthly leaf fall, crown size, form and transparency), any time interval, from a snap photo to a full swing simulation over the entire life cycle of the plantation (say 30 years) with tree growth data provided by the user. ShadeMotion considers tree crowns as regular geometric 3-D objects with variable dimensions and other characteristics (e.g. monthly leaf phenology), and simulates the movement of the sun to estimate the number of hours of shade projected by the crowns of the trees on every point on the plot over the simulation period.

In this presentation we: 1) describe the mathematical and computational strategies behind the software ShadeMotion 5.0, simulate the shade patterns typical of the traditional *Coffea arabica* – *Erythrina poeppigiana* – *Cordia alliodora* coffee production system in Turrialba, Costa Rica; and 2) explain how ShadeMotion is incorporated into the curricula of on-going Farmer Field School projects in Latin America.

## KEYWORDS

Tool, optimal shade canopy design, simulation, shade patterns

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# Agro Forest Nursery: Importance for the rescue of fruit trees and forest species

In order to ensure that a greater number of plants are used, special facilities in which environmental conditions are managed and the most favorable growth conditions are provided for the new plants to continue their development and acquire the necessary strength to transplant them to the place where they will spend the rest of their life. For this reason, the design of a nursery is a fundamental aspect in order to obtain plants ready for planting. Due to the problems and the loss of biodiversity and the great need to reforest, nurseries can function not only as a plant-producing source, but also as research sites where the native species of interest undergo experimentation, in order to promote banks of germplasm and seedlings of native species that allow their characterization, selection, management and conservation. This will allow us to design, develop and adapt the most suitable techniques for the massive propagation of these species. In addition, nurseries can also be training sites where the promoters of these techniques are located in our facilities. With the propagation of fruit and ornamental plants, the entrance plan of our center is being helped considerably.

## KEYWORDS

Nursery, reforest, conservation, propagation and existence

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## Macropropagation techniques for native forest tree species using orthotropic shoots/stem cuttings in different treatments of indole butyric acid (IBA) rooting hormone

The Ecosystems Research and Development Bureau (ERDB) implemented a research study titled “Macropropagation Techniques for Native Forest Tree Species using Orthotropic Shoots/Stem Cuttings in Different Treatments of Indole Butyric Acid (IBA) Rooting Hormone” under the “Genetic Improvement of Forest Tree Species for Quality Wood Production” project during 2012–2018. It was conducted to determine the desirable/applicable IBA rooting hormone treatment for priority native forest tree species and make possible the rapid multiplication of candidate-plus trees (CPTs) for mass planting under the National Greening Program (NGP) or other future tree planting endeavor for reforestation purposes and industrial or commercial forest tree plantation production.

Native forest tree species were selected based on the following criteria: ecological importance and population status (e.g. endangered, rare, threatened, vulnerable); economic importance (i.e. based on regional demand); and c) availability (i.e. hard-to-find and hard-to-propagate using seeds). Germplasms were collected from individual plus trees and subjected to experiments (initial rooting and validation) and laid out in complete randomized design (CRD) with a minimum of 24 orthotropic shoots/stem cuttings per replicate at four (4) replications under various IBA (indole butyric acid) rooting hormone treatments using a non-mist system. Data on rooting survival, number and lengths of roots were gathered and analyzed statistically to determine the desirable/applicable concentration of IBA rooting hormone per target native forest tree species.

The outputs of the study are information and process technologies on macroclonal propagation using orthotropic shoots/stem cuttings. In particular, information was generated purposely on technology for propagation of threatened indigenous and priority native forest tree species using appropriate types of orthotropic shoots/stem cuttings. In addition, the step-by-step procedures on how they can be propagated starting from the selection of phenotypically desirable mother trees up to various subsequent activities such as rooting of the collected germplasm, raising into plantable stockplants and hedge garden establishment, were divulged through generation of Information, Education and Communication (IEC) materials for eventual consumption of the target stakeholders.

Table 3.1 Summary of data gathered for the rooting performance of target forest tree species treated with various concentrations of indole butyric acid (IBA) rooting hormone.

Species	Rooting Survival (%)	Time of Rooting (days)	Rooting Hormone Concentration (ppm)	Threatened Category (DAO 2017-11)
1. Akle ( <i>Albizia acle</i> (Blanco) Merr.)	78.5	60	IBA25ppm	-
2. Almáciga ( <i>Agathis philippinensis</i> Warb.)	97	75	IBA300ppm	Vulnerable
3. Amugis ( <i>Koordersiodendron pinnatum</i> (Blanco) Merr.)	76.5	60	IBA300ppm	Other Threatened Species
4. Anang ( <i>Diospyros pyrrocarpa</i> Miq.)	94.5	90	None	Vulnerable
5. Banuyo ( <i>Wallaceodendron celebicum</i> Koord.)	93.5	60	IBA100ppm	Vulnerable
6. Bignay babae ( <i>Antidesma bunius</i> (L.) Spreng.)	90	45	IBA300ppm	-
7. Bignai Lalaki ( <i>Aporosa sphaeridiophora</i> Merr.)	83.5	45	IBA50ppm	-
8. Dao ( <i>Dracontomelon dao</i> (Blanco) Merr.)	87.5	90	IBA100ppm	Vulnerable
9. Dungan ( <i>Heritiera sylvatica</i> Vidal)	92.5	90	IBA300ppm	-
10. Gatasan ( <i>Garcinia venulosa</i> (Blanco) Choisy)	92.5	45	IBA300ppm	-
11. Ipil ( <i>Instia bijuga</i> (Colebr.) O. Ktze.)	95	60	IBA100ppm	Vulnerable
12. Kalantas ( <i>Toona calantas</i> Merr. & Rolfe)	83	60	IBA100ppm	Vulnerable
13. Kalingag ( <i>Cinnamomum mercadori</i> Vidal)	96.5	75	IBA300ppm	Other Threatened Species
14. Kamagong ( <i>Diospyros blancoi</i> A. DC.)	98.5	90	IBA300ppm	Vulnerable
15. Laneteng gubat ( <i>Kibatalia gilingensis</i> (Elmer) Woods.)	95	75	None	-
16. Lumbayao ( <i>Heritiera javanica</i> (Blume) Kosterm.)	97.5	60	IBA500ppm	-
17. Malugai ( <i>Pometia pinnata</i> Forst. & Forst.)	97.5	45	IBA500ppm	-
18. Mangkono ( <i>Xanthostemon verdugonianus</i> Naves)	97.5	90	IBA300ppm	Endangered
19. Nato ( <i>Palaquium luzoniense</i> (F. Vill.) Vidal)	93.5	75	IBA500ppm	Vulnerable
20. Philippine ash ( <i>Fraxinus griffithii</i> C.B. Clarke)	87	30	IBA300ppm	-
21. Philippine teak ( <i>Tectona philippinensis</i> Benth. & Hook)	90	60	IBA100ppm	Endangered
22. Supa ( <i>Sindora supa</i> Merr.)	93.5	60	IBA350ppm	Endangered
23. Tabon-tabon ( <i>Atuna racemosa</i> Rafin.)	87	75	IBA300ppm	-



Desirable/applicable IBA rooting hormone concentrations for the twenty-three (23) native forest tree species were determined. On the other hand, seventeen (17) of the target native forest tree species were established in the hedge garden to ensure the sustainable production of germplasm that would provide readily available planting materials during uncertain and limited periods. The result of the project is very useful as management input for managers, researchers, policy makers and students. The information gathered is valuable for forest tree seedling producers, nongovernmental organizations (NGOs), forest-based industries and NGP implementers and collaborators.

## KEYWORDS

**Macropropagation, clonal propagation, stem cuttings, orthotropic shoots, indole butyric acid (IBA)**

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# Model of the normal diameter from the *Acacia mangium* will bumper diameter in the Pinar del Río Agroforestry Company

This work aimed to determine an equation of the 1.30 m diameter of *Acacia mangium* based on the diameter of the stump of trees in the Pinar del Río Agroforestry Company. A random sampling was carried out on 100-tree *Acacia mangium* plantations; these trees were marked and the diameter at 1/3 of the diameter and at 1.30 m were measured. Then, using the IBM SPSS 22 statistical software, the models established the curvilinear regression and the linear regression, adjusted by this same software, also analyzing the statistics of predictive capabilities such as the aggregate difference and the root of the mean square error. The Power model, represented here,  $d_{1.30} = 1.02 * d_{tocon}^{0.92}$ , was obtained as the best fit and prediction equation.

## KEYWORDS

*Acacia mangium*, normal diameter, diameter of stump, curvilinear regression, linear regression

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# Young shade tree provision of ecosystem services: First lessons from a large-scale conversion from coffee monoculture to agroforestry in Yunnan Province, China

Local governments in south Yunnan Province, in China started distributing free shade tree seedlings to all coffee farmers in 2012, to support the conversion from coffee monoculture to agroforestry systems. In a few years only, shade trees were planted on virtually all coffee estates in the region (~95,000 ha), making it a rare example of large-scale conversion towards agroforestry.

Mature shade trees are known to provide a range of ecosystem services (improving soil fertility, buffering extreme climatic events, allowing revenue diversification, lowering coffee biannual production patterns, etc.) as well as some ecosystem disservices in the case of poorly selected or managed tree species (competition between shade trees and coffee for resources, higher incidence of some pests and diseases, etc.). In the present study, we measured the provision of ecosystem services and disservices of shade trees only a few years (3–5) after their introduction on coffee farms, to evaluate their rapid on-farm impact. We present here some key findings. Firstly, there is unexpected high tree species richness on coffee farms of Yunnan. Secondly, there is a clear positive impact of all investigated shade tree species on soil chemical and biological quality. Thirdly, there was a marked impact of shade trees on microclimate and they had a protective effect during a frost event in December 2017. Lastly, we show that coffee yield under shade trees could be as high as those measured in open areas, when shade tree species are carefully selected and managed.

This study shows the rapid benefits provided by the introduction of shade trees in coffee farms, and therefore the potential for agroforestry to rapidly contribute to more sustainable coffee production. It sets up a baseline for further monitoring and evaluation of this rare example of a large-scale conversion program. In particular, we advocate for further monitoring of the competition from shade trees, likely to increase as trees grow, and the possible replacement of some tree species by more compatible ones in the coming years. We also advocate for adapting the current intensive farming practices (particularly by reducing current high fertilizer inputs) to maximize the benefits provided by shade trees.

## KEYWORDS

Arabica coffee, agroforestry, China, ecosystem services

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# Local agroforestry knowledge and development of an online decision-support tool (shadetreeadvice.org) for selection of trees to be associated to coffee in Southeast Asia and beyond

In agroforestry systems (AFS), associated trees provide multiple ecosystem services and contribute to 1) improve soil fertility; 2) buffer climate extremes and help adapt to climate change, 3) provide refuge for biodiversity and a micro-climate favorable to biological antagonists to pests and diseases (P&D), and 4) diversify on-farm revenues (fruits, timber, fuelwood, fodder, medicinal products, honey, etc.) and reduce exposure to price volatility, particularly for crop commodities such as coffee or cocoa. Still, associated trees can also compete with crops underneath for water, light and nutrients, or favor some P&D, hence providing ecosystem disservices when farmers use locally inadequate tree species and/or poor agroforestry practices.

There is an untapped wealth of knowledge gained by farmers over generations on agroforestry practices and ecosystem services and disservices provided by trees on their farms. The South-east Asia team has been working with male and female coffee farmers in Yunnan, China, Northwest Vietnam and Central Laos documenting the local knowledge on trees and refining an online decision-support tool (shadetreeadvice.org) to help select the right tree species adapted to the local context.

This presentation will highlight some of the insights from the Yunnan, Laos and North Vietnam studies with respect to soil fertility, gender perceptions of trees and so on. It will present briefly the ongoing studies in Nicaragua, Central Vietnam, Cameroon and Colombia that will contribute to broaden the geographic scope of this tool. Finally, it will also present the latest developments to refine the online tool to make it more user-friendly.

## KEYWORDS

**Agroforestry, coffee, local knowledge, decision support tool**

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# Survival of fruit seedlings intercropped with bamboo species in the Brazilian savanna

Bamboo plants grow well and shade the soil, and their root system is vigorous and abundant. Thus, competition for water, light and nutrients limits or prevents the development of other plant species in the middle of the bamboo groves. However, if there is a control on competition factors, it may be possible to cultivate other plant species in consortium with bamboo, which would provide diversification in farmers' sources of income. In this way, the present work aimed to evaluate the survival and development of seedlings of perennial fruit species, planted under shading conditions of an already established bamboo forest. The study was carried out in an area of the Federal University of Goiás (UFG), in the Brazilian Cerrado region. In June 2019, seedlings of five perennial fruit species of economic interest (avocado – *Persea americana*; mango – *Mangifera indica*; jaboticaba – *Plinia cauliflora*; ambarella – *Spondias dulcis*; and soursop – *Annona muricata*) were planted between the lines of bamboo plants of three species (*Guadua angustifolia*, *Dendrocalamus asper* and *Dendrocalamus strictus*), with four years of planting and spaced 8.0 m × 5.0 m. Before planting the seedlings, the soil was prepared up to 30 cm deep with a subsoiler, in order to cut part of the bamboo roots. The intercropped fruit plants were grown in rows, spaced at 5.0 m between plants and were drip-irrigated to ensure water supply in the dry period of the year, which is from April to October. Bamboos were not irrigated and naturally lost leaves in the dry season, reducing the shading. During the water period, the bamboo plants gained new leaves and the clumps were managed, removing the culms that were more than two years old, in order to reduce the shading over the fruit species. For six months, once a month, the development of plants was evaluated by measuring height and diameter of the stem. The avocado did not adapt to the consortium with bamboo, because in the first month after transplanting, it showed yellowing and burning of the leaves and, by the sixth month, 60% had died. Avocado plant growth averages were –18.4% when intercropped with *D. asper*, 16.1% with *G. angustifolia* and 4.8% with *D. strictus*. Ambarella grew 20.2% in the middle of *D. asper*, 18.6% with *G. angustifolia* and 10.6% with *D. strictus*. The mango grew 25.7% in the middle of *D. asper*, 15.1% with *G. angustifolia* and 3.8% with *D. strictus*. Jaboticaba grew 16.4% in the middle of *D. asper*, 4.9% with *G. angustifolia* and –1.5% with *D. strictus*. Soursop grew 12.8% in the middle of *D. asper*, –7.7% with *G. angustifolia* and 7.7% with *D. strictus*. The management of bamboo species combined with the irrigation of fruit species enabled the cultivation of ambarella, mango, jaboticaba and soursop in consortium with the bamboo species *D. asper*, *D. strictus* and *G. angustifolia*. The avocado species has not adapted to the evaluated consortium system and should be better studied. The study should continue to assess the fruits production.

## KEYWORDS

Intercropping, *Guadua angustifolia*, *Dendrocalamus asper*, *Dendrocalamus strictus*, fruit plants

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# Participatory development of agroforestry practices in Northwest Vietnam: Using quantitative and qualitative data for evaluation and design improvement

The sustainable development goals target livelihood improvement of smallholder farmers, especially in uplands dominated by poor communities and ethnic minorities, through sustainable agriculture. We evaluated the participatory development of two long-term agroforestry (AF) experiments in the Northwest region of Vietnam, in order to assist farmers to shift from the unsustainable practice of sole annual crops to AFs. The performance of two fruit tree-based AF systems, longan–maize–forage grass and *Docynia indica*–forage grass were compared with sole tree and sole annual crops as controls. Farmers' perspectives on the two practices were investigated through interviews.

The 7-year (2012–2018) record on plant productivity shows lower yield of longan in AF compared with sole plantation (0.38 and 1.04 ton ha<sup>-1</sup> year<sup>-1</sup>, respectively), comparable in terms of maize (4.5 ton ha<sup>-1</sup> year<sup>-1</sup>), but AF could provide 15 ton ha<sup>-1</sup> year<sup>-1</sup> of forage grass. The AF system generates a positive annual income of 1018 USD ha<sup>-1</sup> or 2.4 times higher than sole maize while sole longan still has no profit due to high investment cost. In the other AF practice, the tree production (i.e. *Docynia*) was also lower compared with sole tree plantation (1.3 and 4.2 ton ha<sup>-1</sup> year<sup>-1</sup>, respectively) but AF could provide 64 ton ha<sup>-1</sup> year<sup>-1</sup> of forage grass, which resulted in an annual income of 2441 USD ha<sup>-1</sup>, 3.5 times higher than income from sole tree plantation. In addition to higher economic benefits, the two AF practices have a shorter break-even point, at the 2nd year after plantation.

The local interviews revealed that farmers gained a high economic benefit from the AF practices, but also emphasized that the income can be optimized through better management of tree crops, which minimizes both above- and belowground interactions. In addition, as ecological benefits, they noticed the importance of grass strips in reducing soil erosion and maintaining soil fertility, but a wider use of forage grass apart for fodder, is desirable. They also indicated that the expansion and sustainable development of the AF practices in the region will need financial support to tackle the investment, and improved market value chains, especially in terms of market stability. A better knowledge on plot management practice was also identified as an enabling factor for development.

## KEYWORDS

Sustainable agriculture, agroforestry practices, economic benefit, farmer perspectives

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# Profile of smallholder palm oil plantations in Ketapang District, West Kalimantan

Palm oil is Indonesia's main plantation commodity and it is the largest source of foreign exchange after petroleum and natural gas, reaching IDR 265 trillion (USD 16.9 billion) in 2018. Indonesia is the largest producer and exporter of palm oil in the world, with production exceeding 51 million tonnes in 2019 (83% crude palm oil, 17% palm kernel oil), from almost 15 million ha, 55% being large private estates, 41% smallholder estates and 4% large government-owned estates. There has been a massive increase in smallholder estates from only 3000 ha in 1979 to almost 6 million ha by 2019, which shows that the success of oil palm in improving the Indonesian economy is in part thanks to independent smallholders. Unfortunately, the vast area of smallholder oil palm estates is not the most productive, with average oil palm production in smallholder plantations in Indonesia in 2019 being 3.2 t/ha and in Ketapang Regency only 2.1 t/ha, compared with 4.1 t/ha from private estates and 3.7 t/ha on government estates. Smallholder oil palm plantations are also very vulnerable to various environmental, social and legal issues that can limit access to international markets.

To assess the reasons for these differences, Tropenbos Indonesia conducted a survey in August 2019 in Ketapang, of 145 farmers from 9 villages with special attention on independent smallholder plantations. Following qualitative descriptive analysis with frequency distribution tabulation analyzed using the SPSS program, results showed that implementation of good agricultural practices is limited, as is smallholder support; sales were made through middlemen, and most respondents did not know about palm oil certification. Traditional communities generally do not possess land certificates, with full land titles more common in transmigration villages. Further, the low price of oil palm meant that few farmers had expanded their plantations, with production of fresh fruit bunches from independent smallholders the lowest at 8.3 t/ha/y. Funding sources for oil palm management were mostly from farmers' own capital, with only 6.6% from loan funds, with only a limited number of farmers being members of farmer groups, and a general poor knowledge of control methods for pests and diseases. In order to improve the sustainability and inclusiveness of the independent smallholder oil palm sector, the following interventions are recommended:

- (i) mapping as a basis for land use planning decisions
- (ii) limiting GHG emissions and deforestation
- (ii) improving the productivity of independent smallholders
- (iv) supporting collective action and capitalizing on advantages of scale
- (v) facilitating business-based decision-making with smallholders and supporting alternatives.

## KEYWORDS

Palm oil, independent smallholders, good agriculture practices (GAP), land certificates, GHG emissions

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# Disruptive use of Earth observation and machine learning to quantify and monitor regreening efforts and change in land health at scale

There has been a large increase in Earth observation platforms and free moderate- to high-resolution satellite data from space in the last decade through NASA's Landsat 8 and particularly from the European Space Agency's Sentinel program. We present the results of applying Earth observation data from these platforms coupled with systematic field data collection and machine learning to simultaneously quantify land cover, soil properties and processes of land degradation across land restoration intervention sites in eight countries in East Africa, Ghana, and the Sahel. Spatial assessments at 10 to 30 m spatial resolution allowed us to quantify these indicators with a high level of accuracy at scales ranging from individual farmer fields to country and regional levels. A key indicator assessed was soil organic carbon (SOC), which is not only important for soil and land health, but also critical in terms of climate change mitigation potential. At the farm and village scales, these assessments and maps were combined with data collected through structured household surveys to allow for further investigations of coupled social and ecological factors determining the effectiveness of interventions to restore degraded land through agroforestry. By applying consistent indicators and big data analytics of Earth observation data, we show the utility of these approaches at multiple scales, allowing for assessments that simultaneously provide broad insights across large areas and local relevance at the level of individual farming households. This represents major progress in our ability to both assess baseline conditions and monitor trends over time within projects and programs that aim to restore degraded land through tree planting and/or farmer-managed natural regeneration (FMNR). A mobile app, the Regreening Africa App, and online dashboard were also developed for unstructured (or crowd-sourced) data collection of interventions, allowing implementing partners, extension agents and farmers to collect information on their tree planting or FMNR activities. We present the results of analysis that integrate crowd-sourced data with the above spatial assessments based on Earth observations, feeding directly into local decision-making processes related to targeting and monitoring of land degradation efforts in the eight project countries covered by the EC-funded Regreening Africa project.

## KEYWORDS

Earth observation, land health, land restoration, monitoring, Sahel, East Africa

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# Agroforestry systems as a pathway to smallholder livelihoods in Tomé Açu, Pará: Lessons for scaling oil palm agroforestry

Conventional monocrops on large estates have provoked negative impacts on the environment and human populations around the world. Habitat loss/fragmentation is associated to reduction of ecosystems services and has deleterious effects on the well-being of vulnerable communities. Oil palm (*Elaeis guineensis* Jacq.) plantations commonly include these issues (Obidzinski et al. 2012; Lee et al. 2014). In the past decade, oil palm production expanded rapidly in the Brazilian Eastern Amazon, with promising prospects but also relevant challenges (Villela et al. 2014; Brandao and Schoneveld 2015). During this process, many smallholders/family farmers have been marginalized or incorporated as cheap labor. On the other hand, agroforestry systems (AFS) have been suggested as a solution to reconcile economic growth with socio-environmental benefits for small-scale farmers (Porro 2012). Our study aims to shed light on smallholder livelihoods and the role of agroforestry systems in the context of the oil palm industry. We randomly sampled 198 family farmers (land size up to 200 ha) in the municipality of Tomé-Açu, state of Pará, Brazil. Our findings pointed to diverse livelihood strategies, regarding the low explanation of principal component analysis (PCA), the high heterogeneity of production systems and the wide range of yearly income USD 390 to 115,300, average 13,100  $\pm$  15,200. Technology level, material well-being, total income and land size were the most relevant factors, together interpreted as success indicators of financial and physical capitals. While most households (70%) were considered at intermediate success level, this living standard was not achieved by 22% and exceeded by only 8%. The size of AFS planted areas was positively related to the level of success ( $p < 0.05$ ), with an average 30  $\pm$  28 ha per farm and 3  $\pm$  2 members per household. Different types of AFS were adopted by 87% of our sample, in contrast to 13% that adopted oil palm. The AFS average size and age were 1.5  $\pm$  5 ha and 8  $\pm$  8 years old, compared to 11  $\pm$  6 ha and 8  $\pm$  2 years for oil palm. Most farmers (85%) would like to expand their AFS by 2  $\pm$  4 ha, showing a relevant adoptability. The most used species were almost the same of those that farmers preferred for new AFS: cocoa (*Theobroma cacao*), açaí (*Euterpe oleracea*), black pepper (*Piper nigrum*), cupuaçu (*Theobroma grandiflorum*) and andiroba (*Carapa guianensis*). On the other hand, 56% believed that oil palm should not be included inside AFS because of its growing conditions and need for space. The low adoption of conventional oil palm plantations was likely associated with a perception that production systems are inflexible and mainly determined by the palm oil companies, thus neglecting the family farming hardships. We argue that the expansion of oil palm-based AFS would depend on the extent to which the business model and technological package that underpin agreements with farmers provide resources to reduce risks, especially favorable credit conditions, agricultural inputs, technical assistance, as well as adequate plantation size given labor availability. The spatial arrangement of species and AFS composition should incorporate products that have been tested and approved by farmers.

## KEYWORDS

Agroforestry, Amazon, livelihoods, oil palm, rural development

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# Rubber agroforestry systems in Kalimantan, Indonesia, 1994–2019: The evolution

The research project titled the Smallholder Rubber Agroforestry Project (SRAP) was implemented by CIRAD/ICRAF/IRRI from 1994 to 2007 in West Kalimantan. The main objective was to replace old and ageing and economically obsolete 'jungle rubber', the traditional rubber-based agroforestry systems based on unselected seedlings with clonal rubber agroforestry systems based on high rubber clone productivity and adapted to different local situations. From 1994 to 1997, more than 60 on-farm trials plots were established with local farmers in order to test various tree and intercrop combinations. The study of these plots in 2020 provided some conclusions. Rubber agroforestry trials came right in time in 1994, with a strong demand from farmers for rubber systems using good planting material with high productivity, clonal rubber, with low establishment cost and income diversification. But oil palm schemes with private estates came in 1997 with a very strong pressure from these companies (through the policy of concessions) to release land in exchange for 2 ha of oil palm, therefore providing a lucrative alternative to rubber cultivation with full access to credit (but loss of land) and better return to labor. It is now time for rubber replantation, as rubber is at the end of its lifespan, due also to the high impact of diseases and poor tapping practices.

It was very interesting to engage in an in-depth socio-economic survey involving all SRAP farmers, in order to assess the current situation of farmers' income (generated by oil palm/rubber and any other sources) and the farmers' ongoing and planned strategies, as rubber remain a real alternative for income diversification and resilience. The use of Olympe software for income simulation and budget analysis is worth testing to assess various strategies including agroforestry practices. A prospective analysis provided an assessment of the impact of oil palm and rubber price volatility. Low rubber prices did not help in maintaining farmers' interest in rubber; however, farmers know about rubber price volatility over the years and they are not willing to abandon rubber, as crop diversification remains a priority.

Beside the economic analysis of rubber-based agroforestry systems and the role of oil palm in income diversification, three major questions are shaping the research agenda: i) What is the impact of local fruit production derived from agroforestry systems on food security and diet quality of local families?, ii) What is the impact of timber production, both for self-consumption in households and marketing? iii) To what extent are the AF systems under study able to provide better climatic resilience?

## KEYWORDS

Rubber, agroforestry, diversification, Kalimantan, Indonesia

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# A landscape typology of paddy cultivation for robust targeting and upscaling: Action–research in the downstream of Rejoso Watershed, Indonesia

The prominence of land use, particularly agriculture sectors, in affecting a range of ecosystem services (ES) provided from production rural landscapes is progressively recognized; thus, tools and methods to assist in managing impacts of land use on ES provision and guide on-the-ground implementation in sustainable landscape management are indispensable. Production landscapes of rural areas in developing countries face classical problems of unsustainable agricultural practices and diminishing fertile farming land due to rapid population growth and anthropogenic pressures. Here, we develop a typology of production landscapes by considering the characteristics of land cover, farming systems, and socioeconomic aspects of the local communities. We then use this typology as a framework for assessment of approaches to develop some scenarios to support robust targeted sustainable agriculture pilots and recommend their upscaling. The case studied for this action–research pilot is located in the Rejoso Watershed in East Java, Indonesia. The Rejoso Watershed is dominated by horticulture and state-owned production forests in its upstream, agroforestry in the midstream, and paddy fields in the downstream.

To ensure farmers' adoption of sustainable paddy cultivation, we developed demonstration plots showing the conventional practice, i.e. high chemical inputs and inefficient water use, versus the 'technology' one, i.e. optimal uses of inputs, improved planting patterns, managed water regime and biopesticide application. Greenhouse gas (GHG) emissions, water irrigation, pests and diseases, and crop productivity are monitored. Our hypothesis is that the technology intervention will provide higher productivity both in quality and quantity, and hence better economic performance measured by the two indicators, net present value (NPV) or return to land and return to labor (RtL) compared with the conventional one. Methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) emissions as GHG indicators indicate that the introduced technology emitted less CH<sub>4</sub> and N<sub>2</sub>O.

Emphasis has been on areas of downstream paddy farming systems, where water use for agriculture is important and good agricultural practice is rarely applied by smallholders. In this irrigated paddy landscape, parameters in building the typology are crop productivity, paddy field area, percentage of area of crop rotation, dose of fertilizer and pesticide application, intensity of pest (rats), number of artesian wells as an option for irrigation, and flow of irrigation density. Initial data collections include land cover and irrigation system mapping, survey and focus group discussion on paddy cultivation of eleven villages. The production landscape typology we developed, provide information on different clusters of paddy field with different degrees of the above parameters, allowing more robust selection of scenario of interventions for higher adoption of the innovations in each type. Intervention scenarios include incentives for sustainable cultivation in the form of insurance of stable agricultural inputs, micro credit, agricultural insurance, market transparency and capacity strengthening in farmer group management.

## KEYWORDS

Adoption, adoption scenarios, sustainable agriculture, paddy field typology

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# Enhancing food security through landscape restoration: Case studies from Cameroon and Peru

Land restoration provides a solution to the challenges that countries across the globe are facing as a result of land degradation. Countries are committing to restore millions of hectares of land under global and regional initiatives such as the Bonn challenge, AFR100 and the Initiative 20x20. Enhancing food security is one of the objectives for land restoration initiatives. Projects involved in land restoration at community levels, however, may shape their objectives according to the contexts of the communities where they are implementing their projects. Through choices of species selected for regeneration, planting and to be protected, land restoration projects can enhance food security and livelihoods. This study assessed the extent to which restoration projects reflect the goals of food security that are set out in international restoration agendas with case studies from 12 land restoration projects from Cameroon and Peru. By illustrating the different pathways in which the species prioritized by local communities for restoration, and provision of food, firewood, timber, medicine and shade, among other benefits, the paper shows the need for explicitly including food security in restoration projects at community level and also involving communities in restoration decision-making.

## KEYWORDS

Food security, land restoration, land degradation, biodiversity, climate change

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# An example of how bamboo contributes to a circular economy in rural China

Commonly referred to as ‘poor man’s gold’, bamboo is a multiuse woody resource that is widely used in construction, pulping, plywood, handicrafts, and a diverse range of subsistence applications, generating job opportunities and cash income. Bamboo is an exceptional plant that offers climate-smart benefits and is useful for creating a myriad range of products which in turn help in the sustainable development of the economy. Taking an example from a famous bamboo town, Chishui municipality in southwestern China, this paper sheds lights on how bamboo has been used to contribute to green growth in the local economy while offering opportunities to enhance the value yielded in the form of a number of other products. It also indicates the results achieved, not only the production value of bamboo created, but also how many job opportunities were generated (especially for women) and how a circular economy was shaped.

## KEYWORDS

Bamboo, small holders, circular economy, poverty reduction, job creation

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# The hidden potential of agroforestry systems in the coca leaf production areas of Chapare, Plurinational State of Bolivia

Tropical areas are the principal source of fruits and animals that can contribute to a state's food security and sovereignty through the production of horticultural produce, fruits and meat due to the acceleration of biological processes required to fill fruits and gain weight for animals. In spite of the optimal conditions for the production of tropical fruits, and the raising of cattle, the lack of technical and financial services slow the development of this area. The Chapare area has touristic and agrosilvopastoral potential that has not been exploited adequately, but there are a few entrepreneurs that started producing palmito and banana to export overseas. There is a huge domestic demand for tropical fruits such as coipoazu, tangerine, fish (pacu, tilapia), and an international demand for cacao that could be an opportunity for diversification and new incomes for small producers. The Valle of Sacta farm is an experimental unit for enhancing tropical agriculture and natural resources management practices. In this study, we propose an agroproductive approach in order to measure the present types of livelihood capital (natural, physical, financial, social and human) through the use of surveys, semi-structured interviews and participant observation.

The principal results were:

- i) agroforestry systems are 20% more profitable than coca crops
- ii) the agroforestry systems allowed five harvests a year compared with the four harvests for the coca system
- iii) the agroproductive analysis approach is a useful technique to collect data from the field.

## KEYWORDS

Coca, agroforestral systems, livelihoods capitals, tropical fruits, cattle

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# Outcome of agroforestry and its contribution to the household economy of upland farmers in Northwest Vietnam

Agroforestry is considered as a solution for improving the livelihoods of smallholder farmers and reducing land degradation. To bring agroforestry to wider application in Northwest Vietnam, the role of agroforestry in total income of farmers' households needs to be assessed.

Different agroforestry options including fruit trees, annual crops and forage grass have been tested and evaluated in the field. Depending on agroforestry options, the break-even happened in the years 2 to 3. The return on investment (ROI) of five-year investment of longan+maize+forage grass, *Acacia*+mango+maize+forage grass, *Acacia*+longan+coffee+soybeans+forage grass, and teak+plum+coffee+soybeans+forage grass were 7%, 25%, 39% and 59%, respectively. Meanwhile, mono-maize provides an annual income, and ROI of five-year investment was 38%. Compared with annual crops, agroforestry alone required higher investment costs and is slower in providing an attractive income. However, it would be incomplete if the role of the agroforestry area in total household income was not considered. Agroforestry provides agricultural products, which support animal husbandry development, and in some cases, gives the chance for smallholder farmers to do off-farm activities. The number of households for which agroforestry contributed over 30% of total income was considered. It increased from 24% in the 1<sup>st</sup> year after establishment to 31% in the 2<sup>nd</sup> year and up to 59% in the following years.

The study shows that agroforestry plays an important role in changing the household economy. To bring agroforestry to wider application, it should be developed based on local farmers' needs and interests, and moreover, needs to be associated to and combined with the development of other economic activities.

## KEYWORDS

Agroforestry options, exemplar landscape, return on investment, total income

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# Climate vulnerability assessment in a dynamic landscape of West Kalimantan Province, Indonesia

West Kalimantan, the third largest province in Indonesia, has an area of around 14.73 million hectares and a population of over 5.3 million in 2018. Agriculture, forestry and fisheries are the largest contributors to the provincial gross regional domestic product (GRDP). Over the past 30 years, West Kalimantan experienced massive land use change from more forested areas into agricultural areas due to increasing demand for agriculture-based sources of livelihoods. At the same time, there was evidence from provincial climatology research stations, that some changes occurred in the climate, with an increase in temperature, a slight increase in monthly precipitation rate and decreased precipitation frequency, with different trends across West Kalimantan depending on the rainfall patterns, equatorial or monsoonal. A vulnerability assessment was conducted in the seven studied districts (Bengkayang, Mempawah, Landak, Sekadau, Sanggau, Sintang and Kapuas Hulu) through a combination of methods for data collection and analysis: participatory approach by conducting focus group discussions (FGDs) with the local community and governments, spatial analysis of hotspots, fire risks, deforestation potentials, and changes in land use over the past 5 years. Secondary data were also collected through literature reviews and discussions with key stakeholders in West Kalimantan. Clustering of villages in all seven districts was conducted to develop typologies to select and sample locations for detailed participatory data collection, and to understand the potential level of vulnerability and potential interventions to cope with the negative impacts of climate change. In total there are five village types: vulnerable, highly vulnerable, moderately vulnerable, less vulnerable and least vulnerable; these were developed based on the contexts and trends of a set of spatially explicit variables that serve as a proxy of potential climate hazards and capacity to adapt, which together, define vulnerability potentials to climate change.

Extreme climate events, exposures, responses, impacts, determinants of adaptive capacity, climate risks and potential adaptation of different agricultural systems were discussed for each village type. Meanwhile strategies to mitigate negative impacts of extreme climate events were reported at district level. Water, farming systems and marketing of dominant agricultural commodities are used as the main component analyzed in this study to understand exposures and responses of agricultural systems to extreme climate events. Impacts were analyzed at livelihood, commodity and landscape levels.

## KEYWORDS

Village typology, land use change, agricultural-based livelihoods, agroforestry, CaSAVA

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# Integrating local livelihoods in peatland ecological restoration: Case in Central Kalimantan, Indonesia

Integrating local livelihoods into the peatland ecological restoration strategies is expected to enhance local communities' participation in the restoration process. Peatland in Central Kalimantan is currently becoming one of Indonesia's peatland priority areas for restoration. Options of local livelihoods under different contexts of peatland management as framed by Widayati et al. (2016), are used for analyzing each livelihood option, potential and challenge to contribute to the peatland ecological restoration. Enabling factors to integrate local livelihoods in peatland ecological restoration were synthesized from multiple aspects, i.e. remaining tree species in the peatland forested areas, local community preferences on the livelihood options, profitability potential of the livelihood options, peatland degradation level, and policies that related to the community rights in managing peatland areas. The study concludes with recommendations on potential strategies to integrate local livelihoods in peatland ecological restoration.

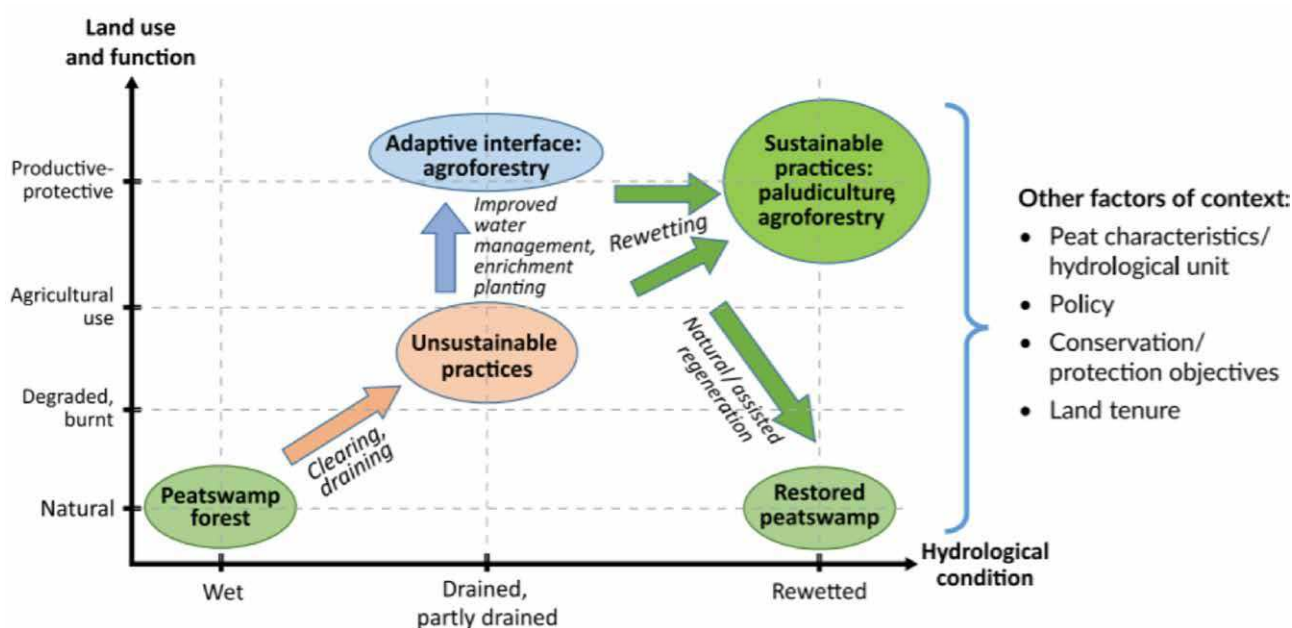


Figure 3.3 Option-by-contexts of peatland management for rehabilitation and restoration (source: Widayati et al. 2016.)

## KEYWORDS

Rewetted, peatland agroforestry, Indonesia

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# Sustainable Lowland Agriculture for Development in Indonesia (SLADI)

Indonesia has the longest coastline in the world. Lowland areas that constitute wetlands of peatland, mangroves and dryland mineral soils in the three largest islands (Sumatra, Kalimantan and Papua) amount to 25% of the total area. The contribution of lowland agriculture to livelihoods and the economy are often marginal if the environmental costs are taken into account. Lowland areas have significant and unique potential to mitigate climate change and also high vulnerability. The national-level governance of lowlands has been complicated and contested.

This study aims to identify options for SLADI. Farming systems, value chains and landscape approaches are interconnected through social–economic–trade–policy–ecological processes. For the farming system, we address the characterization and the options into two stages: (i) broad farming system across diverse resource endowment; and (ii) farming practices of selected commodity species. In 22% of lowland areas, particularly in Sumatra and Kalimantan peatlands, commodity species have been cultivated in unsuitable areas. Commodities have been produced while roads are not available to reach processing and distribution infrastructure in 39% of lowlands. In Papua, 25% of lowland areas have high social risks because of the discrepancy between land demand and land allocation for agriculture. More than 75% of lowland areas in Sumatra and Kalimantan face high environmental risks. The main intervention options are: (i) re-allocation of land; (ii) alignment between agricultural and infrastructure development; and (iii) green investment by partnerships with the private sector.

Farming practices are largely not in accordance with good agricultural practices, mostly due to: (i) planting materials; (ii) on-farm management such as fertilization, etc.; (iii) agroforestry vs monoculture management; (iv) land clearing with fire; and (v) drainage systems on peat. In addition to technology, collective actions around controlled burning and water management are seen to be the best option to combat fire. Agroforestry promotion as the management option to adapt and mitigate climate change should take advice based on evidence from trade-off analysis and on policies to increase awareness and adoption by smallholders.

At the commodity level, most problems are based on: (i) heavy regulation; and (ii) a mismatch between supply and demand in terms of quality, quantity, flow, time and space. In many cases, over-regulation can be counterproductive, depending on the commodities. For the main staple foods with complex market networks, market intervention might be needed, but for timber commodities, reducing transaction costs under trade regulation for smallholder farmers are necessary. Partnerships with the private sector to build smallholder-based processing facilities for some commodities are instrumental.

Lastly, mainstreaming the lowland agriculture into green growth jurisdictional planning and policy is crucial. The integration between spatially explicit land use and infrastructure planning with development planning at jurisdictional level should be bounded by indicators of sustainability to measure progresses. This is timely since Indonesia is preparing its National Action Plan to achieve the SDGs; all provinces have to develop their local action plans. For SDG2 and the interlinked SDGs, specific attention should be paid to lowland ecosystems, given the potentially extreme impacts of the unsustainable management of these ecosystems on the environment, especially in terms of greenhouse gas emissions.

## KEYWORDS

Lowland, agriculture, farming system, landscape approach

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# Community-based land restoration for economic development in degraded drylands of Sumba, Indonesia

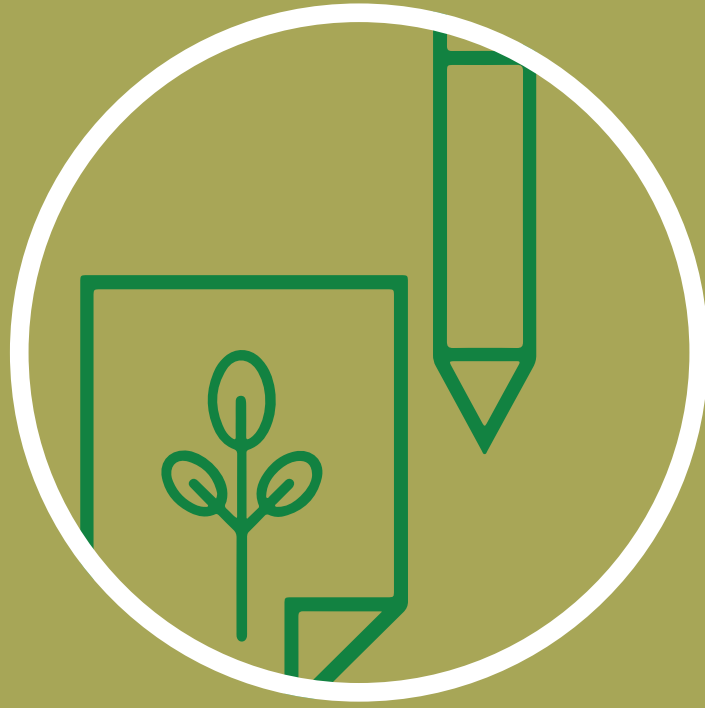
The Haharu landscape of Sumba consists of degraded limestone savannah with remnant hilltop forests and scattered riparian trees in deep gullies. Formerly known as Sandalwood Island, the forest area for sandalwood (*Santalum album*) and 'injuwatu' (*Pleiogynium timorense*) on Sumba declined significantly during the 20th century and was almost entirely lost by the early 2000s. Large-scale timber extraction, repeated clearance and burning of savannah for attempted cultivation, freely grazing livestock, and unsustainable fuelwood harvesting resulted in the almost total degradation of most of the land area. The almost complete absence of trees in the savannahs, combined with limited rainfall, leads to annual water shortages and sub-optimal food production exacerbated by poor soil and water-management practices. Total average household income per year is USD 1205.30, with land ownership being 1–3 ha per household, but nearly a third of all farmland is abandoned; even so, agriculture engages about 92% of households. This makes land restoration and poverty eradication inseparably linked, requiring strengthening capacity of smallholders in agroforestry practices with participatory approaches to economic development. The diverse livelihood strategies of smallholders and local biophysical characteristics are important variables to consider in designing and implementing land restoration through agroforestry practices. Community participation using training of trainers and farmer-to-farmers approaches through tree nursery development, farmer demonstration trials, adoption of marketable trees and crops in agroforestry practices, improved fire management, improved grazing practices, and improved market links has provided lessons learned and guidelines for land restoration activities in Sumba. Centered on the basic tenet that land restoration initiatives will be more successful when partnership is built among smallholders, local governments, and the private sector, when supported with locally appropriate financing schemes and policy enhancement, they will enhance sustainable production, profitability, diversification, ecosystem health and entrepreneurship of agroforestry systems.

## KEYWORDS

Community, land restoration, agroforestry, economic development

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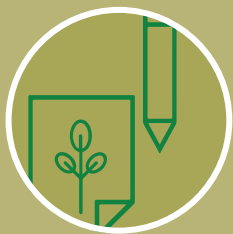
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## **STREAM 4**

Nature-based solutions to address  
the climate crisis





## STREAM 4

### Nature-based solutions to address the climate crisis

The Earth faces a human-made triple crisis of climate, biodiversity, and ecosystems exploited beyond their sustainable boundaries. The planet is likely to not stay below 1.5 or 2.0 degrees Celsius warming unless we undertake unprecedented steps for transformational change. The recent UN Secretary General's Climate Action Summit in September 2019 highlighted how so-called 'nature-based solutions' (NBS) could help contribute to such needed transformational action. NBS are approaches that rely on protecting, restoring and managing ecosystems to solve the climate crisis while creating landscapes that are productive, equitable, and resilient. These include the protection and restoration of forests, mangroves and peatlands, improvements in agricultural land and resource use, the leveraging of the potential of biomass and renewable materials, etc.

This Stream highlighted FTA's NBS solutions, analyzed current trends and barriers, and discussed enabling policies. An NBS framework for policy and action was discussed, as a coherent set of nature-based interventions. The aim of this Stream was to provide practitioners and policy makers with tools to facilitate their efforts for a cooler planet, and to identify areas for further action in research and capacity development.

A framing of NBS for most effective and efficient outcomes was developed, exploring various NBS such as forestry, agroforestry, options for wood production from degraded forests, bamboo, options for water management, and of frameworks such as REDD+, and the policy and practice for better NBS. It also ventured into wood- and bamboo-based products for plastic substitution as well as addressing drivers of deforestation as a pathway to the design of better restoration projects in policy and practice.



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# Framework for NBS in agricultural landscapes

Our planet has reached a state where sustainable, environmentally, economically and socially compatible solutions are urgently needed. Nature-based solutions (NBS) are widely applied in urban and natural forest and wetland ecosystems, but underutilized in agricultural landscapes. Less than 1% of the literature on NBS and green infrastructures (GI) (n>3500 scanned abstracts) concerned rural or agricultural contexts. The success of NBS in Asian agriculture needs to consider that farmers' preferences for sustainable practices are more complex than economic or environmental motives.

Therefore, NBS should be a complementary and people-centered approach, where benefits to people and the environment are considered mutually beneficial. Here, it is defined as: the use of natural processes or elements to, over various temporal and spatial scales, improve ecosystem functions of environments and landscapes affected by agricultural practices, and enhance livelihoods and other social and cultural functions. We present a new technical framework to classify NBS in the agriculture sector. The work draws on a literature review of 188 scientific publications, expert opinions, and a FAO Southeast Asia regional expert consultation (July 2019). The framework is outlined in Figure 1, with four main types of interventions: (1) sustainable practices; (2) green infrastructure; (3) amelioration; and (4) conservation. Critical for achieving substantial impact at scale and over time is planned successions: how to best select and sequence interventions that generate positive biophysical and social benefits in and between agroecosystems, and sustainably expand connectivity of positive interactions. This first attempt at developing a normative framework for NBS in agriculture brings together the conventional divide between production and conservation by bridging urgently needed approaches to restore natural and agroecosystems. Reviewed practices are mapped to the framework, including spatial and temporal scales for anticipated return of benefits, and social implications. Promising models are presented for negotiating and analyzing different farmer- to ecosystem-centered options. Specific recommended next steps for integrating NBS in Asian agriculture are given.

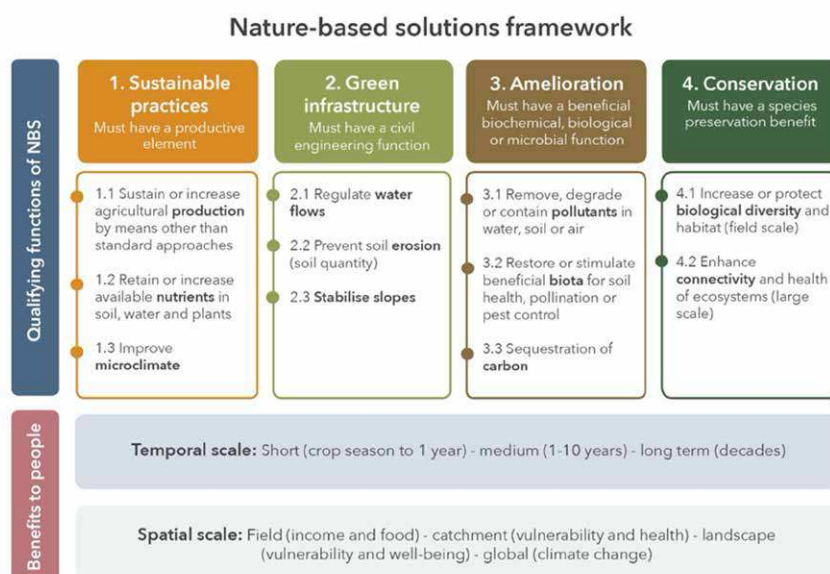


Figure 4.1 Proposed framework for NBS in agricultural landscapes.

## KEYWORDS

Nature-based solutions, green infrastructure, agroforestry, pollution, erosion, agroecosystem

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# A framework for nature-based solutions

The recent IPCC land report (IPCC 2019) points to the urgency and importance of climate change mitigation measures in the land sector – the only sector that can provide ‘negative’ emissions – to keep global warming as much as possible below 2 °C, ideally below 1.5 °C. Developing the deep transformations in how productive landscapes – and ecosystems – are to be sustainably managed is a very ambitious task, given the needed rather short time frame of a decade. Nature-based solutions (NBS) can make a significant impact (Teske 2019); many efforts, initiatives, frameworks and agreements frame the pathways to achieving these emissions reductions and the build-up of carbon sinks. In this context, the Nature-Based Solutions Framework (NBSF) has been developed aiming, to raise ambition, inform national and international transformative agendas, and guide a global paradigm shift towards low-emission and climate-resilient development.

We identify the expected global ambition level for the sector related to the goals of the Paris Agreement, defining the strategic interventions needed to reach this objective at all scales. We are framing the required global contribution of each NBS to reach carbon neutrality in 2050, and then working backwards to establish ‘goalposts’ for 2025 and 2030, aware that ramping up the efforts early will increase the likelihood of achieving the targets. We are carefully considering the impact of anthropogenic interventions on the carbon cycle and on differences between emissions avoidance, reduction and removals, integrating trade-offs and synergies within and between the interventions. Time frames associated with avoided emissions, i.e. reducing and halting deforestation, focus on near-term targets to maximize the immediate mitigation benefit. Time frames for sequestration activities take into account the decades-long time scale for forests and ecosystems to sequester carbon. Different NBS are then prioritized for different periods of time.

The resulting goals break down into spatially and temporally applicable strategies by biomes. They recognize the different actors and finance organizations and the need to address governance, institutional and economic framing conditions. Progress indicators for NBS achievements will be applied both for measuring carbon objectives as well as non-carbon benefits – the latter considered essential to the stability and longevity of sequestered carbon through enhancing ecosystem resilience, conserving biodiversity, and enabling efficient and sustainable development pathways while achieving climate mitigation. These rely on a variety of quantifiable and narrative-based indicators, e.g. measuring socio-economic performance and progress in tenure and other rights (Dooley and Stabinsky 2018), alongside biodiversity and ecological indicators that monitor ecosystem services, watershed and species protection. The overall objective has to be broad and integrative (Soto Golcher and Visseren-Hamakers 2018), in line with the broad and sweeping changes needed to achieve a resilient, sustainable biosphere that sustains biodiversity, functional ecosystems that produce humanity’s needs sustainably and equitably, and that is on a safe trajectory to bring atmospheric carbon down again to levels compatible with life on the planet.

## KEYWORDS

Climate change, land use, forests, mitigation, adaptation, 1.5 degree world

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# The politics of refusal in REDD+ policy and initiatives

For participating REDD+ countries, many questions remain on how to effectively, efficiently and equitably formulate and implement REDD+. Drivers of deforestation and degradation are often highly complex and can form part of dense networks of economic and political interests. Reducing emissions by preventing degradation and deforestation can be seen as a controversial approach in the context of national development paradigms and existing policy frameworks or objectives. What are the political implications of a REDD+ mechanism? How could it be implemented successfully on the ground? Understanding the complex relationships between drivers, agents and institutions within the national context is vital to ensuring effective implementation of REDD+. This presentation focuses on the power and politics of REDD+ in national policy arenas in Vietnam, Indonesia, Myanmar, Guyana, Peru, Brazil, Ethiopia and DRC. Our aim is to identify opportunities for and potential barriers to preventing deforestation and forest degradation, in relation to governance, institutions and the political economy of forests in national REDD+ policy arenas. In particular, we investigate how barriers can be addressed through policy design and implementation and discuss lessons learnt from 10 years' implementation of REDD+ in these eight countries. The presentation is based on longitudinal data and analysis of the Global Comparative Study on REDD+ (GCS-REDD+) which has been implemented by CIFOR since 2009.

## KEYWORDS

REDD+, policies, politics, powers, transformational change

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# Nature-based solutions require adaptive capacity: A case study of the climate vulnerability of Asian tree species

Nature-based solutions to climate change, including conservation and restoration of forests, are expected to contribute to mitigation, adaptation and resilience in socio-ecological landscapes. These terms are not new in climate discourse, yet from a biological perspective they continue to be used vaguely and in ways that do not help design effective climate solutions. Mitigation of climate change through tree-based carbon sequestration in biomass growth can be sustained only if there is sufficient genetic diversity both within and among species to adapt to the rapidly changing environment. Concrete strategies to conserve and enhance forest tree genetic diversity and adaptive capacity as a foundation of mitigation and resilience are widely lacking in currently proposed nature-based solutions. We modeled current and future distributions of 65 native Asian tree species, selected through transnational participatory stakeholder workshops across 15 Asian countries, and evaluated information on environmental variation across the species' geographical ranges. We demonstrate that in the next 30 years, two-thirds of the species will be losing natural habitats in parts of their range due to climate change. On average, the species are severely threatened by climate change in 10% ( $\pm 20$  SD) of their range, and at least moderately threatened in 22% ( $\pm 20$  SD) of their range. The predicted vulnerability to climate change varies widely between species, indicating broad shifts in species compositions. Ecologically and commercially important dipterocarp species are among the most affected species, predicted to lose more than 20% of suitable habitats by 2050 under the plausible high emission pathway (RCP8.5). Loss of habitats exacerbates the loss of genetic diversity, which in turn makes restoring resilient ecosystems increasingly difficult, as suitably adapted germplasm for specific site conditions is no longer available. Current multi-billion dollar investments in forest and landscape restoration are at serious risk of failing unless efforts to enhance the adaptive capacity of tree populations are made an integral part of the planning, implementation and monitoring of restoration projects.

## KEYWORDS

Forest and landscape restoration, mitigation, adaptive capacity, genetic diversity

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# Bamboo's potential to substitute for plastic

Plastics pollution and its health risks to human beings is an increasing concern globally. In 2018, the world's production of plastics reached 359 million metric tons (Statista n.d.). Packaging (39.7%) and buildings & construction (19.8%) are the dominant sectors that drive the demand of global plastics production (PlasticsEurope 2018). The manufacturing and processing of plastics is quite energy intensive, with resins requiring 62–108 MJ/kg of energy; that is much higher than for paper, wood, glass or metals. It also may account for as much as 20% of petroleum consumed globally and 15% of the annual carbon emissions budget by year 2050 (World Economic Forum 2016). However, the recycling rate of plastic products is only 7% globally, 9% in the US (EPA 2020). Due to its very short lifetime, packaging is the largest contributor to plastic waste, accounting for 42% of the total. A recent prediction study implies that investment in waste management infrastructure in developing economies and reducing the fraction of plastics in municipal solid waste will significantly reduce the growth of plastic waste (Lebreton and Andrady 2019).

Bamboo serves as an important part of nature-based solutions and bio-based economy development. Known as 'green gold', bamboos cover over 30 million hectares of land across the tropics and subtropics, and have been proven to help combat a number of global challenges, including rural poverty, land degradation, deforestation, urban development, unsustainable resource use and climate change. The versatile uses and bio-properties of bamboo make it an important part of low-carbon and recyclable alternatives to those with high carbon emissions.

This paper introduces the emerging transitions, with bamboo to substitute for plastic in a wide range of consumption options, and discusses the market potential of bamboo that substitutes for plastic to mitigate the carbon emissions and save the environment.

## KEYWORDS

Bamboo, nature-based solutions, plastic, carbon emission

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## Why do countries need an agroforestry policy?

In 2014, India approved a national agroforestry policy to resolve such bottlenecks as the prohibition of felling and transport of agroforestry species (ICRAF 2016). In its sixth year of implementation, the policy has been effective in freeing: a total of up to 86 farm-grown tree species in 25 Indian states; upgrading a national research center on agroforestry; and establishing the National Sub-Mission on Agroforestry, and the National Bamboo Mission with a budget of USD 146 and 197 million, respectively. ICRAF South Asia contributed to the development of the policy, and now serves as a member of the inter-ministerial committee that oversees the policy implementation, and supports the implementation of the agroforestry mission. The policy has been instrumental in channelizing large investments through state governments and corporate social responsibility funding. India's finance commission has invested \$9.0 billion to encourage states to increase their green cover. More than 60 to 70% of the timber requirement of India is sourced through trees outside forests, including agroforestry which is valued to about \$16 to 20 billion/year. India's green cover has increased by 1.8% during 2015 to 2019, out of which 86% is credited to trees outside forests, including agroforestry.

Globally, Nepal became the second country to approve and launch its national agroforestry policy during 2019. ICRAF-South Asia was the main technical partner and the only non-governmental organization serving the Inter-Ministerial Coordination Committee, which oversaw the policy development. The process was financially supported by the Climate Technology Center and Network (CTCN), FTA and ICRAF South Asia Program.

Member countries of the South Asia Association for Regional Cooperation (SAARC) are working with ICRAF to implement a regional agroforestry program, including policy/strategy development in Afghanistan, Bangladesh, Bhutan, India, Pakistan, Maldives, Nepal and Sri Lanka. ICRAF-South East Asia program with partners in ASEAN countries successfully launched the ASEAN Guidelines on Agroforestry Development (2018); and Rwanda, with assistance from ICRAF, released its National Agroforestry Strategy and Action Plan (2018) for 2018–2027. In addition, countries such as Bangladesh, Belize, Brazil, China, Fiji, France, Guatemala, Kenya and Niger are working on agroforestry strategic plans, strategies, or a policies.

This paper will discuss how agroforestry policies and strategies are catalyzing transformational adaptation of agroforestry leading to economic, social and environmental benefits; and why countries should examine the need for having their own agroforestry policy.

## KEYWORDS

**Agroforestry policy, farm-grown tree species, green cover, deregulated species, trees outside forest**

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# Enhancing the role of area exclosures to build resilience of socio-ecological systems to climate variability and change: A case study from Kalu district, Amhara region

Land degradation and climate-induced shocks and stresses affect the socio-ecological systems of Kalu district. The district is recognized as one of the chronic food insecure and drought-affected areas in Ethiopia. Hence, natural resources management activities including area exclosure are widely practiced in the area to address problems associated with these two pressing factors. Even if area exclosure offers enormous environmental benefits, the knowledge on its role in building socio-ecological systems resilience is limited. This requires us to investigate the roles of and exclosures and their links with building resilience and understanding community perceptions of these roles. It further requires us to know the trends and variability of rainfall and temperature in the area and how they affect the system. The study area was purposively selected and multistage stratified random sampling techniques were employed to identify sample households. Both qualitative and quantitative data were used. Quantitative data were collected mainly through a household survey administered to 346 randomly selected households. A complementary focus group discussion and key informant interviews were also performed. Non-parametric statistical tests were employed to analyze the long-term climate trend and its magnitude; and descriptive statistics including Chi-square test of independence and goodness of fit test were employed to analyze survey data. SPSS v20, Stata v13 and XLSTAT were used for analyzing both climate and survey data. The results indicated that the area received a mean annual rainfall of 1017.9 mm and was characterized by non-significant declining annual and seasonal rainfall trends, low annual rainfall variability ( $CV < 20\%$ ), moderate to higher seasonal and monthly rainfall variability ( $CV > 20\%$ ), high mean precipitation concentration ( $PCI = 16.6$ ) and increasing trend of negative rainfall anomalies ( $SRA < 0$ ). Significant warming trends of annual and seasonal temperatures ( $p\text{-value} < 0.0001$ ) were observed with a mean temperature of  $19.5^\circ\text{C}$ . These imply the existence of both flood risks and loss of available moisture via evaporation that affect the resilience of socio-ecological systems. Test results revealed that exclosure has allowed restoration of degraded lands and significantly contributed to the resilience of social and ecological systems ( $p = 0.000$ ). Almost all respondents showed positive attitudes towards exclosure practice and perceived its contribution to their resilience building. The link of exclosure with resilience is found mainly through increasing availability of environmental resources needed to enhance the adaptive capacity of both systems and by reducing risks induced from climate-related disasters. In conclusion, exclosures have shown a promising potential contribution in restoring degraded landscapes as well as building resilience to prevail against the negative impacts of climate change and variability. Moreover, in order to sustain the practice and better benefit the community, its scaling up requires giving due emphasis to improving management practices, economic returns, social supports in protecting benefits of female and poor households, and other emerging issues.

## KEYWORDS

Area exclosure, climate change and variability, resilience, restoration, shock, socio-ecological, stress

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## The potential of mixed plantations: Lessons from Latin America

Interest in mixed plantations as reforestation schemes for commercial and restoration purposes is becoming widespread, yet overall outcomes are scarce and poorly documented. In this study, I reviewed and synthesized the state of the art on mixed plantations in Latin America and their potential role in landscape restoration and as a novel production system. This was based on a systematic review of the literature from 2004 to mid-2019 (inclusive); 140 potentially relevant articles were retrieved, 49 of which were selected for further critical analysis. Most of the studies were carried out in Brazil, Panama or Costa Rica. The majority of the evidence comes from research plots and some from NGO-led reforestation projects.

Many of the studies were focused on evaluating growth performance (survival, growth in height and diameter, plot productivity), site/species selection (types of mix) and silvicultural management of mixed stands. Fewer published studies researched about physiological performance and conservation value (biodiversity) of the mixture at either plot or landscape level. Based on the review, trends in growth productivity for local-native species were identified and specific management practices aimed at increasing survival rates of the planted species were documented.

Overall, mixed plantations were also considered among the effective and available approaches to recover degraded land (pastureland) or facilitate forest-dependent species regrowth in agricultural landscapes. We recommend extending the review of policies and incentives available to promote diverse plantation schemes to better achieve production, restoration and conservation goals across Latin America.

**KEYWORDS**

Mixed plantations, diversification, restoration practices, novel systems, growth performance

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# Establishment of rattan plantations

Rattans are spiny climbing palms that belong to subfamily Calamoideae of the palm family. Rattans are important components of the forests where they are present and are indicators of the integrity of the ecosystem when present in adequate numbers, indicating regeneration. Rattans have been collected as an important non-wood forest product from forests from time immemorial and the extent of harvesting was until recent times sustainable, since adequate natural regeneration occurred. It is becoming increasingly clear that most rattan resources in the world are already under threat due to unsustainable harvesting practices and the clearing of forests, leading to loss of germplasm and even the threat of extinction of some species. This state of affairs has resulted from the absence of inventories of rattan resources and overexploitation due to cutting permissions being given based on demand rather than on an assessment of sustainable harvesting levels.

Rattan world trade was to the tune of USD 27 million for rattan raw materials and USD 177 million for transformed products and there has been a decline over the past decade (INBAR 2018). It is estimated that approximately 20% of all rattan species are used commercially in the furniture industry or for matting and basketry, and in the 1970s Indonesia was the supplier of about 90% of the world's requirements of rattan (Dransfield and Manokaran 1994).

Since rattans contribute substantially to the livelihood and economic status of the local communities in many countries of the world, it is important to establish plantations of rattan and ensure sustainable availability and sufficient economic returns. Although there have been a number of studies undertaken on rattan systematics, propagation techniques and plantations, it is important to gather the pertinent information into a document that would serve those who are interested in establishing economically viable rattan plantations so as to sustain the raw material production and the industry that supports the livelihoods of a significant number of people.

Globally, rattans supply for the furniture and handicraft industry mainly depends on the resources from secondary and virgin forests. Deforestation, overexploitation and habitat modification caused the dwindling supply of raw rattans for the furniture industry and most of the rattan industries are in a phase of setback. The only way to overcome this issue is to ensure identification of commercially important species, establishing high-quality plantations and ensuring continuous supply of high-quality rattan poles. This in turn will help the uplift of the socio-economic status of communities engaged in rattan production, processing and trade. In addition, since rattans need support trees for their growth and development, establishment of rattan plantations will definitely contribute to the care, protection and conservation of trees as well as the improvement of ecosystem services.

## KEYWORDS

Rattan, plantations, livelihood, forest, ecosystems

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# Climate change mitigation potential of implementing sustainable management for bamboo forests in Kenya

The bamboo sector can significantly contribute to climate change mitigation because bamboo is one of the fastest growing plants in the world and a substantial amount of carbon can be stored in bamboo forests and bamboo products. *Oldeania alpina* is the indigenous bamboo species in Kenya, occupying about 133,273 ha. The study aimed at understanding the climate change mitigation potential of implementing sustainable management for bamboo forests in Kenya. The species plays a critical role in the regulation of water flow, soil erosion control, socio-economic development, biodiversity conservation, provision of ecosystem services and improved local livelihoods. Data were collected in 43 randomly selected plots, in natural unmanaged bamboo forests, in four ecosystems: Mt. Kenya, Mt. Elgon, and the Mau and Aberdare ranges. The data were collected in accordance with the protocol developed and approved by Kenya Forest Service (KFS) and Kenya Forestry Research Institute (KEFRI), Department of Resource Surveys and Remote Sensing (DRSRS), University of Eldoret (UoE) and Natural Resources Institute Finland (Luke). The results show that aboveground carbon stock in Kenya varies ranging from 20.6 to 45.4 tonnes ha<sup>-1</sup>. Total aboveground carbon stored in bamboo forests is 4,899,699 tonnes of carbon. It is estimated that under sustainable bamboo forest management, annual aboveground carbon stock removal is 6.2 to 13.6 tonnes ha<sup>-1</sup>. If this carbon is locked in durable products, the total carbon locked in durable products over a period of 30 years is 37 million tonnes of carbon. It is recommended that the bamboo forests should annually or biannually be harvested and utilized as biomass energy or other suitable products to make use of its capacity for climate change mitigation and furthermore to reduce fire risks in the forests.

## KEYWORDS

Bamboo, climate change, carbon stock

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# Sustainable tree crop plantation planning in East Kalimantan, Indonesia

Berau District in East Kalimantan Province is a forested district with significant forest remnants in Borneo. Within the past decades, Berau District has experienced tremendous changes in land uses to meet the needs for economic development. Nowadays, the rapidly increasing area of monoculture palm oil amount to 10% of the total area of Berau District. Considering the environmental and social problems of having only one commodity species as an option, this study, at the request of the local government, focuses on finding alternative commodities to oil palm to be developed in the area. In particular, we focus on rubber, coconut, cocoa and pepper because these are the mainstay commodities listed in the Berau District planning document.

The study aims to: (i) characterize the land use changes in Berau during the past three decades; (ii) understand the drivers of land use changes to the five main commodities; and (iii) design options for commodity planning based on land suitability and preferences of local farmers. We combine technical analysis and modeling with a participatory approach.

We identified 65 types with the underlying causes of land changes currently based on economic factors. Based on that condition and through local sectoral participation, sustainable plantation planning can be prepared, which is expected to determine commodity products that meet the conditions of natural resources and provide proper economic development. Analysis of the research data was done using ALUCT, LUMENS and WANULCAS. The study, in order to identify plantation contexts, overlays several environmental datasets and plans that have been determined inclusively based on the needs of estate planning. The data used land cover, biophysical, socio-economic and policy aspects.

During 1990–2018, forest degradation affected more than 20% of the Berau District, and the source of plantation area changes of 8% came from logged-over forest. This condition can confirm that the pressure of land use changes on forests is quite tremendous. This study analyzes land suitability. The results show that the actual land suitability for pepper and coconut are in the suitable class, while the majority of palm oil, rubber and cocoa are in the marginal class. Even so, the palm oil commodity uses by far the largest plantation area in Berau.

This is due to good market trends and the support of several policies from local governments that have brought in many palm oil investors. The intervention area will provide a reference for the location and intervention options for plantation planning by adopting Good Agriculture Practice (GAP). GAP needs to be applied to overcome various major commodity productivity problems in Berau District. This improvement is aimed at various limiting factors that affect productivity, as explained earlier, namely genetic factors, biophysical environment, management and social culture. Analysis of future productivity and profitability with good agricultural practices is carried out by establishing assumptions of improvements that can be made to the limiting factors of productivity. Pepper, cocoa and palm oil are potential commodities because they have a high profitability value, whereas rubber and coconut commodities are quite vulnerable if they are farmed with additional agricultural inputs.

## KEYWORDS

Sustainable plantation, context, intervention, productivity, commodity

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# Bamboo-based feeding alternatives for tropical cattle farming: A case study in Colombia

In tropical areas, cattle farming has increased considerably during recent years. Therefore, grassland is one of the largest land uses and occupies important areas in tropical countries. These systems have been established instead of traditional land uses and even an important portion of forest area has been eliminated to establish pastures. This situation is one of the causes of land degradation and loss of ecosystem services (ES), and cattle farming is currently considered an important source of greenhouse gases. In order to promote alternatives for better cattle farming, different strategies have been employed to mitigate the abovementioned negative conditions. The use of new sources of feed is one strategy to optimize cattle systems, especially when species used have a better nutritional quality and are capable of providing other ES. In this sense, the introduction of woody species can be adequate because they can provide both feeding and ecological benefits. Bamboo species are widely distributed in the tropics and can provide alternatives for feeding in cattle farming systems. In this study we assessed the potential of nine bamboo species to provide forage to be used for ruminant feeding. The bamboo species included were: 1) *Bambusa heterostachya*, 2) *Bambusa longispiculata*, 3) *Bambusa multiplex*, 4) *Bambusa vulgaris*, 5) *Gigantochloa apus*, 6) *Guadua angustifolia*, 7) *Oateia acuminata*, 8) *Phyllostachys aurea*, and 9) *Schizostachyum brachycladum*. A proximate analysis and in vitro digestibility were conducted and then three bamboo species were selected for assessing palatability. The proximate analysis, in vitro digestibility and the facility for collecting forage, were criteria for selecting species for a palatability evaluation. The palatability assessment was carried out in a trial where a daily complement of bamboo leaves was offered during a week to five cows (weight of 225 kg each). The cows were freely grazing in a pasture during the time of the trial. The bamboo leaves were placed into troughs with three replicates per species. Troughs were strategically located in the trial area. After the proximate and digestibility analysis, three species (5, 6 and 8) showed the best qualities (e.g. in vitro digestibility over 50% and crude protein around 15%) with values comparable to other woody species used in silvopastoral systems. The palatability trial showed a low acceptance of animals for the three bamboo species. Probably, the abundance of grass and also the fact that bamboo leaves were offered pure, without any additional supplement that would increase the costs associated with this alternative, were factors influencing the low consumption by the animals. Bamboo species are grasses and therefore may be easily adapted for being integrated to pastures. In addition, they grow fast and might be managed to be browsed directly by animals. These results showed the potential for new feeding resources for better cattle farming with some advantages of bamboo species over traditional woody species used in silvopastoral systems, related to adaptability and fast growth. However, it is probable that it works better for those areas with scarce feeding resources, where animals have less feed on offer.

## KEYWORDS

Proximate analysis, in vitro digestibility, cattle, palatability, woody species

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# Assessing the impacts of on-farm land restoration practices on gender roles and relations in the drylands of Kenya: Risks and opportunities for gender equality

Land restoration, defined as activities that reinstate ecosystem functionality and increase the productivity of degraded lands, has the potential to not only help mitigate climate change through biosequestration, but improve the well-being and livelihoods of billions of people around the world (UNCCD Secretariat 2012). Yet, despite this potential, not all may benefit or do so to the same extent. Given different roles and responsibilities and access to and control of resources, gender is one dimension along which the costs and benefits of restoration are likely to be differentiated (Collantes et al. 2018). With unprecedented global commitment to land restoration (e.g. Bonn Challenge, AFR100, SDG 15), it is critical to understand the implications of different restorative practices on men and women's time and labor and their access to the benefits of restoration, to ensure both social and environmental outcomes are achieved. Within the context of a donor-funded restoration initiative that involved over 1500 farmers in the eastern drylands of Kenya, this study used mix methods to explore the implications of two on-farm restoration technologies (tree planting and planting basins) and the way in which they were disseminated, for women's time, labor and involvement in farming decisions. Our findings suggest both conflictual and collaborative aspects of gender relations may influence labor allocation and decision-making power within the household, and that on-farm land restoration practices present both risks and opportunities for gender equality in terms of distribution of workloads and agency over farming activities. For example, while planting basins may increase women's involvement in land preparation activities and thus workload, they reduce time spent weeding and may increase women's autonomy over the timing of land preparation. Cultural norms over women taking part in strenuous labor may hinder the uptake of restorative practices such as basins and tree planting, but these norms are changing, in part, due to women's increased participation in agricultural training sessions and the absence of men on farms. Women's increased access to knowledge and information also relates to an increased involvement in farming decisions and ability to try new practices, especially when these practices prove to be productive. However, limitations for women's participation persist depending on the type of decisions and the resources required to act. These findings highlight that socio-cultural context matters for land restoration, not just the biophysical, and that the design and dissemination of such nature-based solutions need to consider gender roles and intra-household dynamics, and the wider socio-economic context within which restoration is occurring.

## KEYWORDS

Gender dynamics, land restoration, agroecosystems, decision-making, labor

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# Ecosystem-based adaptation options as nature-based solutions to climate change and variability: Practical insights

The drylands of Africa are being affected significantly by climate change and variability. The impact is being felt at different levels even among countries depending on the resources available (assets, capacity and infrastructure) to adapt to the consequences. The Gambia is one such country being affected severely. In this presentation, we delve into the overall framing of Ecosystem-based adaptation (EbA) and what it takes to implement EbA options under constraining social, environmental and governance contexts. The key social challenge in this case is whether the EbA options could be acceptable to the community and its intrinsic rules and by-laws, which govern the way of life of the members of the community. This also includes gender-based resource allocation and representation and seasonal migration. The environmental challenges involve the state of the natural resources, i.e. level of degradation, moisture availability for proper functioning of the ecosystems, fire (particularly bushfires), free-roaming domestic animals and seed and seedling sources for the species that could perform well in current and future climatic conditions. Governance challenges are mostly addressing issues of land rights (tenure), market access, access to production inputs and institutional collaboration among those departments having key stakes in implementing EbA options. Addressing such challenges requires:

- 1) knowing what options fit in which context both in the current state and future scenario;
- 2) designing EbA options using a bottom-up process;
- 3) aligning with long-term national goals and targets;
- 4) providing information and communication on climate information; and
- 5) empowering and building the capacity of communities and local actors.

## KEYWORDS

Energy, ecosystem, population, Africa, restoration

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# Evaluating the impacts of different types of REDD+ interventions on forests and people

Since its inception over 10 years ago, REDD+ (Reducing Emissions from Deforestation and forest Degradation plus enhancing carbon stocks) has been piloted through more than 300 subnational initiatives across the tropics. Initiative implementers are applying REDD+ intervention packages that in customized ways combine disincentives (e.g. restrictions on forest access or conversion) and incentives (conditional or non-conditional) to allegedly achieve better protection of forests. Through CIFOR's Global Comparative Study on REDD+, we evaluated the forest conservation and community well-being impacts of 22 subnational REDD+ initiatives in Brazil, Peru, Cameroon, Tanzania, Indonesia and Vietnam. We combined socioeconomic surveys in 150 communities and nearly 4000 households (including control groups) in 2010–2012 (pre-intervention) and 2013–2014 (post-intervention), with an analysis of global forest change data (2000–2015), to assess how different interventions affected changes in income, assets, perceived well-being and forest cover at the community level. We found a reduction in forest cover loss at half of the REDD+ sites, with better conservation outcomes in places where there was higher treatment intensity of disincentives. Both intervention types had neutral impacts on income and assets, but higher exposure to disincentives led to decreases in overall perceived well-being, except when balanced out by incentives. Although disincentives may be an effective REDD+ instrument for conserving forests, other measures are clearly needed to safeguard and enhance community well-being. This critically needed empirical evidence on REDD+ performance on the ground is relevant to policy makers and practitioners interested in developing REDD+ strategies that can provide both conservation and livelihood benefits.

## KEYWORDS

Climate change mitigation, conservation, livelihoods, impact evaluation

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# Climate change from the margin: Intersecting inequities in adaptation to climate change in the West African Sahel

People and species living in drylands have adapted over millennia to cope with extreme climatic variability. Diverse human populations in the drylands have created behavioral dynamics and social relations that enable reciprocity and mutual responsibility to use highly variable resources. For instance, mobility is a complex socio-ecological mechanism that relies on highly fine-tuned rules and norms to build the strategic exploitation of sporadic water and pastoral resources in an ecosystem characterized by high spatial and temporal climate variability. It allows different social groups to mutually manage and share resources through long-term traditional, negotiated tenure agreements, rights and responsibilities. Mobility is rooted in a broader governance system, and it is central to the identity of mobile pastoralists. While considerable attention and resources have been made available for the humid tropical forests, there has been a lack of comparable sustained attention on drylands. Local knowledge systems in drylands, the adaptive alliances woven through the coexistences of multiple identities and visions to manage and negotiate the landscape and the future are precious human experiences and knowledge systems, yet they sit on the periphery of the climate change agenda. Furthermore, within and outside the drylands, the repertoire of marginalization in the climate change debate includes those of major groups without social power: women, pastoralists and poor farmers.

Taking deliberately an opposite approach – focusing on climate change from the margin – this presentation will use case studies from the West African Sahel to illustrate the profound socio-ecological interactions and environmental and sociological shift happening within drylands systems.

The analytical approach used in the case studies aligns with theories on gender and climate change to include social differentiation. It relies on intersectionality as a tool to bring together existing concepts (e.g. vulnerability, adaptive capacity) to critically assess and enrich both common climate change and gender debates and theories. Using an intersectionality approach unveils emancipatory pathways and challenges the dominating narratives on vulnerability research. Through the examination of the intersecting factors and conditions by which power is not only produced and reproduced but also actively resisted, intersectionality calls for a more complex approach to address the system that creates power differentials, rather than the symptoms of it.

## KEYWORDS

Adaptation, Sahel, gender, drylands

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# Carbon sequestration and carbon emissions reduction through bamboo forests and products

Because of their fast growth rates, giant woody bamboos are already considered effective CO<sub>2</sub> absorbers. Carbon can be further sequestered in durable harvested bamboo products and even higher carbon emissions reductions are possible if bamboo products replace non-renewable, carbon-intensive alternatives.

Research so far on the total carbon sequestration and carbon emissions reduction potential of woody bamboos is scattered and diffuse. This paper provides an overview of existing peer-reviewed scientific literature on bamboo carbon sequestration and carbon emissions reduction potential from forests and through bamboo products.

The results show that, in general, bamboo has a lower total ecosystem carbon (TEC) (94–392 tonnes of carbon per hectare [tC/ha]) than natural forests (126–699 tC/ha), but a similar TEC to tree plantations (85–429 tC/ha). However, if the carbon stored in harvested bamboo products is included in calculations, the carbon emissions reduction potential of a managed giant bamboo species forest such as *Phyllostachys pubescens* (Moso) can be significantly higher than for a Chinese fir (335 tC/ha versus 253 tC/ha) growing under the same conditions.

Although dependent on the bamboo species, in the case of Moso bamboo, the combined carbon sequestration and carbon emissions reduction potential of reforesting degraded grassland with bamboo could reach 213.9–395.2 tC/ha of reforested land, or around 785–1450 tons CO<sub>2</sub>. The situation is reversed if the bamboo plantation is not managed, which relates to a combined carbon sequestration and carbon emissions reduction potential of only 49.5 tC/ha for unmanaged Moso bamboo, which shows the importance of bringing bamboo forests under management.

To arrive at more robust conclusions, additional research is required, including studies on the influence of various growth factors.

## KEYWORDS

**Bamboo, carbon sequestration, carbon emissions reduction, product displacement, durable products pool**

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# Scalable solutions for carbon neutrality in woodfuel systems in sub-Saharan Africa

Why woodfuel and climate change? A third of the world's population rely on solid biomass for cooking and heating using traditional cooking appliances. Other users are small–medium businesses. Unsustainable harvesting of wood and inefficient processing techniques contribute to deforestation and greenhouse gas emissions. Inefficient practices along the life cycle are estimated to result in 6–9 kg of CO<sub>2</sub>eq per kg of charcoal produced. There are opportunities for solid biomass to provide renewable energy while mitigating negative climate impact. We will present proven solutions to affordable, cleaner and carbon-neutral cooking bioenergy that also enhances food security.

Firstly, sustainable wood sourcing reduces emissions substantially and can contribute to net carbon sequestration. Management of ecosystems of natural and invasive woody species and tree-based agroecosystems can increase the sustainable supply of biomass for woodfuel while enhancing other ecosystem services. *Acacia drepanolobium* yielded 18 Mg/ha of wood suitable for charcoal in Kenya in a 24-year rotation. Yield and rotational periods could be improved with low-cost farmer-managed natural regeneration where coppices are allowed to grow into trees for woodfuel and other products. In Tanzania, leguminous *Gliricidia sepium* intercropped with maize yielded 1.3 Mg/ha of wood in 2 years, with additional benefits of nitrogen fixing subsequently enhancing crop yields and access to fodder. In the Democratic Republic of Congo, rotational woodlots of *Acacia auriculiformis* produced 145 Mg/ha of woodfuel over a 10-year period, while contributing to soil fertility for crop production. Secondly, estimates show that use of highly efficient kilns can reduce GHG emissions from charcoal production by 80%. We are improving access to affordable and more efficient wood–charcoal technologies, while assessing impacts on emissions, charcoal yields, user needs and preferences. Thirdly, shifting to highly efficient cookstoves can reduce GHG emissions by 63%. We are integrating cleaner cooking in local communities through use of efficient stoves that reduce fuel use by 20–60% and indoor air concentration of pollutants by 40–97%. Successful utilization of 100 million improved stoves by households in developing countries could reduce emissions from woodfuel by 11–17%. Fourthly, a circular bioeconomy promotes energy recovery, pollution and waste reduction and carbon sequestration. Woody residues are processed into affordable and cleaner cooking fuel briquettes, while biochar is produced from charcoal waste and charred woody residues using household micro-gasifier stoves, drum kilns and Kon Tiki kilns. Application of biochar at rates of 1–10 Mg/ha for maize (*Zea mays*) and kale (*Brassica oleracea*) resulted in increased yields from 0.9 to 4.4 Mg/ha and by 33%, respectively, in rural Kenya. With sustainably produced and processed biomass, burying carbon in the soil results in negative CO<sub>2</sub> emissions (sink). Successful woodfuel climate action depends on use of efficient technologies, existence of good governance and enabling policies that incentivize compliance to sustainability and facilitates competitive value chains. Adoption of the technologies is still low due to cost, skills and labor requirements and most importantly failure to fit well into local techniques and meet people's needs. We recommend application of social, economic and environmental/climate indicators in assessing woodfuel sustainability.

## KEYWORDS

Sustainable woodfuel, negative carbon impact, enabling policy

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# Biochar production and use provides multiple benefits for smallholder agroecosystems

The majority of households in rural Kenya use firewood in open fires for cooking and heating and there is growth in the use of charcoal. These cooking systems are associated with negative impacts on health and the environment. One novel nature-based solution to address some of the challenges is the biochar-producing microgasification cookstove that can improve energy efficiency, women's burdens and health, agricultural production and climate change mitigation. This innovative cooking system provides an opportunity to reduce fuel consumption, reduce the indoor air pollution in the cooking area, thereby improving well-being especially of women and children, and when added to soil, the biochar produced while cooking sequesters carbon and increases agricultural yields. This win-win-win technology has been developed and tested in transdisciplinary research co-learning and co-designing through a participatory approach with locally adapted communication products and tailor-made training sessions at grassroots level. Through our research, these improvements have been proven under field conditions in three sites located in a coastal region, a highland area and a lowland area in Kenya. This research has involved 150 farming households that produce biochar in locally manufactured GASTOV Top-lit Updraft (TLUD) gasifier cookstoves and use the biochar in their own fields. Fuel use, indoor concentrations of carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and fine particulate matter (PM<sub>2.5</sub>) in cooking areas, and biochar production potential was measured in 75 households during cooking of a meal of the household choice. The produced biochar was used in farmer-managed field trials with maize (*Zea mays*) and kale (*Brassica oleracea*) comparing biochar to normal farming practices. Cooking a meal, on average saved 18% of fuel compared with the three-stone open fire. In addition, 200 g biochar was produced, which corresponded to 17% of the biomass used. Concentrations of CO, CO<sub>2</sub> and PM<sub>2.5</sub> were reduced by 73%, 30% and 90%, respectively (Gitau et al. forthcoming). A large proportion of fuel was from pruning of agroforestry trees and about 40% of farmers in the coast and highland exclusively sourced their firewood from trees on farm (Gitau et al. 2019; Njenga et al. 2019). The trees pruned for firewood included fruit trees, timber trees, medicinal trees and other commercial crops such as coffee, tea and macadamia nuts. Growing trees on boundaries and for shading coffee and tea were the main agroforestry systems. Yield increases of maize were significant and correlated positively with biochar dose (Sundberg et al. In press). Cooking with firewood in the gasifier+using the charcoal produced as fuel and using the gasifier+using the charcoal produced as biochar reduced the climate impact in carbon dioxide equivalents (CO<sub>2</sub>e) by 69% and resulted in negative emissions of -695 kg CO<sub>2</sub>e per household per year, respectively. Biochar systems in rural Africa can thus contribute to climate change mitigation through carbon sequestration and reduced fuel use. Biochar technology can help to solve the problems of energy and food insecurity while enhancing the ecosystems services of rural agroecosystems. For enhanced impact, there is a need for going to scale through effective communication and stakeholder engagement processes.

## KEYWORDS

Biochar, cooking, emissions, fuel, women

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# Operationalizing nature-based solutions through forestry and agroforestry

“Nature-based solutions” (NBS) are being increasingly promoted to address climate change and other societal challenges. They are defined as actions that use ecosystems to help societies address a variety of environmental, social and economic challenges in sustainable ways. NBS are explicitly considered as alternatives to human-made infrastructure and integrate conservation and protection of biodiversity as a basis or a goal. Three main types of NBS have been identified: making better use of existing natural or protected ecosystems, developing sustainable management protocols and procedures for managed or restored ecosystems, and creating new ecosystems. However, most NBS projects relate more to conservation or to the creation of new ecosystems than to improving managed ones.

The purpose of this poster is to apply the concept to managed ecosystems, focusing on forestry and agroforestry, and to analyze decision-making processes at play in order to propose an operational framework to provide NBS through forests and trees. Managed ecosystems are already managed for a purpose, or several, making the integration of a new objective more complex. We propose here to consider NBS as a binding concept between ecosystem managers and other stakeholders, including policy makers: a simple alternative solution to human infrastructure to be implemented by ecosystem managers through options integrated in the broader perspective of sustainable forest management and landscape approaches, thanks to an appropriate enabling environment. Such a definition invites us to clearly distinguish two groups of actors: decision makers and the various stakeholders in need of an NBS on the one hand, ecosystem managers that will implement it on the other hand; with two levels of governance: a dialogue between these two categories and an evidence-based and inclusive process to fine tune implementation options that inform it (see Figure 1).

The construction of an NBS can be summarized in four steps: (1) identification of an external need or demand; (2) proposal of an NBS by ecosystem managers, often with conditions to implement it; (3) enabling conditions from external stakeholders; and (4) implementation integrated in the management of the ecosystem, as part of sustainable forest management and/or landscape approaches.

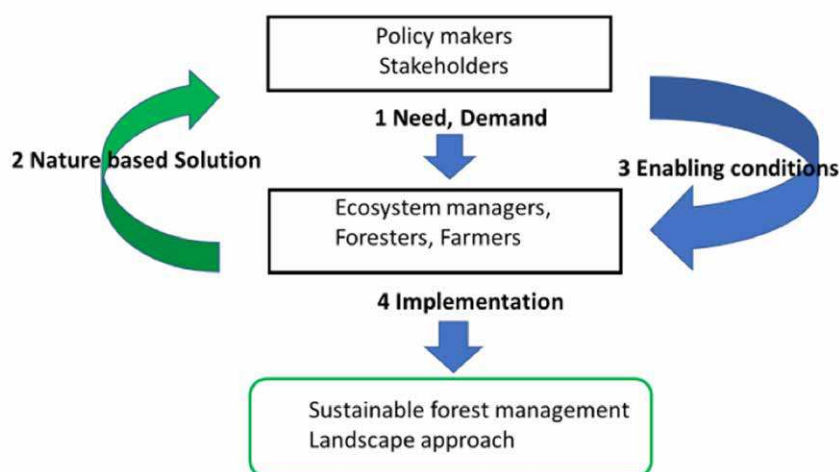


Figure 4.2 Constructing NBS in forestry and agroforestry in four steps.

## KEYWORDS

Nature-based solutions, forest- and tree-based solutions, sustainable forest management, landscape approach

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# Using publicly available remote-sensing products to evaluate REDD+ projects in Brazil

The continuity and improvement of REDD+ projects require rigorous impact evaluations of existing on-the-ground interventions. In this study, we assess the suitability of using publicly available remote-sensing (RS) products to evaluate such projects in the Brazilian Amazon. We reconstruct annual forest loss of 17,066 farms using two ready-to-use datasets – GFC and PRODES – and assess the consistency between them. Next, we estimate the impact of a sub-national REDD+ project using matching on pre-treatment outcomes to adjust for the self-selection of farmers into the program. Results suggest that the two RS products are statistically different, with GFC detecting systematically higher rates of deforestation than PRODES.

Despite the inconsistency between datasets, we estimated that an average of about 2 ha of forest was saved during the early years of the project (2013–2015) on each participating farm, regardless of the source of RS data. However, results from the regional-scale product (PRODES) are more precise, with smaller p-values and narrower confidence intervals associated with the estimates. Also, we failed to detect a positive impact of the program during the last year (2016–2017), suggesting that the program's effects were primarily realized in its first years.

Our estimates using PRODES data moreover suggest that participants increased deforestation over 2016–2017 because of the program. These findings suggest that GFC and PRODES may not be suitable for accurately monitoring, reporting and verifying (MRV) annual deforestation at the farm level. Thus, payments for environmental services (PES)-based REDD+ projects should not rely on these products to verify individual-level compliance. However, despite the inaccuracy of forest cover loss estimates at the individual plot level, such RS products represent a valuable source of data from which to evaluate forest conservation projects. Since the noise in the data is randomly distributed among plots, impact evaluation techniques can be used to provide robust estimates of the average treatment effect of the program.

Based on these findings, we recommend REDD+ project evaluators to cross-validate results using multiple datasets and to prioritize the use of locally designed RS products when available. Also, our results indicate that the project has failed at inducing more sustainable agricultural practices in the following years, as the additionality disappeared even before the end of the program. If these findings are externally valid and can be generalized to other similar programs, they would have significant implications for the status of PES-based REDD+ projects in the Brazilian Amazon. Finally, the results indicated that project sponsors need to emphasize permanence objectives in REDD+ contracts, in particular, to safeguard against economic shocks such as the rise in agricultural commodity prices, which lead to deforestation.

## KEYWORDS

REDD+, remote-sensing products, impact evaluation, deforestation, Brazilian Amazon

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# An overview on forests, agroforestry and trees in national adaptation plans (NAPs)

The national adaptation plan (NAP) process was established under the UNFCCC in 2010 for least-developed and other developing countries to identify and address their medium- and long-term adaptation needs. Most developing countries had initiated the process and to date, 18 have shared their first NAPs on the UNFCCC website. Some developed countries have prepared similar documents. The objective of this presentation is to give some preliminary insights on how forests, trees and agroforestry are considered in the current NAPs. It will successively consider the way forests and trees are integrated in the institutional process, the main vulnerabilities identified for forests and trees and the measures aimed at their adaptation, and how agriculture and other sectors integrate forests and trees for their own adaptation.

Most of the NAPs are organized by sectors, generally chosen because of their particular vulnerability to climate change and/or their role for the overall adaptation of the country, with a cross-cutting section. The sectors and their precise delineation generally correspond to specific line ministries to facilitate preparation and implementation of the plan. Forests are often included in the biodiversity/ecosystem sector of the NAP, as in many countries it is the Ministry of Environment that is responsible for forestry. For Chile for instance, forests are included in biodiversity, except for planted forests that are part of the sylvoagropastoral plan. In most cases, agroforestry is covered in the agriculture section of NAPs. Some NAPs are organized by subnational areas. In addition, most NAPs integrate the possibility of having actions that are subnational.

The main risks identified for forests and trees in the NAPs are increased climate variability, increased heat and drought, increased risk of extreme events, salinity in coastal areas, forest fires, pests and invasive species. The main measures promoted are sustainable forest management, biodiversity conservation, monitoring and risk management systems, conservation and sustainable management of genetic resources and to anticipate future changes; for instance, planting seeds from hotter or drier areas to get adult trees more adapted to the future climate.

Almost all sectors contain measures that use forests and trees as an adaptation means. A first group concerns natural resources management, to restore degraded land, reduce soil erosion, restore water catchments, protect water tanks and rivers as well as coastal planting to reduce shoreline erosion and protect against storms. A second group concerns agriculture, with wind breaks, shade trees and agroforestry in general, focused on biophysical rather than economic resilience. A third one regards the protection and greening of cities to reduce the urban heat island effect, while taking into account increased fire risks.

Tree- and forest-related measures generally focus on a single biophysical adaptation benefit but are often lacking specificities on implementation details ('how') or on the needed enabling environment, showing a lack of concertation with forest and tree specialists. This is consistent with broader findings that the weakest components of the plans submitted to the UNFCCC are 'Coordination and Participation'. It calls for greater involvement of forests and tree researchers and stakeholders.

## KEYWORDS

NAP, national adaptation plan, adaptation, climate change, forests

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# The effects of a REDD+ initiative on deforestation and well-being: A panel study in the Brazilian TransAmazon

REDD+ was designed as a mechanism to achieve multiple objectives, mainly reducing emissions from deforestation and forest degradation and increasing carbon stocks, but also to address human co-benefits (e.g. poverty reduction and local well-being)<sup>1</sup>. Although REDD+ was launched more than one decade ago, there are still few robust impact evaluations of its outcomes on the ground. Some of the evaluations suggest weak effects, which could support some questioning of the continuity of the mechanism, although the findings were based on short time-span evidence. Our study aims not only to help understand which are the REDD+ outcomes on the ground but also to identify which factors translate into more expressive results. This information can be used to improve REDD+ initiatives, preventing them from being replaced by another panacea. We estimated early (~3 years) and late (~8 years) average treatment effects on forest conservation and perceived well-being of a REDD+ initiative in the Brazilian TransAmazon Highway region, which combines payments for ecosystem services (PES) and Integrated Conservation and Development Projects (i.e. incentives for low-impact activities) to reduce deforestation by smallholders. We then investigated whether the adoption of low-impact activities partially explains these effects, by searching for heterogeneous effects among smallholders who adopted/did not adopt those activities. Data came from interviews in three years (2010, 2014, 2019) from a panel-based survey directed at 98 households (treatment: 47; control: 57), as a part of CIFOR's Global Comparative Study on REDD+. We adopted a quasi-experimental design with pre- and post-intervention data, estimating effects through difference-in-differences with matching. Our results indicate positive average treatment effects in the early period (i.e. an average of ~6.8 ha to ~8.5 ha was conserved per household and we detected a trend of increase in well-being), but no significant increases in the later period. However, we found positive forest effects in the later period (i.e. an average of ~12.7 ha to ~17.8 ha was conserved) for the households that adopted low-impact activities, although no significant average treatment effects were detected for the whole sample. Therefore, it seems that the adoption of low-impact activities helped to boost forest conservation, especially in the long run. Our results suggest that it is important to search for heterogeneous effects for the REDD+ initiatives in order to better understand its outcomes and to identify which factors can bring better results. This information can help REDD+ initiatives to address the climate crisis by conserving forests and to achieve co-benefits.

## KEYWORDS

REDD+, forest, well-being, PSE, ICDP

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# Participatory assessment of vulnerability to climate change and variability and other hazards at landscape level

Rural landscapes all over the world are subject to an increasing number of hazards, of which climate change and variability are those of greatest concern in the long run, albeit not necessarily the most urgent priority in the short term. Seeking greater resilience of landscapes to such hazards (climate change and variability, changing trade policies, market changes) is becoming a priority of many international cooperation programs that are oriented at supporting forest and agricultural development. The Working Landscapes and the Mobilizing More for Climate programs funded by the Dutch Ministry of Foreign Affairs and in which Tropenbos International is coordinating or co-coordinating partner are no exception. For such programs to be successful, they do not only need to identify to what hazards the landscapes they work in are exposed, and what is needed to face those hazards. They also need to achieve the buy-in of local stakeholders, analyze the sensitivity of local land use systems to the hazards as well as analyze local capacities to cope with the hazards or adapt to the changes caused by those hazards. In this context, Tropenbos International worked with its network partners in Indonesia and Ghana in the adaptation of the FAO framework methodology for climate change vulnerability assessment of forests and forest-dependent people to the needs and conditions of the programs' landscapes. Here we present the findings of this adaptation as well as the results of the participatory assessments in the Ketapang-Kayong Utara and the Juabeso-Bia and Sefwi-Wiawso landscapes in respectively Indonesia and Ghana.

We discuss briefly some of the major strengths and weaknesses of the application of the methodology in a landscape context, and provide recommendations to improve the methodology and its usefulness for planning climate actions at the landscape level. Our findings suggest that the methodology is a good tool for local stakeholders to start reflecting on changes occurring in their landscape; that current policies, the application of the existing normative framework and current administrative processes are of greater immediate concern for stakeholders than climate change; and that underlying causes of current changes in the landscapes are not well known. Increased numbers of fires, for example, were linked to poor management practices and drier seasons, but the latter was not linked to changes in climate and its variability. Linking changes to climate change or variability is often interrelated with public knowledge and hear-say, rather than an analysis of the correlation between real changes in the landscape and data on its underlying causes. Application of the participatory assessment, therefore, needs to be done by experts who have a good scientific/technical knowledge of the hazards and the possible consequences for the types of land use currently existing in the landscape where the assessment is being implemented.

## KEYWORDS

**LULUCF, forest functions, agricultural practices, climate risk, income diversification**

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# What place for land use in the Koronivia Joint Work on Agriculture in UNFCCC?

Land use and land use change (including related policies) interact with climate and climate change (including related policies) in multiple ways. The purpose of this presentation, resulting from a collaboration with FAO, is to recall those interactions, synthesizing recent reports, and how land use is considered in the work of the United Nations Framework Convention on Climate Change (UNFCCC) in order to examine if the Koronivia Joint Work program on issues related to Agriculture (KJWA) of the Subsidiary Body for Implementation (SBI) and Subsidiary Body for Scientific and Technological Advice (SBSTA) might offer opportunities to better consider the role of land use in addressing climate change under the convention.

Land use and land use change are contributing to global climate change. Conversely, climate change increasingly impacts land use. Land use is key to mitigation as well as to adaptation through its impacts on local and regional climates and on natural disaster management. Climate change and the policies to address it will drive major land use changes. Land use is also an area where synergies and trade-offs between adaptation and mitigation are generated, as well as where considerable potential for SDG co-benefits may be realized. These potential co-benefits can be a strong incentive for action. Managing these synergies and trade-offs call for an integrated approach at different scales (landscape, national, regional, global). Before the creation of the KJWA, most of the work on land use under the convention was focused on the contribution of terrestrial carbon sinks to mitigation, especially that of forests. The potential contribution of land use to mitigation is acknowledged by the convention but has generally been insufficiently integrated in its implementation mechanisms. Moreover, the compartmentalized approach of the UNFCCC (including the distinction between emissions and sinks, forests and agriculture, mitigation and adaptation, and poor consideration of co-benefits) has its reasons but has not facilitated a holistic approach to the consideration and integration of land use within the work of the convention.

While the KJWA has an agriculture entry point, it also presents an opportunity for land use-related issues to be better considered under the convention. Covering adaptation and mitigation, often combining them, it is conducive to better management of synergies and trade-offs. It fully integrates socioeconomic and food security dimensions of climate change, key entry points for SDG co-benefits. It has thus a considerable potential to support countries' action on the ground and to inform the other bodies of the convention on the specificities and needs of the sector. Given the importance of the relationship between agriculture and other land uses, shared issues, competition for land and potential positive interactions, including ecosystem services, we find there would be value in better integrating land use as such into the future work of the KJWA. It would enable parties to deepen their understanding of the potential of agriculture for climate action. It could also facilitate a broader consideration of land use-related issues at the interface between climate action and food security, including in the revision and implementation of the NDCs.

## KEYWORDS

Land use, climate change, UNFCCC, Koronivia Joint Work on Agriculture

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# Active restoration in secondary and degraded tropical forests as a nature-based solution to answer the global wood demand

In this talk, we will address issues related to the potential of tropical secondary and degraded forests (SDFs) as sustainable and complementary alternatives for wood production, from case studies in Central American countries. We will also discuss the potential of wood production in SDFs as an effective NBS for the climate crisis, i.e. associated to effective mitigation in the future.

Tropical secondary (1) and degraded (2) forests are disturbed forest areas, growing in formerly deforested areas (1) or which have suffered from unsustainable human activities, such as unplanned and repetitive logging or fire (2). They have consequently lost their capacity to provide a high level of goods and services.

SDFs are important worldwide as they account for swathes of forest landscapes and are invaluable forest ecosystems related to biodiversity recovery, carbon storage, but also a diversity of other forest ecosystem services.

However, they are fragile and endangered forest ecosystems, as they are located in highly dynamic pressured landscapes and are susceptible to catastrophic events. Without appropriate silvicultural management designed to increase their economic value, they may well be cleared for more economically productive activities.

Moreover, the increasing demand for tropical timber in recent decades and in the near future may worsen the pressure on these fragile ecosystems.

We suggest that active restoration implemented towards wood production in SDFs may amount to a sustainable and complementary alternative for wood production in the future. Wood production is definitely an opportunity for SDF conservation in the context of the increase in wood demand, while limiting pressure for wood demand on the remaining natural forests. Moreover, SDF maintenance and restoration through secondary forest dynamics contribute significantly to the maintenance of crucial ecosystems services in the context of the climate crisis.

Following the CATIE project on secondary forest dynamics and valuation in Central American countries (IKI Funding program 2017–2020), we are setting up with FTA support (2020), work on the assessment and the improvement of wood production potential from secondary forests through analysis of data from national forest inventories in Central American countries.

During the FTA science conference 2020, we will present the first results of this work. We will discuss the limitations and opportunities associated with wood production in tropical SDFs nowadays in the global context, but also the mitigation potential associated to wood production in these SDFs.

## KEYWORDS

**Active restoration, secondary forests, degraded forests, increase in timber demand, mitigation potential**

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# Restoring degraded land for bioenergy: A cross-cutting element for landscape sustainability

Primary energy demand in Indonesia has increased by over 43% between 2005 and 2016, while at the same time domestic energy supply has failed to fulfill these needs, leading to a reliance on energy imports. Meanwhile, vast areas of degraded and underutilized land could be utilized for biofuel production, potentially fulfilling both demands for energy, and for land restoration with concomitant environmental and socio-economic benefits. This paper provides an overview of the potential and challenges associated with biofuel production from degraded and underutilized land in Indonesia. Preliminary findings indicate that a number of biofuel species are suitable to be grown on degraded land using agroforestry systems. They could thus help restoring land that may not be otherwise suitable for agricultural production and/or reforestation. Our initial findings also show that farmers prefer tree species they are accustomed to and know how to grow and manage, and they need to be able to rely on stable markets. Supportive agricultural extension services such as knowledge and technology for honey production can provide added value to biofuel production, in addition to social (e.g. strengthening social solidarity, employment opportunities) and environmental (e.g. carbon storage, soil moisture, erosion control, biodiversity) benefits. Meanwhile, to make this initiative successful, supportive measures in the form of favorable government policies and regulations are needed. To maximize the benefits from biofuel production on degraded land in Indonesia, further research is needed on the capacity of biofuel species and species assemblages to restore degraded lands in different biophysical profiles. This includes an analysis of biofuel production feedstocks, viable business models, stable markets and potential co-benefits.

## KEYWORDS

Degraded lands, landscape restoration, biofuel species, socio-economic benefit, people's preference, policy



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# Nutritional analysis of bamboo shoots from selected bamboo species from Kenya

A nutritional assessment of five types of bamboo shoots found in Kenya was undertaken to establish their nutritional potential in order to enhance their value for the purpose of conservation and utilization. The bamboo shoots were obtained from Nyahera in Kisumu County, Nguriunditu in Kiambu County and KEFRI-Karura. *Dendrocalamus giganteus*, *Dendrocalamus membranaceus*, *Dendrocalamus asper*, *Oxytenanthera abyssinica* and *Bambusa vulgaris* were analyzed for moisture content, proximate composition, minerals and vitamin content. Their calorific value was also determined. The moisture content for the shoots ranged from 89.91% to 92.11%. The fiber content ranged between 17.57% and 34.3% on dry weight basis (dwb) with *D. membranaceus* recording the lowest value. Fat content was very low. The crude fat content in species ranged from 1.15% dwb to 2.75% dwb with no significant difference in the values of *D. giganteus*, *D. membranaceus* and *B. vulgaris*. The protein content in *D. membranaceus* was lowest at 18.9% (dwb) and highest in *B. vulgaris* at 38.68% dwb. *D. giganteus* had a higher ash content 12.84% than the other four bamboo species. *Dendrocalamus giganteus* had higher levels of vitamin C (4.17 mg/100 g on wet weight basis (wwb)) than all other species while *B. vulgaris* registered the lowest content at 2.03 mg/100 g wwb. Riboflavin content was generally low in all the samples with *D. asper* registering the highest levels of 0.005 mg/100 g wwb and *O. abyssinica* with the lowest (0.02 mg/100 g wwb). The levels of niacin (B3) in the shoots was highest in *B. vulgaris* at 0.38 mg/100 g wwb while in *O. abyssinica* it was below the detection limit of the equipment (of 0.01 mg/L). The magnesium content in *Dendrocalamus asper* (3.31 mg/100 g) was the highest while *O. abyssinica* was lowest at 0.09 mg/100 g (dwb). Aluminum content was highest in *Dendrocalamus membranaceus* (39.25 mg/100 g). The calcium content was in the range 2.33–31.25 mg/100 g dwb. Iron was highest in *B. vulgaris* (5.31 mg/100 g dwb) and lowest in *D. giganteus* (0.83 mg/100 g dwb). Copper was considerably low in all the bamboo shoots analyzed with none being detected in *B. vulgaris*. Zinc was highest in *D. membranaceus* (1.95 mg/100 g) and lowest in *B. vulgaris* (0.1 mg/100 g dwb). The potassium content was low except for *O. abyssinica* which registered a higher value of 236.7 mg/100 g than *D. asper*, and *O. abyssinica* had the highest calorific levels at 417.17 Kcal/100 g and 464 Kcal/100 g dwb, respectively, with *D. membranaceus* registering the lowest content of 393.99 Kcal/100 g dwb. The findings in the nutritional content in terms of fiber, protein and minerals make bamboo shoots a potential meal for consideration in households. Their conservation and utilization can therefore be enhanced in order to provide additional nutritional resources to communities where the shoots are found in Kenya. Bamboo also has potential for land restoration. Promoting utilization of bamboo shoots together with planting of bamboo in degraded lands can result in income generation for households as well as environmental management.

## KEYWORDS

**Bamboo shoots, nutritional composition, Kenya, utilization potential**

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# Unravelling climate change and its impacts at various temporal and spatial scales to develop climate-resilient nature-based solutions

Climate change has become one of the biggest threats to nature and humanity. Today, we are witnessing another humanitarian crisis due to extreme weather events such as floods, droughts and increased frequency and intensity of dry spells in many Eastern African countries. This will have a potentially devastating impact on agriculture and forestry, which are the main livelihood sources in Africa. Predictions of climate change in Africa are characterized by a high degree of scientific uncertainty due to the limited availability of long-term high-quality climate data and insufficient understanding of the physical processes of interacting atmospheric circulation patterns in model simulations. It is becoming increasingly evident that pattern of growth, water use efficiency and survivorship of tree species are sensitive to climate variations, and stress-induced mortality is prevalent. There is also a substantial gap in fundamental knowledge concerning how tree species grow in response to climate variability, and therefore how they might react to future climatic change. Our approach considers large-scale climate gradients and different temporal scales (inter-annual and intra-annual variations) and combines multi-parameter measurements. We will present methods and tools, including tree ring analysis and stable isotopes to measure hydroclimatic records and the history and frequency of extreme drought events; and characterize drought tolerance and the water use efficiency of trees and forests and its implications to validate global climate models and strategies for sustainable water resources management, climate-smart restoration, among others. We will further discuss the need to generate knowledge, data and predictive systems in Africa to make evidence-based climate-resilient development actions and policy decisions to increase the resilience of people's livelihoods and the environment.

## KEYWORDS

Resilience, restoration, climate change, drought tolerance, extreme events

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# The decision context for nature-based solutions in a Peruvian watershed: Adaptation in people's minds and on the ground

Nature-based solutions (NBS) are receiving increasing attention for adapting to change climate and reducing its impacts on water resources. There is a growing interest and awareness of the value of managing, conserving and restoring ecosystems for their role in regulating water, protecting soils and increasing the resilience of social–ecological systems in watersheds. In the Peruvian mountains, some adaptation programs emphasize NBS options, such as the conservation of cloud forests, the restoration of forest cover, and the conservation or restoration of wetlands and grasslands. At the same time, other adaptation programs focus on technological and infrastructure options based on bricks-and-mortar, such as dams, reservoirs and water treatment facilities. In between, traditional options have been used for centuries by local communities to address water problems by combining NBS and small-scale infrastructure. The different options have a potential for providing water adaptation benefits but they differ greatly, for example, in terms of equity (e.g. when a dam benefits mostly urban and powerful actors) and co-benefits (e.g. scenic beauty, carbon sequestration or wild plant supply). Decision-making on adaptation options is challenging because of the lack of knowledge on the effectiveness of different solutions and because of the diverging opinions on their relevance among decision-makers. Using mixed methods, this study analyzes options for adaptation and water management in the Andes in Peru. We propose a critical analysis of decision contexts and the implications of adaptation options for ecosystem services and equity. We identify different doctrines and preferences for technological or NBS options and relate them to stakeholder worldviews. The contrasting discourses on adaptation options can be associated with different conceptions of equity and different opinions on the role of government, communities and the private sector in water management. We also explore whether some options are favored by decision rules and power relations. Analyzing the interactions between stakeholders and ecosystem services and understanding the trade-offs between ecosystem services can help explain the different positions in favor of or against NBS. This research highlights the importance of power relationships in adaptation decision-making, as such relationships favor the values and knowledge of some stakeholders and give priority to their preferred adaptation options.

## KEYWORDS

Adaptation, climate change, nature-based solution, water, mountain

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# Africa needs to manage its ecosystems properly to avoid severe energy poverty in the near future

Africa has one of the fastest growing human populations on the planet. The continent is also characterized by a high rate of ecosystem degradation, specifically the loss of its forest resources. Further, over 80% of its population relies on biomass-based energy, i.e. firewood and charcoal. The penetration of technological solutions (e.g. solar panels) to curb the energy scarcity is very minimal and alternatives such as nuclear energy and hydropower are still at their infant stages. Hence, the energy needs of the growing population of the continent is being met mainly by ecosystem products. In this presentation, we quantitatively demonstrate the crucial relevance of Africa's ecosystems in meeting the growing energy demands of the population of the continent. The results emerged from a three-pronged analysis: from biomass energy systems, from hydropower energy systems; and from biowaste and other agricultural waste perspectives. Proposed measures of managing the ecosystem involve defining the carrying capacity of its ecosystems from energy perspectives, restoring degraded ecosystems, reducing the extraction pressure on ecosystems, and innovations both to maximize energy utilization efficiency and to replace the traditional energy sources. Policy support and community empowerment and involvement remain crucial.

## KEYWORDS

Energy, ecosystem, population, Africa, restoration

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# Can REDD+ reinforce law enforcement? Evaluating the local impacts of an incipient initiative in Madre de Dios, Peru

Conservation and sustainable management of tropical forests are key to mitigating greenhouse gas (GHG) emissions and therefore keep projected global warming below 1.5° C by 2030, as was recognized in the Paris Climate Agreement. Given this importance, initiatives ranging from national strategies to localized projects seeking to Reduce Emissions from Deforestation and forest Degradation and enhance carbon stocks (REDD+) have been implemented tropics-wide over the last decade. Yet, surprisingly little is known about their environmental and well-being impacts (Duchelle et al. 2018). Furthermore, REDD+-type interventions are often embedded into contexts influenced by other policies with similar purposes (e.g. forest law enforcement), making their attributive impact evaluation methodologically challenging (Ferraro and Hanauer 2014). Here we analyze one local REDD+ project, involving Brazil nut concessionaries in the Western Amazon, implemented close to Peru's trilateral border with Bolivia and Brazil, an area of high ecological relevance threatened by recent road improvements that have allowed intensifying land clearing drivers such as crops expansion, cattle ranching, illegal logging, and notably, informal artisanal gold mining (Chavez 2014). In parallel with the REDD+ initiative, state inspections to verify compliance with the forestry normative have intensified in the study area. Combining longitudinal data from remote sensing and households' surveys corresponding to 196 concessionaires participating in the REDD+ Global Comparative Study (GCS) led by the Center for International Forestry Research (CIFOR), we evaluate the project's impacts vis-à-vis the intended goal of mitigating deforestation and forest degradation while improving participants' well-being. To do so, we use a before–after control–intervention (BACI) approach (Sills et al. 2017), combined with matching techniques and multivariate regressions, so as to minimize any participation selection bias. Furthermore, we make advances on evaluating interactions of both interventions put in place in the study area, even considering endogeneity issues between some outcomes and government inspections. We find no significant effects of the REDD+ initiative on any of the assessed land cover change outcomes. Nevertheless, forestry law enforcement actions implemented by the state through field inspections of Brazil nut concessions were found to have contributed to decrease deforested areas, and aggregated deforested and degraded forest areas by 1.15 ha and 1.3 ha on average per year, respectively, in each concession for the 2012–2018 period. In addition, individual statistically significant effects of both policies on negative perceived well-being were also found. However, we find evidence that participation in the REDD+ project dissipates the forest conservation effects achieved by field-inspections, and the negative well-being perception of audited concessionaries. Finally, we discuss the mechanisms enabling these findings; how the REDD+ project's impacts have been conditioned by low treatment intensities caused particularly by interrupted funding and consequent delays; and the potential of combining elements from both intervention approaches to reinforce environmental and socioeconomic proposed impacts.

## KEYWORDS

Propensity score matching, policy mix, deforestation, forest degradation, well-being

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# Learning lessons from a REDD+ initiative: Assessing the implementation process, forest and community outcomes, and impacts on local households in Central Kalimantan, Indonesia

The traditional rural populations of Indonesia are highly dependent on forests for products and services for both market and subsistence. Thus, their livelihoods are threatened by economic development activities that lead to deforestation. In this context, international efforts to reduce emissions from deforestation and forest degradation, or REDD+, can potentially be a win-win for local and global populations, protecting livelihoods while mitigating climate change. However, there is significant controversy over whether REDD+ can achieve this potential. The controversy partly reflects highly varied understandings about what REDD+ really is and how it is being implemented on the ground. To shed light on this debate, we present a detailed explanation of how one REDD+ project has been implemented and a counterfactual-based evaluation of its livelihood impacts. The Katingan Mentaya Project was launched in 2009 and issued its first carbon credits in 2017. To generate these credits, the project proponent implemented a bundle of interventions, which we categorize as restrictions on forest access and/or conversion, forest enhancement, non-conditional livelihood enhancements, conditional livelihood enhancements, environmental education and tenure clarification. Drawing on community meetings and household survey data collected at three points in time (2011, 2014 and 2018), we examine trends and estimate a difference-in-difference model in a matched sample to quantify the impacts of these interventions on income from the forest and forest clearance for agriculture.

## KEYWORDS

Forest, deforestation, climate change, REDD+, livelihoods

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# Landscapes in motion: Linkages and feedbacks between landscape dynamics and human migration

Human migration and mobility have always been an important feature of how people interact with their environment and, in recent years, there has been an increased interest in understanding mobility drivers and effects. Yet links between mobility, migration and landscape changes have been largely overlooked in the landscape-related literature and the environmental impacts of human mobility are missing in the migration research field. This paper aims to fill those gaps by capturing and analyzing the diversity of linkages between human mobility or migration and landscape dynamics. These linkages can be framed in different ways. Mobility and migration induce significant changes in rural and urban areas, by direct demographic and social changes or indirectly through the investment of remittances in the landscape of origin. Using a pathways analysis approach, we examined different migration trajectories and their impact on the use and the management of ecosystems in several case studies in dryland areas. We explored the impacts of remittances on various human activities and ecosystem use or management. We also analyzed how knowledge, values and rules evolved along the migratory pathways and affect ecosystem management. The results highlight different types of feedback between human migration and social and ecological processes in the landscape of origin. They also show various feedback loops between migration and landscape recovery or degradation. Migration can induce adaptive or maladaptive pathways, which have profound consequences for landscape sustainable or unsustainable trajectories. Rather than conceptualizing mobility and landscape dynamics separately, development and landscape conservation policies need to better integrate mobility and migration in their analytical frames in order to achieve long-term, desired, landscape conservation and development outcomes.

## KEYWORDS

Adaptation, migration, drylands, landscape

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# Shortening of organic value chains through the Participatory Guarantee Systems in the Plurinational State of Bolivia

Third-party certification has been a cause of small farmers' exclusion from participating in high value chains such as organic and fair-trade chains. The three major certification schemes that have ruled the market during the last 30 years are: Fairtrade, Organic and Rainforest Alliance. Exclusion of producers from these value chains have increased rural poverty in coffee-producing countries since 2000 due to the participation of commercial cartels that demand third-party certification schemes for exporting to the North. In response to this unfair economic exclusion, alternative certification appeared at the right moment to include these economically and socially marginalized small farmers with the participation of service providers, organized consumers groups and producers. In Bolivia, Law 3525/2005 for the promotion of organic agriculture and non-timber forest product (NTFP) collection allows the participatory certification through the Participatory Guarantee Systems (PGS) based on IFOAM's guidelines, which are a voluntary process developed by the involved actors in the short organic value chains that verify the production, transformation and commercialization. In this study, three study cases were chosen in order to be described and assessed:

1. Achocalla (municipal PGS)
2. Eco-Feria (private PGS)
3. CIOEC (communal PGS).

The results showed that municipal PGS are much more successful than private and communal PGS due to the social capital and financial capital involved. Communal PGS cannot be sustainable because there are differences between producers' associations and they do not maintain a continuous supply of organic products for local markets. Private PGS are not successful either, due to the specialization and the lack of product supply during demanding seasons.

## KEYWORDS

Third-party certification, participatory certification systems, non-timber forest products, types of participatory guarantee systems, legal frameworks

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# Potential of tree crop commodities as a bioenergy source

Globally, biomass accounts for 10% of total final energy consumption, and 85% of the rural population in less developed countries depend on biomass for energy. With the high carbon emissions from fossil fuels and the negative health effects of fuel wood and charcoal, modern bioenergy emerges as a sustainable clean energy source. Modern bioenergy has been underscored as a sustainable way of ensuring energy security while reducing the adverse health effects of traditional biomass combustion and climate change. When generated from forest and agricultural waste, it reduces the pressure on the forest for wood energy and enhances biodiversity. Tree commodities are extensively cultivated in different parts of the globe and significant amount of residue is left to rot after the marketable parts of the tree commodities have been exploited. A significant part of this residue is far above the required quantity for soil fertility and can be an important feedstock for bioenergy generation. This paper evaluates the potential of bioenergy from seven tree commodities (coffee, cocoa, oil palm, cashew, industrial round wood, walnuts and almonds) globally, based on sustainable extraction from residues. The estimates reveal that sustainably extracted residue can produce up to 382.138 million bone-dry tons per year of biomass. This can potentially yield 16–428 terra watts hour<sup>-1</sup> (TWh) per year of bioelectricity, which represents 142.857%–382.143% of current electricity generation from renewable sources excluding hydroelectricity in sub-Saharan Africa. A total of 2.4 to 6.78 billion liters of bioethanol can potentially be produced while 1.7–4.52 billion liters per year of Fischer Tropsch diesel can equally be generated from tree commodities. Large-scale conversion and use of tree commodities for bioenergy generation is at the experimentation phase for all the tree commodities except for palm oil. Significant progress in policy formulation and large-scale application of biomass conversion for palm oil is ongoing in Malaysia and Indonesia. The evolution of policy, financial, technical and human capacity in bioenergy generation from tree commodities is at different levels on different continents and for different tree commodities. Implementation of these policies is also low due to serious financial, technical and human capacity gaps. For this potential to be realized, significant policy coordination at the regional and country levels is required. Tree commodities development should incorporate sustainable bioenergy generation from tree commodities as a strategic action. For bioenergy to effectively meet its potential from tree commodities, significant policy coordination for bioenergy from the different tree commodities is imperative. Government lead is very important for the effective development of policies and instruments to promote bioenergy generation. Capacity building, R&D and finance are capital to the development of bioenergy from tree commodities. Most efficient conversion technologies for tree commodities should be tested across different production regions, and efficiency parameters adjusted to regional specificity. Appropriate standards should be put in place that identify bioenergy generation as green projects and qualify them for green bond financing. These standards can be accompanied by sustainability criteria that assure the sustainability of the feedstock.

## KEYWORDS

Biomass, feedstock, climate change, energy, tree commodities

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# Phylogenetics study of Ethiopian indigenous and introduced bamboo species based on ISSR markers

**Background:** As one of the most important non-timber forest resources or a potential alternative to wood and wood products and the fastest-growing plant in the world (91 cm (35 in) per day), bamboo is a member of the grass family (i.e. Poaceae) and constitutes a single subfamily Bambusoideae. The most recent classification systems have listed 1642 species of bamboo worldwide and Africa has forty-three (43) species. Ethiopia has 67% of the total area of bamboo in the continent Africa and 7% of the world total totaling more than 1.44 million hectares. There are two indigenous woody bamboo species in Ethiopia: the highland bamboo (*A. alpina*) and the lowland bamboo (*O. abyssinica*). There are more than 40 species of bamboo introduced to the country and they are under multiplication in different sites. Although bamboos have ecological and economic importance, scientific inquiry particularly on the phylogenetics of indigenous and introduced bamboos is lacking. Therefore, the aim of the present study was to investigate the phylogenetics of the indigenous and introduced bamboo species and to identify the closest species to the Ethiopian bamboos using ISSR primers.

**Methods:** Silica gel-dried young fresh leaves from each of the 31 species of bamboo were collected for DNA extraction and PCR amplification. Fifteen (15) from thirty-eight (38) ISSR primers were screened and chosen for PCR amplification and band generation. The bands that were clearly visible and repeatable on the electrophoresis map were marked as '1', the absence of a band at the same site was marked as '0' and '?' for the ambiguous bands.

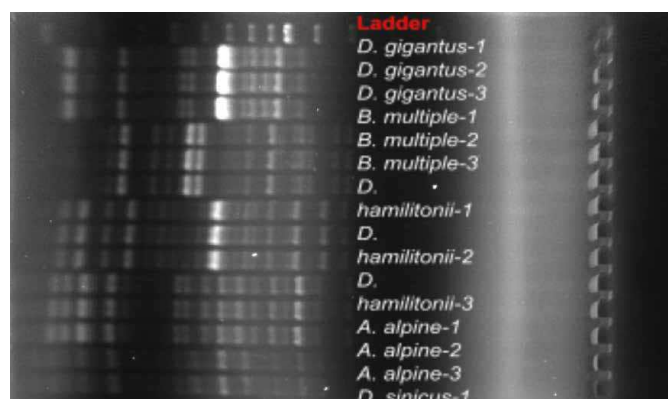
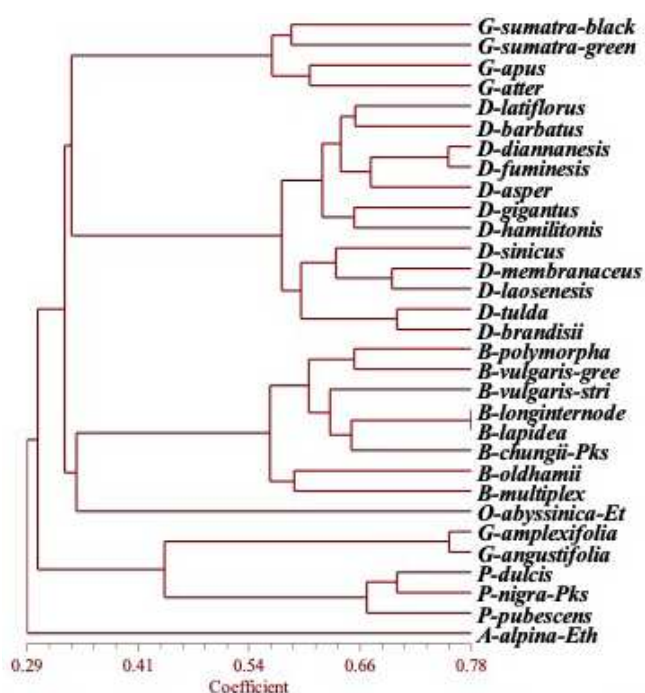


Figure 4.3 A representative of ISSR electrophoresis profile of 31 species of bamboo using UBC-835 (A) and a dendrogram depicting clustering patterns for thirty-one (31) taxa of bamboo based on Jaccard's similarity coefficient (B).



Results: The highest expected heterozygosity (H), polymorphism information content (PIC) and discriminating power (D) were observed by anchored primers in general and 3'-anchored and/or dinucleotide repeats (UBC-834 and UBC-835) in particular. A dendrogram from the total primer was split into two clusters; the main cluster was divided into two sub-clusters. All the 31 taxa were split into different sub-clusters. Specifically, the result of the total primer shows that, Ethiopian woody bamboos (*O. abyssinica*) clustered with tribe *Bambusa* (paleotropical woody bamboos) and *A. alpina* clustered with *Guadua* (neotropical woody bamboos).

Conclusion: There is a long history of species being moved around the world by humans. Over the past three centuries, human-mediated species dissemination has increased with increasing global traffic. Introduced species can provide substantial benefits and naturalize (consistently reproduce) in their new ranges and some naturalized species can have undesirable consequences or invade (spread from introduction sites). Finding and introducing the scientifically approved, invasive, economically important and environmentally friendly bamboo species to the degraded and deforestation lands might be necessary and good for the country. In this study, we provide the first assessment of the phylogenetic relationships of the indigenous and introduced bamboo species using ISSR markers. The closest bamboo species to indigenous Ethiopian bamboos were identified and the extent of the level of polymorphism, marker efficiency, Nei's genetic diversity (H), Shannon diversity index (I), and cluster analysis were also examined. We believe this is important for our understanding of the phylogenetic relationships of indigenous and introduced bamboo species. However, more studies involving molecular markers giving greater genome coverage and detailed phylogenetics relationships are required to identify the closest and most important bamboo species.

## KEYWORDS

**Bamboo, introduced and indigenous species, ISSR markers, phylogenetics, non-timber forest**

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# Bamboo pellets for sustainable bioenergy production in Ghana

Nearly 50% of Ghana's overall primary energy use is obtained from biomass. This energy is consumed mostly in the household sector in the form of charcoal or firewood. The degradation of forest resources due to increasing over-exploitation especially for meeting the energy needs of the large rural and urban populations highlights the need and urgency to identify alternative bioenergy resources. As a modern bioenergy feedstock, the use of bamboo biomass is becoming increasingly promising given its fast-growing nature and regenerative character. While the utilization of bamboo for other uses has been well documented in Ghana, a review of its potential specific to bioenergy production has not been done in Ghana. Within this context, and using available information and case study examples from other developing countries, the study assessed the potential for bamboo pellet production for bioenergy in Ghana based on economic, social and environmental considerations and the policy environment (requirements) needed for it to be sustainable. The findings of the study showed that the potential for developing sustainable bioenergy production from bamboo is good but will need technical, institutional, policy and government support for it to fully emerge as an industry. The use of bamboo pellets as a biofuel is economical, energy efficient, environmentally friendly and sustainable compared with traditional energy sources including charcoal. Although bamboo provides new opportunities for biomass pellet production and trade, its market uptake is only now emerging in Ghana. The major challenge in the utilization of bamboo biomass residues is the uncertainty of uninterrupted supply of the resource for utility-scale bioenergy generation. The use of industrial and bamboo processing waste and blends of residual biomass with that from wood processing industries must be promoted as a sustainable feedstock for the near- to medium-term future. The sustainable and commercial production and use of bamboo pellets must be encouraged with a range of education and awareness-raising actions as well as policy incentives for sustainable supply, production and utilization of bamboo pellets.

## KEYWORDS

Bamboo, biomass, pellets, bioenergy, commercial

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# Bamboo as substitute feedstock for charcoal production in Africa

Estimates suggest that about 80% of sub-Saharan Africa's population relies on traditional biomass fuels for their energy needs. The associated environmental destruction is a subject of discussion among conservation scientists and practitioners. Nevertheless, this high use of biomass energy in Africa is expected to remain the same into the foreseeable future. The urgency of the need to find sustainable feedstock in order to improve the environmental impacts of biomass energy production and use cannot be overemphasized. Bamboo is increasingly attracting attention as a feedstock for biomass energy due to its fast growth, renewability and abundance in tropical regions. It is the fastest growing woody species, able to grow up to about 1 meter in a day. Harvesting can start 3–6 years after planting. The closest competitor in Africa, *Acacia*, takes 5–7 years to be ready for harvesting. Once the rhizomes are established, new shoots of bamboo can grow to their full size and height in a single year, only hardening in subsequent years. The extensive and long-living rhizomes ensure continued re-growth after harvests without the need to replant. The rhizomes also have a tendency to spread, producing new shoots as they spread. The result is an exponential increase in the number of shoots as a bamboo plantation ages. This, when properly harvested, can be an extremely renewable source of biomass energy feedstock. INBAR's introduction of bamboo charcoal/briquette technology into Ghana between 2009 and 2013 and the subsequent uptake of the technology by some commercial entities have demonstrated that bamboo is a suitable alternative feedstock for charcoal and briquette production. Indeed, the practice of producing charcoal from bamboo is not new. China has a long history of producing charcoal from bamboo, and currently produces over 100,000 tons of bamboo charcoal annually. Bamboo charcoal compares favorably with conventional wood charcoal in terms of its biomass fuel qualities. Bamboo has a unique anatomy that gives bamboo charcoal higher absorption capacity when compared with conventional wood charcoal. This quality makes bamboo charcoal a better option when used as an absorbent material. The many countries in Africa that are naturally endowed with bamboo resources have the potential to ameliorate the environmental impacts of charcoal production and use by substituting bamboo for the forest trees being used. For this to happen, it is necessary to create awareness on the suitability of bamboo for charcoal and briquette production and to transfer bamboo charcoal technologies to charcoal producers.

## KEYWORDS

Bamboo, feedstock, charcoal, bioenergy, renewable

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# Bamboo, a sustainable biomass energy source for Africa

A new UNEP study calls for urgent action to address the production and consumption of biomass energy in Africa. This study has found that biomass production in Africa accounted for 90% round-wood production in 2016, of which 16% was converted to charcoal, and identifies a number of opportunities for achieving sustainable biomass energy production, marketing and consumption systems in Africa.

In Asia, bamboo has been shown to serve as a viable and more sustainable alternative biomass fuel. Due to its extremely fast growth and high productivity, ability to undergo selective harvesting annually the 2–4 year old culms, high heating value, and carbon sequestration, bamboo is an ideal sustainable alternative biomass fuel. Bamboo-based firewood is cleaner and produces less pollution than wood firewood. Bamboo charcoal has a calorific value of 26–29 MJ/kg, equivalent to wood charcoal. Bamboo honeycomb charcoal briquettes enhance the energy output, as they burn through gasification from the inside outwards.

This abstract aims to promote the production and consumption of bamboo firewood and charcoal, which, due to its cleaner processing technology, and sustainable resource base is thought to be an attractive and sustainable alternative for wood-based biomass-derived energy sources.

In Africa, INBAR has implemented an EU bamboo biomass project, IFAD-EU South-South Knowledge Transfer project and Dutch-Sino Bamboo project related to bamboo biomass energy. INBAR will continue to implement projects in Africa to promote bamboo as a sustainable bamboo biomass energy source through:

- Developing a sustainable bamboo resource management and harvesting system
- Demonstrating and extending innovative bamboo firewood, charcoal, and briquette production and improved stoves
- Implementing a value chain and market study of bamboo biomass energy
- Raising awareness, building capacity, and promoting marketing, policy development, and investment in bamboo biomass energy.



Photos show African bamboo plantation, firewood, charcoal, briquette and improved stove.

## KEYWORDS

Bamboo, biomass energy, charcoal, innovation, investment

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# Bamboo agroforestry as a land use option for household energy needs and food security in Ghana

Available literature indicates that fuelwood consumption is a major cause of deforestation in Ghana. Similar to many parts of Africa, wood fuels currently provide 71% of Ghana's total annual energy demand; hence, with rising household energy demands, the rates of deforestation and the concomitant negative effects on beneficial ecosystem services are set to increase unless new systems of integrated land uses are developed. In Ghana, sustainable forest management has been made a priority, and government and scientists are now advocating the use of bamboo agroforestry to reduce pressure on major commercial timber species sometimes sourced for household energy needs. Although Ghana has more than 300,000 hectares of bamboo, it is currently underutilized. Bamboo's characteristics of fast growth and high renewability make it an efficient and renewable substitute resource for charcoal and wood fuel production. In Asia, bamboo-based intercropping systems are confirmed as suitable land use approaches for increased productivity of food crops and non-food biomass. However, there are limited available data to verify the suitability of the technology in Africa and elucidate the ecological principles by which the system works. Therefore, we are currently conducting a 4-year pilot study in Ghana to: (1) assess local knowledge, governance and economics of bamboo agroforestry; (2) evaluate the ecological interactions within bamboo-based intercropping systems and accentuate implications on soil and crop productivity; and (3) perform a life-cycle analysis of bamboo charcoal using environmental and social indicators. This paper presents the study design and preliminary results, and indicates how the premise of the study fits into Ghana's Growth and Poverty Reduction Strategy. Further, the paper draws on the study's potential to influence policy and district-level recommendations for household energy needs and food security.

## KEYWORDS

**Bamboo, food security, renewable energy, agroforestry**

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## **STREAM 5**

Inclusive governance for sustainable  
landscapes



## STREAM 5

### Inclusive governance for sustainable landscapes

This Stream focused on decision-making at the intersection of policy and practice, together with the institutions that support or obstruct inclusion, transparency and accountability in decision-making processes. It addressed the concepts, approaches, tools and practices that enable evidence-based effective, efficient and equitable prioritization, decision-making and implementation at the landscape level. At the heart of these processes are a set of governance challenges. These include maneuvering the different mandates and boundaries of multiple organizations and institutions working in a landscape; the power relations and gender imbalances embedded in the political economy of decision-making; and the challenges of reconciling conflicting social, economic and environmental objectives.

Concepts, practice and tools associated with “participation” in landscape governance have been analyzed with the objective of defining its various expressions and meaning, and thus identifying ways to contextualize and better understand its myriad manifestations.

Further to this, a variety of specific topics in tenure and landscapes were discussed. Land tenure is widely recognized as highly relevant to sustainable landscape management, restoration and livelihoods. Yet with a mix of widely varying local and customary practices, formalization procedures and threats to tenure security, this extreme diversity and complexity can be a difficult topic to study and even more challenging to resolve in practice, especially at scale.



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**Anne Larson** - Team Leader, Equal Opportunities, Gender Justice & Tenure, CIFOR

**Marlène Elias** - FTA Coordinator of Gender Equality and Social Inclusion



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# Participation in a state of (climate) urgency: Lessons from a comparative study of multistakeholder forums

As interest grows in multi-stakeholder forums (MSFs) to address land use and climate change, it is important to understand how these processes can better foster the kind of participation that leads to equitable and just outcomes. There is nothing particularly new about supporting participatory processes to address conservation, sustainable development or climate change initiatives relating to land and forest use. But there is a new risk, as the need for transformational change pulls in two directions. On the one hand, addressing land use change in light of the climate crisis is recognized as a complex problem that needs policy and practice at all levels to be aligned toward a common vision. Hence, the call for participation and collaboration is heard virtually everywhere in these arenas. On the other hand, there is an overriding sense of urgency – it we do not act soon, we will lose the climate battle. How can we assure the rights of indigenous peoples and local communities are not sidelined in this process? How do MSF participants, from organizers to grassroots actors, view power relations and inequality in these processes? What are effective ways to assure inclusion?

This research analyzes perspectives on participation and inequality among different actors across 13 subnational MSFs in Brazil, Peru, Indonesia and Ethiopia. The forums bring together subnational (and sometimes national) governments, NGOs, grassroots organizations and, at times, private sector stakeholders. All of the MSFs aim to conserve forests and/or improve land use. We examine how different MSFs address power differences and inequalities (or not) and, specifically, the obstacles and opportunities for actors from marginalized groups (indigenous people, peasants, women) to voice their concerns and to influence the forums' agenda and outcomes.

For each forum, data were collected through 30 to 40 structured, in-depth interviews. This included 4–5 key context interviews covering topics such as the drivers of deforestation and perspectives on inequality; interviews with forum organizers to understand the MSF's goals, noting that most are one aspect of broader initiatives; detailed interviews with forum participants; and up to 10 interviews with non-participants. The results suggest that participants, overall, are optimistic about the potential of the forums. However, there is a fundamental problem in that organizers generally do not see power as something to resolve in the MSF; rather, they see participation as a seat at the table. In contrast, indigenous peoples are thinking more broadly about inequality. In spite of optimism, there is an underlying concern that not everyone is 'playing the same game.' That is, MSFs are presented in the spirit of the round table, where everyone is equal, bringing their piece to solve the puzzle at hand; but many participants worry that others might be playing poker, using the forum to advance their own interests to the detriment of weaker groups. This underlying concern is stronger among indigenous peoples but appears to be shared widely among other participants as well.

## KEYWORDS

Participation, multistakeholder processes, inequality, climate change

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# The politics of payment for forest environmental services refusal in Vietnam

Since 2008, Vietnam has launched its National Payment for Forest Environmental Services (PFES) policy across the country. The government considers this policy as a breakthrough as it has helped to reduce the burden on the state budget and provided financial incentives for local people to protect forests. The government claims that PFES has generated USD 85 million per year and could contribute up to 15% of household income. However, in Son La Province, six H'mong villages have refused to participate in the national PFES scheme, despite intensive pressure and government campaigns. This paper aims to explore the underlying reasons for this refusal. More specifically, we want to address two research questions: 1) What are factors that lead to local resistances to the PFES program? and 2) What are the strategies that the government and local people have adopted to overcome these refusals?

The paper contributes to the field of environmental politics and governance in several ways. First, current literature on payment for environmental services only focuses on analyzing the effectiveness of economic incentives to enhance local participation in forest protection and development programs. However, adoption or rejection is often rooted in cultural, social and religious contexts. Our study fulfils the need to understand underlying reasons that discourage people from implementing forestry policies and the need to inspire new anthropological approaches to understand environmental policies and indigenous living that are attentive to a more contemporary, ongoing political reality. Secondly, refusal studies are limited by the lack of ethnographic perspectives (Ortner 1995). This paper analyses the myths and misconceptions of refusal through an analysis of indigenous politics and the conflict of multiple authorities in H'mong society. Our paper also helps policy makers and researchers to look beyond the act of refusal itself, and into the greater meaning of this act. The act of refusal becomes a means of reclaiming people's and the community's voice and to gain recognition in the existing world and reflect how trustful stakeholders perceive each other. Understanding refusals can help us to understand "the internal politics of dominated groups...the cultural richness of those groups... [and] the subjectivity—the intentions, desires, fears, projects—of the actors engaged in these dramas" (Ortner 1995, 190). Understanding refusal also helps us to understand stakeholders' stance, living principles, and historical narrative that influence their behaviors. Moreover, PFES has been considered a successful story and is being advocated for wide replication across Vietnam and Mekong countries. This study and its analysis on indigenous refusal of PFES would help safeguard the policy in place and draw out areas that need further improvement before it can be scaled up. These lessons learnt can also help upcoming initiatives such as Reduce Emissions from Deforestation and Degradation (REDD+) to avoid any potential negative impacts on indigenous people. Finally, refusal is often portrayed by policy makers and researchers as a negative response. However, our study highlights that refusal can also be a positive sign for change and needs to be carefully considered and addressed by policy makers.

## KEYWORDS

Vietnam, Payment for Forest Environmental Services, REDD+, refusal, resistance

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# Participatory use of a tool to assess governance for sustainable landscapes

Sustainable management of resources is crucial for balancing competing livelihood, economic, and environmental goals. Since forests and other systems do not exist in isolation, comprehensive jurisdictional approaches to forest and land use governance can help promote sustainability. The ability of jurisdictions to provide credible evidence of their progress towards sustainability is essential for attracting public and private sector investments and maintaining local stakeholder involvement. The Sustainable Landscapes Rating Tool (SLRT) provides a way to establish credibility by assessing some of the enabling conditions for jurisdictional sustainability through assigning ratings and justifications for 100 indicators across six themes: land use planning & management; land & resource tenure; biodiversity & other ecosystem services; stakeholder coordination & participation; commodity production systems; and institutional learning & development. We applied this rating tool in 19 states and provinces across six countries (Brazil, Ecuador, Indonesia, Cote d'Ivoire, Mexico, Peru) that are members of the Governors' Climate and Forests (GCF) Task Force. Each SLRT assessment was completed using publicly available information about relevant policies, programs, and initiatives, interviews with stakeholders in the jurisdiction, and a multi-stakeholder workshop to validate the indicator ratings.

This paper explores the effects of stakeholder involvement in the validation process (i.e. modifying indicator ratings), along with stakeholder perceptions of the tool's usefulness. Our analysis shows that changes in ratings were influenced by the presence of certain stakeholders (especially government officials). Ratings of indicators on stakeholder coordination/participation and commodity production systems changed most often, and indicators on corruption and child labor generated heated discussions during the validation workshops. These results indicate the importance of balancing different interests in such assessments, and highlight the important role of non-governmental stakeholders, including private sector representatives, in compiling and validating the assessments. Overall, most participants agreed that the tool is useful for the jurisdiction to assess itself and its coordination gaps, although it is probably more beneficial for specific stakeholders, such as local government agencies focused on land use and planning. Further, we find that the validation workshops also provided a space for discussions across government agencies, civil society organizations, producer organizations, indigenous peoples and local community representatives, and researchers about improving policy and governance.

Our findings from the analysis of a participatory approach to collecting and validating data can be used to inform future research on environmental governance and sustainability.

## KEYWORDS

**Stakeholders, participation, jurisdictional approaches, environmental governance, data validation**

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# Comparing property rights regimes to understand livestock management decisions on degraded forest margins in Western Kenya

Restoring degraded lands is a key strategy for improving rural livelihoods in African smallholder communities. One challenge facing restoration initiatives has been the lack of complete information on the socio-economic factors driving degradation, particularly the role of property rights. In countries such as Kenya, intense pressure on natural resources due to the expansion of agricultural and livestock herds has resulted in encroachment on state-managed forests. The dynamics driving expansion and degradation play out across a range of property rights regimes, from private, individual and communal properties to public lands, with distinct stakeholders and varied factors influencing their behavior. The effectiveness of restoration strategies will require a broad understanding of biophysical and socio-economic factors effecting land management decisions.

In this study, we examine variation in property rights across Kuresoi and Nyando, two distinct ecological zones in Western Kenya to explore how different tenure regimes provide incentives or disincentives for restoration. In each zone, the project selected 30 sites, called ecological response units (ERUs) representing three management states from degraded to stable lands. To gather socio-economic information on the farmers using these plots, we interviewed the landowners where ERUs were placed and systematically sampled an additional 60 households in each zone to place the ERUs in context. We conducted an intra-household survey with approximately 240 households from multiple villages in the two zones. The survey gathered information on land holding characteristics, property rights and general resource access of each household. It also generated information about livelihoods, livestock and pasture management practices and local perceptions of land degradation processes. In addition, participatory prospective analysis with community members, local leaders and other stakeholders will be used to examine historical patterns of land use change, to assess factors driving degradation and to evaluate potential options for restoring grazing lands. Results from the survey illustrate variation in the land tenure in Kuresoi and Nyando. Analysis of secondary data on historical change in land holdings and population provided additional information on change where land degradation had occurred at both sites. Initial results indicate that while livestock management activities of men and women are governed by customary practice, the local institutions and authorities that define customary rules for livestock management are weak and poorly adapted to change. For example, while customary roles for livestock management grant men authority over major decisions, women decide about day-to-day management activities. This means that women are key decision makers in practice who should be consulted to understand local land use. Also, change has brought the expansion of private landholdings, which has given some individuals greater control over grazing and enables them to invest in management strategies such as fencing, paddocking, and controlling herd size. However, households with little or no private land that formerly depended on community commons for grazing have struggled with the enclosure of communal lands. Successful efforts for restoring degraded lands and improving grazing management require a clear understanding of how tenure rights regimes influence local decision making to provide incentives that are attractive to both men and women.

## KEYWORDS

Kenya, governance, degradation, livestock management, tenure security, forests

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# Farmers' perceptions and preferences about land tenure security: Implications for sustainable landscape management, a Southern Cameroon case study

Land tenure and tenure security continue to be important subjects of research as far as agriculture and especially agroforestry development are concerned. From a landscape perspective, a wide variety of land uses may be influenced by varying perceptions of land tenure and tenure security, making it complex to propose solutions at such a scale. As agroforestry and tree planting continue to be important catalysts for landscape approaches, it is important for research to find the right solution to tenure security. Although some authors criticize the potential of land titles as an option to guarantee tenure security, others argue that evolving cultures and competition over land will create increased demand for security over land, and land title is seen as one possible option. Up till now, there is not enough information on whether farmers prefer either formal or customary institutions, as both compete to regulate access to, and ownership and security of, land and natural resources. It is however clear that their choices may be influenced by the levels of transaction costs involved in both processes, which evidently are higher in the case of formal institutions. This study attempts to provide information about farmers' preference for tenure security by examining the case of farmers from two cultural backgrounds in Cameroon, characterized by different levels of population density and intactness of indigenous local institutions. Results show that, even though existing traditional institutions provide enough security to encourage tree growing, a significant majority of respondents were in favor of land titles to guarantee private ownership and security of land in the medium to long term. The paper concludes by focusing on the problem of tenure security and sustainable landscape management through the lens of institutional change and questions why research has not given due attention to reducing transaction costs involved in land registration to the extent that some traditional institutions in place favor destructive interventions to secure land such as the first-come-first-served informal policy practiced in most cocoa-forest frontiers in Cameroon. Overall it may be said that within the context of increasing erosion of traditional institutions, local communities in Cameroon should be given the opportunity to increase their traditional tenure security through formal community land registration. In this way, individuals within such communities can subsequently obtain individual titles, which is a much cheaper and easier process and, in this way, it will incentivize sustainable landscape interventions.

## KEYWORDS

Formal/informal institutions, land titles, tenure security, farmers' preferences, landscape approaches

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# Gender-responsive forest tenure reforms? Lessons from Indonesia, Peru and Uganda

There is wide agreement that clear, secure rights over land and natural resources are key components for addressing poverty and food insecurity. However, in practice, forest rights remain highly insecure. First, the vast majority of the world's forests continue to be under state ownership by statutory law (76%), while often overlapping with customary tenure regimes without harmonization between statutory and customary laws (Wily 2018). Second, despite important progress in constitutions and national laws in countries where good laws exist, implementation and enforcement remain a major challenge. Third, even in situations where collective tenure is recognized, women are often marginalized and participate much less than men in decisions regarding land and forest use, management and benefit distribution (Agarwal 2001).

While we have learned much over recent decades from progress in tenure rights recognition worldwide, there are still important knowledge gaps. We need to understand under which conditions reforms can lead to better outcomes for women and other marginalized groups. Institutional arrangements and discriminatory social norms limit women's access and control over resources and are often tied to their relationships with male relatives (Meinzen-Dick et al. 1997). Women often face different risks as tenure reforms are implemented, raising concerns about dual exclusion because of both the security of collective tenure rights and their status as women (Larson et al. 2019).

This paper uses the framework developed by Doss and Meinzen-Dick (2018) to analyze the context of existing threats and opportunities as catalysts of change in reforms. The framework allows for better understanding the conditions that enhance women's ability to participate and benefit from reforms. We explored these issues by leveraging the data collected by the global comparative study (GCS) on forest tenure reforms conducted by the Center for International Forestry Research (CIFOR) in Uganda, Peru and Indonesia from 2014 to 2018. Building on this multi-actor, multi-method comparative study that combined research, engagement and capacity building, we collected information around the factors that influence the emergence and implementation of forest tenure reforms.

Our results show that there has been important progress in the three countries analyzed. Nevertheless, outcomes on the ground depend on various characteristics of implementation. Results presented here show that there is a need to establish clearer guidelines on how women, different ethnic groups and other vulnerable groups should be accounted for in implementation processes. A key implication of the low participation of women in the formulation of access and use rules promoted by ongoing reforms means that outcomes of reforms are less sensitive to women's concerns and needs. Interventions around reform implementation such as convening processes, or mapping exercises that do not involve different groups, may risk formalizing or perpetuating existing internal forms of social differentiation.

## KEYWORDS

Forest tenure reforms, gender, Peru, Indonesia, Uganda

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# A tentative causal chain to assess the effectiveness of jurisdictional approaches to reduced deforestation

Sub-national jurisdictions are increasingly promoted as strategic levels of governance for achieving zero deforestation objectives. Jurisdictional approaches (JAs) emerged as government-led, holistic approaches to forest and land use management across one or more legally defined territories. Despite increasing popularity amongst the science and practitioner communities, there is a lack of robust empirical data documenting their effectiveness. A major challenge to evaluation is that it remains relatively unclear what is meant by JAs. For this reason, this paper aims at clarifying the concept of JAs specifically to facilitate its evaluation. We argue that this overall objective can be partly achieved by creating a generic causal chain for JAs. Indeed, the design of the three main types of approaches that are applicable to evaluate JAs could be significantly improved if they were based on a causal chain. Defining a causal chain can also be useful to identify the intervention dimension of JAs. Indeed, JAs do not correspond to unguided processes of institutional change but rather entail a number of purposive actions that are aimed at achieving jurisdictional sustainability, which compose a jurisdictional program. Clarifying the intervention dimension is in turn necessary to implement the two evaluation approaches that emphasize causality and allow drawing important lessons to improve, replicate and scale up JAs. We design a tentative generic causal chain for JAs by integrating existing empirical knowledge on JAs with middle-range theories from the literature on collective environmental governance. This generic causal chain for JAs is articulated around two second-tier intermediary outcomes – namely the emergence of collaboration and social learning – in order to achieve the first-tier outcome of JAs, namely the definition of a coherent set of collective and locally devised rules, plans and interventions. The literature on social learning and on the emergence of collaborative arrangements for the management of natural resources proved to be helpful to clarify assumptions underlying the links between second- and third-tier outcomes, i.e. the conditions fostering collaboration and social learning. Building a generic causal chain was also helpful to define the boundaries of jurisdictional programs and justify corresponding strategies. We conclude by saying that this generic causal chain shall be improved through the implementation of more research aimed at testing the different causal links and potentially identifying new ones in real-life case studies.

## KEYWORDS

Jurisdictional approach, collaboration, social learning, zero deforestation, evaluation

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# Landscape democracy and sustainable land restoration: Evidence from Shinyanga, Tanzania

Inclusive land restoration is increasingly considered as a critical sustainable pathway to achieving sustainable development goals (SDGs) in developing countries. Literature suggests that good governance and democratic practices enable successful sustainable natural resource management. We review the extent to which landscape democracy enabled successful land restoration to inform future efforts. We examine how key democratic principles including participation, representation and legitimacy, actor interactors, equity and fairness, accountability and transparency and respect for local knowledge are deployed in a long-term successful land restoration experience in Shinyanga, Tanzania. To achieve this, we apply the FAO-PROFOR (2011) guiding framework for Assessing and Monitoring Forest Governance (Piabuo et al. 2018). Evidence suggests that all principles contributed positively to successful restoration except for accountability and transparency. Building on local knowledge and institutions, local rules and norms in restoration constituted the foundation of success. Actors identify the enhancement of incentives, equitable benefit-sharing mechanisms, performance and accountability instruments as key democracy aspects that would benefit land restoration at the landscape level. The cohesion and synergies amongst the different actors as well as the local governing structures – recognizing both formal and informal institutions' interactions – are key determinants in the outcomes of restoration.

## KEYWORDS

Landscape democracy, governance, actor interactors and power dynamics, restoration, Tanzania

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# Incentives for landscape restoration: Lessons from Shinyanga, Tanzania

Owing to high rates of land and forest degradation, there is consensus that forest landscape restoration is a global priority, with the Bonn Challenge and the New York Declaration on Forests committing to restore about 350 million hectares by 2030, globally. However, there is a need for incentives that motivate these restoration efforts and disincentives aimed at restricting activities that result in further land degradation. We provide insights and understanding of the incentives and disincentives measures applied within the forest restoration systems through a case study in the Shinyanga region of Tanzania. Incentives that have promoted forest landscape restoration in Shinyanga include: conservation benefits and ecosystem services, education and information, Reducing Emissions from Deforestation and forest Degradation (REDD+), well-defined property rights and increasing land prices, and awards. Disincentives include: penalties, quotas and permits. Adapting the framework by Minang (2018) on incentives and disincentives within ecosystem services, Figure 1 shows the various incentives and disincentives identified within the Shinyanga region as well as potential incentives that could be applied within the Shinyanga case study. Intrinsic incentives that are derived from self-desire within an individual such as conservation benefits and ecosystem services, and education and information were preferred within the Shinyanga region compared with extrinsic incentives which relied more on external factors such as REDD+ and awards. Nonetheless, a combination of both incentives and disincentives has led to the success of restoration in Shinyanga; positive incentives worked better for privately owned lands while regulatory disincentives worked better for communally owned restoration lands. High levels of social equity and trust have enabled the functioning of these incentives while a robust governance structure at local level has been instrumental in enforcing the disincentives.

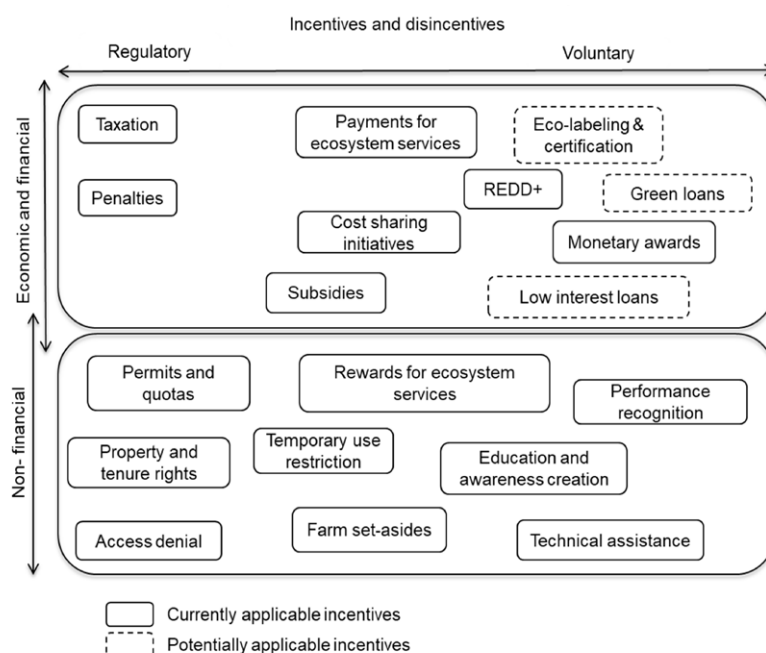


Figure 5.1 Coordination across landscape sectors, levels and actors.

## KEYWORDS

Incentives, disincentives, forest landscape restoration, ecosystem services, local knowledge and institutions

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# Actor's position and relation in the initiation of conservation sites extension on the landscape of western Java's upland

Western Java's upland area covers West Java and part of Central Java Provincial Administration area, which is one of the sanctuaries of important biodiversity in Indonesia for avifauna, primates and mammals. Particularly for avifauna, the upland area became the last sanctuary after the disturbance and distraction by anthropogenic activities such as agriculture, plantations, settlements or infrastructure. On the other side, Java Island is facing constant pressure by human interventions affecting the decline of its ecological carrying capacity. The frequency of hydrometeorological disasters, water crisis threats, and the jeopardy on the biodiversity become indicators that the island must increase its ecological carrying capacity. From the collision of two interests, the following question is raised: Is there still any opportunity to expand the conservation site in western Java as an effort to increase the island's carrying capacity? To address that question, this research intended to find the opportunity through the lens of actors. The research uses the Collaboration/Conflict, Legitimacy, Interest and Power (CLIP) framework in the Provinces of West Java and Central Java covering 21 upland areas to identify response, position, and inter-actor relations if the extension of the conservation site on the landscape of western Java's upland is implemented. Through the interaction of various actors, the research found that to allow collaborative and less conflictual conservation site extension efforts, there are five conditions that need to apply: the availability of existing sites that qualify for ecosystem rehabilitation, the willingness of the land right holder to provide land for conservation voluntarily, the availability of institutional arrangements and monitoring mechanisms on sites, the compatibility with the regional government's spatial plan, and minimum potential of conflict of interest. In general, there is a conflictual relation between actors but commonly not manifested, causing difficulties for creating a common vision to manage and develop forest management collaboratively. Mostly, the initiatives come from the non-governmental organizations and academicians as the representatives of a habitat's interests, but we only get insignificant responses from the policy makers. A landscape approach offering multisector, multiactor, and multi-interest management is a solution to keep all stakeholders involved in the conservation effort without losing their control over the forest. The approach also ensures that forest can be multifunctional, where conservation also can be implemented together with production and social welfare. Regarding the five clusters of research, the study found that the Southern Bandung cluster has the highest potential for the extension because it gives the opportunity for multistakeholders to collaborate. Actors in this cluster have an open mind about the dynamics and the discourse of conservation, inclusive governance, and many dominant actors have sufficient power to change the policy.

## KEYWORDS

Conservation site extension, western Java's upland, landscape approach, multiactor, CLIP framework

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# Assessing governance in the landscape of the Upper Suriname River area

Landscapes are defined as coherent and multi-functional geographical areas where multiple stakeholders and their interests are connected. Often conflicting claims to the land and competing interests exist. It is essential to understand how a landscape perspective, as an integrated approach to governance, can be used to balance the different interests in the decision-making process and coordinate spatial rules and regulations for sustainable resource management. The Upper Suriname River area provides various ecosystem services and products to the local Saamaka community. Increased accessibility to the area and intensification of land use may result in an increase in the likelihood of land use conflicts.

This study aims to assess governance in the landscape in order to 1) identify challenges in landscape governance through a participatory baseline analysis, and 2) promote dialogue among stakeholders and help identify strategies for improved governance. Stakeholders of the area discussed and scored four performance criteria, each with their own indicators, on inclusive decision making, culture of collaboration, coordination across landscape sectors, levels, and actors, and sustainable landscape thinking and action. Of all indicators, accountability has the lowest score and sense of community the highest. The results showed that there are different governance systems in the landscape, but that there is insufficient vertical and horizontal coordination. There is also a need for transparency and accountability. Next steps in the study include facilitating a multistakeholder platform. The assessment will be repeated in the next year to see how the performance criteria have improved.

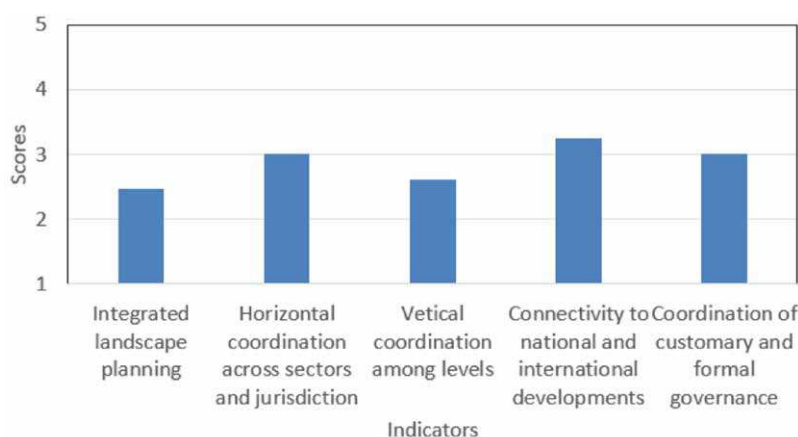


Figure 5.2 Coordination across landscape sectors, levels and actors.

## KEYWORDS

Landscape governance, land use, decision making, participatory

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# The contribution of community forestry to the Sustainable Development Goals (SDGs): Case of community forest concessions in the Maya Biosphere Reserve, Petén, Guatemala

In the Maya Biosphere Reserve (RBM) in Guatemala, a process has been developed for more than 20 years for forest management through a forest concession system under the administration of the National Council of Protected Areas (CONAP). These concessions were granted to 12 community groups and 2 local industrial companies in order to stop deforestation in the Multiple Use Zone (ZUM) that covers an area of around half a million hectares under concession. One of the requirements for the management of the concessions was to obtain forest certification and keep it valid throughout the contract period.

The contribution of community forestry to the Sustainable Development Goals (SDGs) of the nine active community concessions was evaluated. For this, the goals of each of the SDGs related to the work carried out in the concession process were selected. A series of indicators was constructed, using a qualitative methodology to obtain data from a variety of sources through a review of technical, scientific and gray literature and key actors.

Community concessions in Guatemala were found to contribute to the scope of the 17 SDGs and contributions were identified in 45 of the 162 targets. Their contribution to the well-being of people in economic, food, health, and education terms is highlighted, as well as its contribution to the conservation of forests, cultural heritage and the environment in general, through practices of sustainable use of timber forest resources, non-timber products, tourism and others.

The concessions in Petén constitute a public-private alliance that involves the local population in the management of natural resources in a transparent, organized and planned manner, as a powerful tool that contributes to peace and social justice, as well as to human development and sustainability.



Photo 5.1 Mr. Carlos Chi. – Concessionaire  
Integral Forest Association of San Andres Peten AFISAP

## KEYWORDS

**Sustainable Development Goals (SDGs), Maya Biosphere Reserve (RBM), forest concessions, community forest management, community forestry**

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# Strengthening the participatory process of reconciling forest, agriculture and other land use data at the local level in Indonesia

Inaccuracy and dissimilarity of the data on the land use planning process are always considered as the core problem of data conflict in Indonesia. A lot of effort has been put in by the government to solve this problem. Since 2011, the Government of Indonesia (GoI) already issued Law number 4/2011 on Geospatial Information. This law makes it mandatory to produce an Indonesia National Standard (SNI) on spatial maps. Based on the regulation hierarchy, there is a mandate to develop the derivation of this law into technical regulation.

The delay in making derivative rules resulted in business-as-usual practice in local government. It is consequently causing more conflicts in data on land use planning. In 2015, the GoI issued the Economic Strategic Policy Package number VIII, which contained the One Map Policy, referring to the government's priority to establish a geospatial reference, one standard, one database, and one geoportal to accelerate the implementation of national development. As part of the decision, a clear work plan was also prepared to form the basis for implementing one-map initiatives across the country.

Although the policy has established firm commitments and intentions from the GoI, its implementation still has to face several challenges at the local level, such as the unavailability of formal procedures, guidelines and mechanisms in dealing with data conflicts. Based on this condition, we used the Driver–Pressure–State–Impact–Response (DPSIR) framework in multistakeholder-participatory processes to identify the driving force of problems and most suitable responses to address conflict data on land use planning in Indonesia through provinces and districts. The methods consist of several key steps to obtain: (1) compilation of Indonesian National Standard (SNI) data, (2) analysis of the overlapped data; (3) development of the typology of data conflict; (4) discussion among stakeholders and decision-maker; (5) a field survey and ground checking; and (6) prioritization of the data reconciliation process.

This study showed that there are many conflicts over forestry, community plantations, large-scale plantations, agriculture and various other land uses that exist today. The list of problems and recommendations for participatory resolution was successfully identified, and a framework was built that can be used as a reference by the government to be legalized in policies in conflict reconciliation of the data. Those are very much needed to support the development process in the forestry and agriculture sectors at the local level and wherever there are various uses of land for multiple needs.

## KEYWORDS

Land use conflict, driver, reconciliation, planning, governance

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# Policy gaps and opportunities for scaling agroforestry to meet climate change, biodiversity and restoration challenges in sub-Saharan Africa

Agroforestry is an effective response to combat climate change, reverse land degradation, and enhance biodiversity on farms and pastoral lands while enhancing livelihood and nutrition benefits to millions of people in sub-Saharan Africa. However, the policy space and institutional challenges can limit adoption and scaling up of agroforestry, reducing the capacity to realize its full potential. Through systematic desk reviews, national workshops and discussions with local communities, we interrogated key policies in agriculture, the environment and climate change that affect agroforestry implementation in eight countries in sub-Saharan Africa. We identified opportunities, gaps and challenges for scaling of agroforestry. These include lack of policies to support agroforestry as well as limitations in existing policies, fragmentation and lack of coordination among relevant sectors and stakeholders, and inadequate capacity for implementation, including insufficient or ineffective resourcing and advisory services. The opportunities include the existence of relevant policies, strategies and institutions that can be strengthened through the various ways outlined in the paper. Five recommendation domains to create an enabling policy, legal and institutional environment for agroforestry development were identified through the study, which are: Develop and implement a national policy, strategy and action plan for agroforestry development; Coordinate implementation of agroforestry development; Land and tree tenure must be secure; Integrated research, advisory services and monitoring and learning systems are needed; Provide incentives.

## KEYWORDS

Agroforestry, restoration, climate change, biodiversity, food security

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# Operationalizing the landscape approach in Indonesia: Landscape governance in fostering an integrated landscape management approach

Aiming to restore 41.2 million ha of degraded forest lands, the landscape-based approach has been promoted to overcome competing commercial land uses in Indonesia, with the main challenge coming from the lack of integrated planning. This paper discusses options to operationalize the landscape approach using landscape governance principles applied under adaptive collaborative management (ACM). Three cases representing different management approaches and three landscape characteristics are discussed: (i) the Ecosystem Restoration Concession Model in Sumatra with the dominant forest landscape; (ii) the Forest Management Unit Model in Yogyakarta in Java with a mosaic landscape following an intensive agriculture-and-forest interface; (iii) in West Timor and Sumbawa of the Eastern Indonesia, the grand strategy document on integrated timber and non-timber forest products production at the landscape level has been developed under a participatory approach.

The paper used landscape governance within the framework of the integrated landscape management approach (ILMA) in recognizing the multi-functionality and multiple objectives of different competing or complementary land uses. Further, AMC prioritizes an inclusive and participatory approach that is then applied to map components under landscape governance in the three landscape-based management schemes. Important findings included different approaches in defining the landscape boundaries that could include central government-driven jurisdictional approaches and combined approaches using different criteria. Using a participatory approach in defining the landscape boundaries fosters more systematic processes in operationalizing the landscape approach, even under central government-driven jurisdictional approaches.

## KEYWORDS

Operationalizing landscape approach, policy and socioeconomic perspectives, integrated agroforestry management

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# Unpacking ‘gender’ in joint forest management: Lessons from two Indian states

Gender inequalities and social exclusions in community-based forest management have garnered attention, particularly in South Asia (e.g. Agarwal 2010; Nightingale 2011). Yet, framings that homogenize women and marginalized groups fail to capture the nuanced processes by which such exclusions occur. Despite provisions for women in local community management institutions, numerous constraints hinder their active participation in forest governance (Agarwal 2001). Understanding participation in joint forest management (JFM) requires attention not only to gender, but also to the diversified interests and experiences women hold and the unequal power relations in which they are enmeshed. Based on semi-structured interviews with women and men farmers, JFM committee members, local authorities, NGO staff and Forest Department officials, we explore emic perspectives of how social differentiation shapes participation in JFM. We compare the situation in Karnataka, a wealthier Indian state that is considered exemplary for JFM, with that in Madhya Pradesh, a poorer Indian state inhabited by tribal populations, where JFM is poorly functional. We show that exclusions in Uttara Kannada occur along gender and caste lines, whereas among tribal groups in Mandla, women of certain ethnicities are particularly disadvantaged in JFM despite their extensive forest use. Classifying marginalized groups into homogeneous categories (e.g. as Scheduled Tribes or Scheduled Castes), as do Indian laws addressing tribal issues, detracts focus from the inequalities that occur among groups, and from their relevance in shaping local experiences. Place-based environmental and political economic histories further shape local interests and participation in JFM. We argue that a focus on gender is necessary but not sufficient to understand social exclusions in JFM, and that gender must be understood in relation to other factors of social differentiation.

## KEYWORDS

**Social inclusion, intersectionality, collaborative governance, gender norms, caste**

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# Is there a need to consider policy implementation theory in landscape and jurisdictional governance debates? Preliminary insights from an implementation assessment of 11 initiatives in the Brazilian Amazon

The rates of deforestation in the Brazilian Amazon have soared in recent years, even though these numbers were significantly reduced in relation to historical averages between 2004 and 2012. While policy changes and enforcement strategies implemented by the Brazilian federal government have been identified in the literature as the main causes for the success in reducing deforestation in that period, state-level policies that were implemented in the same period have also been found to have a significant impact. Nevertheless, evaluation studies of these state-level initiatives have focused only on their effects on the rates of deforestation, while neglecting the processes of implementation behind the successes and failures of these state initiatives. This paper aims to fill this gap by conducting an ex post evaluation of the implementation processes of three key policies adopted by the State of Pará: the Pará 2030 program, the Green Municipalities program, and the Plan of Action for the Prevention Control of Deforestation in the Amazon PPCDA . It adopts the notion of polity, one of the three dimensions of governance, that refers to the formal and informal rules of the game; in other words, “the institutional architecture in which politics and policy-making take place” (Lange et al. 2013 ). By conducting semi-structured interviews and surveys with policy makers and ‘street-level bureaucrats’ in the state of Pará, we will process-trace the policies’ implementation processes by identifying the theory of change behind each intervention, and then linking it to the inputs, processes and outputs observed in each case. This analysis will shed light on the causal mechanisms behind the successes and failures in the implementation of these interventions, exploring aspects of the policies’ cycles that have been black boxed in previous evaluation studies. By doing so, this paper leverages important insights to the global debates on jurisdictional approaches and overall discussions on how states, corporations and civil society organizations should align efforts to reduce deforestation.

## KEYWORDS

Zero deforestation, low-emission development, governance, polity, Brazilian Amazon

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## Empowering local governments for low carbon development planning in Indonesia

Low carbon development (LCD) aims for climate change mitigation without making sacrifices to development. This approach has been widely adopted, especially in developing countries. The Government of Indonesia has embraced the principle within the new national medium-term development. The LCD planning process requires an approach that allows interaction between the economic and environmental factors. One model that is simple and suitable to be used at the regional level is the environmentally extended input-output (EEIO) model. The EEIO model integrated the conventional input-output model of transactions of economic sectors with the environmental factors consisting of agriculture, forestry, energy consumption and waste production. The interaction between both groups of factors produces an indicator called emission intensity that captures the magnitude of emissions resulted per unit of monetary GDP being produced. Policy scenarios that are simulated in the EEIO model will offer outputs to be used in trade-off analysis and in developing an LCD plan. Under the LCD plan, it is expected that the emission intensity can be reduced, i.e. a decrease in carbon emissions in the economic activities that produces the GDP, without reducing the GDP. The EEIO approach is adapted into a tool called Red-CLUWE.id (Reducing Carbon Intensity from Land Use, Waste, and Energy sectors), that is currently being developed by ICRAF to be used for province-level planning processes in Indonesia, as requested by the Ministry of Development Planning. Red-CLUWE.id facilitates the province-level governments to carry out integrated low-carbon development planning across sectors. It has been tested and applied in a handful of training series to the province-level governments. This simple but integrated tool allows local planners and practitioners to solve the climate crisis and achieve sustainable development at their jurisdictional level, and eventually national level, without compromising development and economic growth.

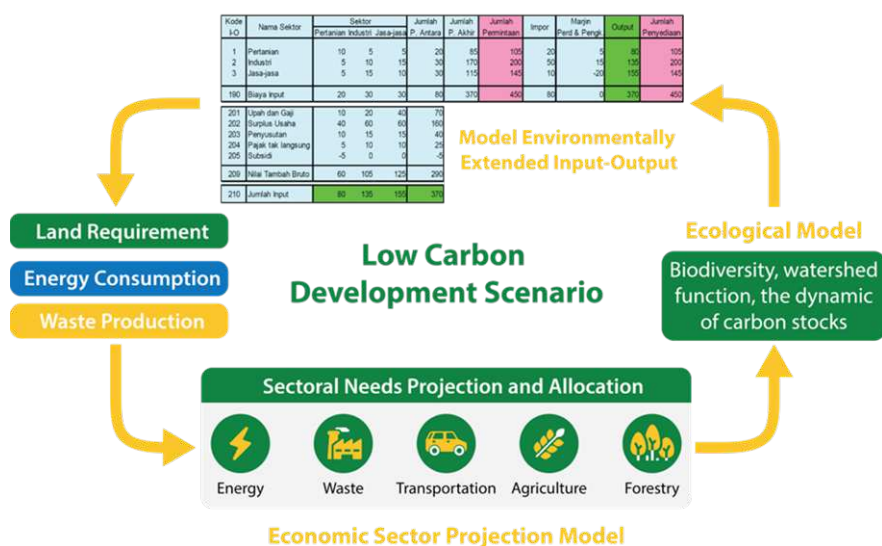


Figure 5.3 The Framework of Low Carbon Development Planning.

## KEYWORDS

**Keywords:** Climate, environmentally extended input output (EEIO), low carbon development

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# Analysis of governance in urban wetlands: A case study on the Las Piñas–Parañaque Critical Habitat and Ecotourism Area (LPPCHEA), Metro Manila, Philippines

Wetlands are among the most productive but most threatened ecosystems in the world. With the increasing urbanization, wetlands continue to be developed and exploited, while more actors get involved in their governance. Weak institutional arrangements and lack of well-established coordination are regarded to be indirect drivers of change that negatively impact wetlands, mangrove forests, and their resources. This study aimed to assess how institutional arrangements affect coordination of actors in the management of an urban wetland. Understanding how institutional arrangements affect the level and nature of coordination are instrumental in identifying appropriate management strategies to address the problems in the aforesaid site. The multi-functional nature and services of urban ecosystems, particularly wetlands, are vulnerable to threats associated with urbanization, climate change and land use change, and thus, sustainable management is in dire need. The study investigated the governance network of Las Piñas–Parañaque Critical Habitat and Ecotourism Area (LPPCHEA) in Metro Manila, Philippines, which is a wetland park and protected area bordering two highly urbanized cities. It is a declared Ramsar site under the Ramsar Convention of UNESCO for its significant biological features. It is also considered as the last remaining mangrove frontier in Metro Manila. A multi-institutional management council manages LPPCHEA. For this study, semi-structured interviews and a document review of relevant secondary data were employed. Data were analyzed using ATLAS.TI, a type of qualitative data analysis software. Findings revealed that there are existing laws, policies and regulations mainly supporting the conservation of LPPCHEA. Actors are highly knowledgeable of their roles and responsibilities within their mandate. Despite the presence of a legal framework, neglect in coordination was observed due to unclear delineation of roles and responsibilities and undocumented agreements. In some instances, overlapping of roles is duties are found.

Coordination among these actors ranged from low to high ratings. Weak institutional arrangements created institutional complexity in the network. The findings of this study benefit the institutions and may serve as a guide to understand the complexity in managing urban wetlands within the environmental limits. It may provide recommendations to practitioners and policy makers towards developing an effective management approach and scientific policy, respectively, that is lacking in the field of urban wetland management.

## KEYWORDS

Wetland, urban, governance, mangroves

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# Participation for inclusive and sustainable landscapes, or why achieving more equitable and resilient multi-stakeholder forums requires reflexive and adaptive learning

This presentation examines the participatory development, implementation and impact pathway for a monitoring tool to facilitate reflexive and adaptive learning in multi-stakeholder forums (MSFs). The tool, developed by a team of CIFOR Scientists, MSF participants in Indonesia and Peru, and partners from an indigenous organization (Organization of Indigenous Andean and Amazonian Women), has recently been adopted by the Peruvian Natural Protected Areas Service (SERNANP) as an official tool to monitor its own participatory processes.

A recent realist synthesis review of the scholarly literature on MSFs carried out by CIFOR revealed that those forums that integrate adaptive learning into their processes are more likely to reach equitable and effective outcomes (Sarmiento Barletti et al. 2020). To apply this finding while supporting research participants – grassroots members of the National Organization of Andean and Amazonian Indigenous Women of Peru (ONAMIAP) and SERNANP's participatory governance team – CIFOR facilitated the development of a tool as part of an engagement phase with the participants of two forums that were part of its comparative study of multi-stakeholder forums; this study included research in 14 sites in Brazil, Ethiopia, Indonesia and Peru. Research focused on forums at the subnational level that were set up to address land use, land use change and forestry issues, and brought together government, non- governmental, grassroots and private sector stakeholders. Two MSFs legally required as part of the governance of protected areas in the Peruvian Amazon and a climate change-related MSF in Indonesia were selected for tool development.

Tool development was inspired in research findings but also responded to participants' desire to reflect and learn about their process from within rather than being evaluated from without through indicators that may not reflect their priorities or aspirations for their forum. MSF participants also noted the 'technical' aspect of the tools available, which did not invite much reflection on or learning from or discussion about their forums' processes and goals. The process led to the development of six research-based indicators, derived from CIFOR's analysis and 12 'local' indicators in total, derived from 4 workshops carried out with each MSF; another 1 with ONAMIAP, and validated at a final workshop with SERNANP staff. Each indicator was designed as a statement for participants to agree or disagree with. These were followed by a set of four discussion questions aimed at guiding reflections related to the indicator. Following reflection, participants noted down the three main lessons arrived at from the discussion questions, and recognized the three main challenges to improving the indicator by the next monitoring period and how they would address them.

The presentation discusses the method through which the tool and its impact pathway were developed, as well as lessons learned for effective science for impact from the design, implementation and engagement process as the tool was adjusted to SERNANP's needs, while respecting the priorities of participants at workshops. The presentation will close by engaging with scholarly and practice-based debates on participatory monitoring approaches – both to developing and implementing tools – as part of equitable and resilient land use and forestry initiatives and problematize the idea of 'unbiased' monitoring methods.

## KEYWORDS

Participation, monitoring, social learning, impact, sustainability

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# In the face of persistent challenges, would Ethiopia achieve its FLR target by 2030?

Ethiopia is halfway through the implementation of its widely talked about Climate Resilient Green Economy Strategy that aims to protect existing natural forests and re-establish forests so that forests can sequester half of the nation's carbon emissions by 2030. Ethiopia is set to rehabilitate 22 million ha of degraded forests and lands through participatory forest management (PFM) (to sustainably manage natural forests), area enclosures (to restore degraded hillsides and other communal lands), sustainable land management (SLM) (using soil and water conservation measures on private and communal farm and grazing lands), and large-scale national tree planting campaigns (to increase tree cover). SLM initiatives are costly and attract donor-assisted investments but hardly integrate trees on rehabilitated landscapes. NGOs are actively leading PFM while GOs are spearheading other initiatives. Although these initiatives have enjoyed high-level target-setting and mass mobilization support, which can be mentioned as strengths, they are still fragmented, lack proper planning and monitoring, leave economic objectives in favor of conservation, fail to actively engage communities in objective setting and identifying means to achieve objectives, in reconciling socio-economic and conservation goals, in clarifying landownership and use rights, and in addressing institutional weaknesses of both government and community-based organizations at local levels. The major actors in FLR, the state, NGOs and communities rarely come together to review and learn from experiences and facilitate scaling up of successful practices. FLR initiatives also fail to align with nationally prioritized areas for FLR. Community-based collective governance is yet to be promoted to help ensure equitable distribution of costs and benefits arising from FLR interventions. Using quantitative and qualitative data from rehabilitated landscapes, we conclude that unless the chronic challenges are addressed, Ethiopia may not be able to achieve its FLR targets. Specific recommendations are provided to address these challenges.

## KEYWORDS

Area enclosure, participatory forest management, sustainable land management, community participation, forest land tenure

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# One Map initiative to support land use and development planning in Papua and South Sumatra, Indonesia

Green growth is a pathway to achieving sustainable development goals of Indonesia. Green growth planning is crucial in directing the pathway, with a sustainable land use plan that allocates land to meet multiple functions and needs being the foundation of it. One of the biggest obstacles to land use planning throughout Indonesia is the lack of available, accurate, and easily accessible data and information on biophysical data, such as land suitability, socio-economic characteristics, and land-related policies and regulations.

In 2015, the Government of Indonesia issued Policy Package number VIII of the Economic Strategy, which includes the One Map Policy. This policy puts the geospatial information systems development on the front burner. These information systems are to adhere to one standard, one database, and one geoportal and the implementation is mandated nation-wide. However, implementation faces numerous challenges at the subnational level, due to: (1) the lack of strong technical capacity of the local governments and other stakeholders in compiling, integrating and synchronizing maps; and (2) no clear principles, procedures, guidelines and mechanisms in dealing with data conflicts and inconsistencies, which is very common across various datasets produced and maintained by different sectors in Indonesia.

This three-year study by ICRAF aimed to strengthen the capacity of local governments in developing and managing their one map systems as well as providing them with the technical tools and how-to guidelines. The targeted areas are South Sumatra and Papua provinces, with one district in each province to pilot the vertical coordination in developing one map systems. We develop a capacity development needs assessment tool to assess the capacity of stakeholders in developing and managing a one map system that contains relevant data and information on land uses, and land use-related factors and development.

The tool also allows the assessment of increased stakeholders' capacity after the study has been implemented. In addressing the data reconciliation, we develop a technical, semi-automated tool to allow stakeholders to compile, integrate and synchronize their data and information. We adopted the Planning Unit Reconciliation module of LUMENS (Land Use Planning for Multiple Environmental Services) and the Drivers–Pressure–State–Impact–Response (DPSIR) approach to assist stakeholders in formulating the options to solve the data conflicts and inconsistencies.

The assessment conducted after the study showed improvement of capacities of the government officers in all targeted locations in terms of the system, institutional and technical aspects in developing and managing one map systems. In particular, improvement was shown in the understanding and commitment of the stakeholders in adhering to the one map regulation at the province and regency levels, in the standards and procedures of one map implementation, and in the active one map working group to implementing the compilation, integration and synchronization processes. Beyond the project implementation, the strong commitment and consistency of the government are key in maintaining the one map systems. The pathway to this is by getting policy and regulations in place. Within the four target jurisdictions, three have formalized their commitments in the form of local regulation.

## KEYWORDS

Data and information management, capacity strengthening, One Map initiative, data reconciliation

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# Achieving green growth through inclusive and evidence-based planning as a jurisdictional landscape approach

The Green Growth Program was launched in Indonesia in 2013 by the Ministry of National Development Planning and aimed for: (1) sustainable economic growth, (2) inclusive and equitable growth, (3) economic, social and environmental resilience, (4) healthy and productive ecosystems in ecosystem services provisions, and (5) reduction of greenhouse gas emissions. Some provinces in Indonesia have produced their Green Growth Masterplan and Roadmap (GGP), specifically for the land sector and other related sectors, by integrating a land use plan and spatial plan with their development plan.

Considering the critical roles of lowland areas, landscape-level analysis of lowland ecosystems has been conducted in conjunction with jurisdictional planning of South Sumatra, Jambi and Papua provinces. While the agriculture sector's contribution to regional GDP is in the range of 9–16% in the three provinces, for lowland areas it does contribute 63–88%. The linkages between the agricultural sector and the other economic sectors are less or close to 1, indicating that not much economic multiplier effect is generated in the regions. Depending on the lowland management, the emissions produced by lowland areas can be way beyond their proportional areas. The lowlands in South Sumatra contribute 78% of the total emissions of the province from only 36% of the total area. The three provinces have common strategies within their GGP, namely: sustainable land use planning; restoration and increased land productivity, including through diversification; improvement of value chains and connectivity; and maintenance of ecosystem services. The provincial context also influences the GGP strategy. Fire management is huge in South Sumatra; Jambi has sub-province strategies and Papua has integrated village development. Setting aside the lowland only, in South Sumatra Province, the green growth scenario can increase regional GDP by 5% compared with BAU; by 8.6% in Jambi Province; and by 11.6% in Papua Province.

South Sumatra has the largest potential to reduce emissions from lowland areas compared with the other two provinces. Papua has the highest potential to increase regional GDP, while at the same time reducing emissions significantly. Jambi's potential for emission reduction in lowland areas is low, which also reflects the low share in emissions of these lowland areas (21% from total). The emissions intensity of Jambi's lowland areas is also the lowest among the three. Considering that Jambi is the only province that has a specific zoning strategy based on its ecosystems, we assume that other economic sectors play more significant roles than do the agricultural sector in lowland areas. Unfortunately, there is no available disaggregated data for lowland GDRP for non-land-based sectors.

Whilst the tool, framework and ideas of GGP have been taking its momentum, the implementation side of it is yet to be pushed further. Public funding, partnerships with the private sector, performance-based financing and blended financing are yet to be explored. Equipped by a set of indicators, GGP should be ready to take the next step, if the funding is available.

## KEYWORDS

Green growth, sustainable development, landscape approach

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## **STREAM 6**

Designing, implementing and evaluating  
research for development impact



## STREAM 6

### Designing, implementing and evaluating research for development impact

Researchers are under increasing pressure to demonstrate that the research they do contributes to positive change and helps to solve pressing societal challenges. As a result, research is being conducted in a more transdisciplinary way, with deliberate efforts to engage stakeholders in the co-generation and co-production of research, and to incorporate processes and partnerships that facilitate knowledge translation.

Appropriate evaluation is needed, not only to evidence research impact, but also to generate learning to improve research design and increase impact. Given that an increasing amount of research for development is being done in a more engaged transdisciplinary way, intervening on multiple variables, and with multiple pathways to impact, reductionist experimental and quasi-experimental impact assessment methods are not sufficient because they do not accommodate complexity well.

This Stream focused on the challenges related to evaluating and measuring research impact, and discussed the need for a complex-aware approach to research evaluation that challenges researchers to broaden their scope and ensure societal relevance in their research.



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# Applying the principles: What lessons can Viet Nam country case contribute to the assessment of FTA's integrated impacts?

Assessing the impacts of research projects has been the focal interest of not only researchers but also donors and concerned government agencies. On the one hand, such assessments are expected to provide evidence of the achievements of intended research objectives (e.g. developmental and environmental impacts) as well as of the quality and effectiveness of research. On the other hand, lessons learned from assessments will also support learning and adaptive management in research projects as well as in designing future research programs/projects. Assessing the impacts of the Forests, Trees and Agroforestry (FTA) program is a challenging task, as it is an integrated program with five distinct research themes, under each of which there are multiple (bilateral) projects. At the same time, FTA is expected to come up with solutions to address pressing societal problems and contribute to create impacts at scale. Over the last few years, a number of FTA research projects have been implemented in Viet Nam both by CIFOR and ICRAF. Yet, there has been no assessment to date on the integrated impacts that FTA research projects have generated in the country.

This presentation provides the audience an update of the process as well as the preliminary findings from the application of FTA's impact evidencing strategy in the context of Viet Nam. The assessment takes place in 2020 and aims to provide evidence for the 'impact stories' that FTA has generated in Viet Nam in terms of adoption of improved varieties and improved management practices, increase in yield for key food staples, poverty alleviation, reduction of agricultural-related greenhouse gas emissions, prevention of land degradation and restoration of degraded land, and avoided deforestation. Findings from the assessment are also expected to contribute to improved learning and experience sharing, as well as the design and management of ongoing and future research programs. Most importantly, the experience from Viet Nam will contribute to improve FTA's integrated impact assessment methodology.

## KEYWORDS

Assessment method, environmental impacts, development, learning, Viet Nam

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## Assessing the effectiveness of FTA research on the oil palm sector

A substantial portion of FTA research aims to contribute to impacts by informing and influencing policy and practice in forest, agroforest and landscape management. A prime example is CIFOR's program of research on the oil palm sector in Indonesia since the early 2010s. This research has engaged with a wide range of stakeholders to provide research-based information and analysis, as well as capacity strengthening and networking, to influence the policy discourse and decision-making. A series of projects have researched social and environmental trade-offs, sustainable commodity supply, social inclusion in the oil palm sector, and biodiversity conservation, and other topics related to oil palm production and trade in Indonesia and internationally. This study applies a theory-based outcome evaluation approach (Belcher et al. 2020) to assess the societal contributions of four of these projects. The analysis explores the multiple impact pathways through which the research contributed to policy and practice changes in the oil palm sector, the extent of those changes and how they were realized, as well as gaps and opportunities to improve research design, implementation, adaptive management and evaluation for effectiveness. The lessons apply directly to ongoing oil palm research and more broadly to policy-oriented research-for-development.

**KEYWORDS**

Outcome evaluation, research evaluation, oil palm

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# Evaluating the restoration of the commons: A quasi-experimental impact assessment of a large-scale land restoration initiative in India founded on the tenets of local collective action and property rights

The Foundation for Ecological Security (FES) is spearheading the ambitious Promise of Commons (PoC) initiative, which aims to restore 30 million acres<sup>1</sup> of degraded common lands (primarily forests and pastureland) across eight states in India by 2023. This intervention will present the design of a quasi-experimental impact assessment that is being pursued to evaluate both the longer-term and intermediate outcomes of the core intervention model FES employs at the village/habitation level in four states—Andhra Pradesh, Karnataka, Odisha and Rajasthan.

This intervention model was significantly informed by CGIAR research and engagement on collective action, property rights, and landscape governance, most notably through the CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI). The study is situated in the context of a multifaceted impact assessment strategy for the PoC initiative. Here, in addition to this study, a longer-term phase-in design is being pursued and, within it, one or more imbedded field experiments aimed at optimizing FES's intervention model. This quasi-experimental study takes advantage of a large initial round of data collection taking place under this overarching impact assessment strategy. Propensity score matching (PSM) has been used to identify a set of currently unreachable revenue villages that are statistically similar (vis-à-vis FES's official targeting criteria) to others where it has intervened from 2000 to 2015. Following data collection in at least 72 'treated' and 216 'untreated' habitations – which are all (save for those in Andhra Pradesh) nested within these matched revenue villages – a second round of matching will ensure that these 'treated' habitations are, themselves, statistically similar to their untreated counterparts against more refined, habitation-specific measures of the targeting criteria. The two sets of habitations will then be compared against selected ecological, socioeconomic and institutional outcomes measures. Difference-in-differences estimation with reconstructed baseline data (via remote sensing and respondent recall) will be used to further mitigate program placement bias, and qualitative follow-up work will be undertaken to add depth to key findings and interrogate unexpected or perplexing results. Ecosystem services valuation work will further aid enhancing the study's policy relevance. Given that the above matching process inevitably sacrifices external validity at the expense of internal validity, we will complement the main study with an analysis of land health indicator trends vis-à-vis indicators derived via remote sensing on a statistically representative sample (~400) of intervention habitations (>5000) located in the four main states in which FES directly intervenes.

<sup>1</sup> 12 million hectares

## KEYWORDS

Land restoration, impact assessment, common pool resources, property rights, collective action

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# Assessing progress towards realizing FTA's collective end-of-program outcomes and estimating potential impacts

Precisely measuring FTA's achievement of (or contribution to) its set targets is a challenging task. Started in 2010, FTA CRP comprises five distinct research themes (i.e. flagship projects [FPs]), and each FP comprises multiple projects, most of which are funded bilaterally. Moreover, the program targets a set of 25 demand-driven operational priorities focusing on different areas of the program.

Approaching the end of FTA phase 2 implementation in 2022, an Integrated Impact Estimation Strategy was developed by Hughes (2019) to demonstrate how FTA has been able to address five key global challenges since its inception in 2010, namely:

1. Accelerating rates of deforestation and forest degradation
2. High prevalence of degraded land and ecosystem services
3. Unsustainable land use practices widespread
4. Persistent rural poverty with increasing levels of vulnerability
5. Rising demand and need for nutritious food for both current and future generations.

These challenges have been addressed by multiple strands of research cutting across the program's five FPs and undertaken by various global, regional and country research teams. Assessing both the importance and scale of the challenges on the one hand and documenting and evaluating what is being done to address them on the other is expected to facilitate a fair and holistic assessment of the extent to which the program has contributed to the targets. Evaluating each individual research project separately would be infeasible and would not capture the collective and synergistic contributions at the program scale. It would further risk missing the added value of the program, as individual projects and operational priorities target different components of FTA's theory of change. In addition, FTA's research initiatives are at different maturity levels. As such, assessing the impact of each in isolation would undervalue their potential scientific and impact contributions, failing to explicate the program's integrated 'impact story'.

The FTA's impact evidencing strategy comprises the following five elements:

1. Challenge framing: Expounding on the nature of the challenges FTA is working to address – including their associated cause and effect mechanisms – is a key step in the strategy. This is expected to assist in estimating plausible ranges of FTA's actual and potential impact contributions.
2. Research and engagement documentation: Efforts will be made to systematically document what work has and is being undertaken vis-à-vis each challenge. This will aid in identifying the specific root causes and effects that are being addressed, as well as setting things up from the impact estimation framework's subsequent steps.
3. Overarching and nested theory of change specification: To further structure the evaluative work associated with the above five challenges, the implicit and overarching theories of change for FTA's collective efforts vis-à-vis each challenge will be explicated.
4. Evidence synthesis: Several FTA project and program evaluations have already been carried out. An obvious starting point will, therefore, be to compile and synthesize this evidence.
5. Evaluation execution: Building on the research-to-impact framework developed by Ofir et al. (2016), different approaches to monitoring, evaluation and learning (MEL) are required within each sphere.

The CIFOR Research to Impact (RTI) team, ICRAF Impact Acceleration and Assessment (IAA) unit, the Royal Roads University (RRU) and the Alliance of Bioversity International and CIAT Development Impact Unit have joined forces since June 2020 to implement and execute the strategy, assessing progress towards realizing FTA's collective end-of-program outcomes and estimating potential impacts.

The presentation and discussion will provide further details on the evaluation approach that is being followed, progress to date, key challenges and the way forward.

## KEYWORDS

FTA, impact assessment, outcome evaluation

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# Research quality and impact for place-based, complex research

Much of the research done by FTA aims to inform and support desirable changes in the state of landscapes and livelihoods, and these changes are generally labeled as 'impact'. The complexity of the problems and context-specificity of results mean that some commonly used approaches to assessing research quality and impact are not useful for assessing the impact arising from this type of work. To address this problem, we use two methodological frameworks, i) the issue–attention cycle (Downs 1972) and ii) the R-in-D (research in development) paradigm (Coe et al. 2014) to explore the connections amongst methods, quality and impact of research aiming to influence policy change and farmer practices, respectively. This analysis suggests that impacts arise through different pathways, from outputs derived at all steps in the application of these methodological cycles, rather than simply occurring as the end result of a linear process. Evaluating and making the most of these multiple pathways to impact requires more diverse approaches and indicators than those routinely used in research organizations today. Navigating complex networks to impact requires concomitant diversity in how research quality is defined and assessed.

## KEYWORDS

Impact, policy, context specific, research quality

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## A quality assessment framework for transdisciplinary research

Researchers and research organizations are under increasing pressure to demonstrate that their work contributes to positive change and helps solve pressing societal challenges. There is a simultaneous trend toward more engaged, transdisciplinary research (TDR) that is complexity-aware and appreciates that change happens through systems transformation, not only through technological innovation. Research increasingly seeks both to generate knowledge and contribute to real-world solutions, with strong emphasis on context and social engagement. As boundaries between disciplines are crossed, and as research engages more with stakeholders in complex systems, traditional academic definitions and criteria of research quality are no longer sufficient. There is a need for a parallel evolution of principles and criteria to define and evaluate research quality in a TDR context. We built on a prototype TDR quality assessment framework developed from a systematic review of the literature (Belcher et al. 2016) and experience as researchers in a research-for-development context. Four main principles emerged: relevance, including social significance and applicability; credibility, including criteria of integration and reflexivity which supplement traditional criteria of scientific rigor; legitimacy, including criteria of inclusion and fair representation of stakeholder interests; and effectiveness, with criteria that assess the degree to which research is positioned for use. We have applied, tested and refined the 2016 framework. This presentation provides an overview of the key concepts, presents the revised framework and scoring tools, and summarizes lessons learned for applying the framework for research planning, monitoring and assessment (ex ante and ex post).

**KEYWORDS**

Research evaluation, transdisciplinary, sustainability science, research quality

**REFERENCES**

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# Stage gating in One CGIAR

The draft 2030 CGIAR Research Strategy notes that “stage-gate decision points will be used to manage CGIAR Project sub-components. CGIAR Projects will be divided into distinct stages, separated by assessment and decision points known as ‘gates’”. This presentation will briefly describe the concept of stage gating, challenges in implementing it across the CGIAR research portfolio and reflections on advancing the concept forward in time for 2022. The presentation draws on discussions during a May workshop on stage gating (May 12–14) and at the CGIAR 2030 Research Strategy meeting (June 16–19). The purpose and principles for stage gating have been widely agreed among CGIAR stakeholders, but several complexities have been raised, including (a) different types of research, beyond generation of innovations, (b) inter-dependencies of different types of research towards outcomes and impacts, (c) R4D partnerships that extend beyond CGIAR, and (d) variable starting points for One CGIAR projects given previous research. The session will focus on these stage-gating challenges and seek inputs from FTA scientists on how to address them.

## KEYWORDS

Stage gating, performance management, priority setting





The CGIAR Research Program on Forests, Trees and Agroforestry (FTA) organized over 10 days from 14 to 25 September 2020 its decadal conference. The fully digital event titled Forest, trees and agroforestry science for transformational change gathered more than 500 scientists from the programme and its working partners, from 69 countries across the globe, with more than 100 presentations and 40 posters. The conference also featured a set of science – policy – implementation panel discussions, including around controversial issues, with high profile scientists and key stakeholders, as well as a series of keynote speeches.

The present publication gathers the 179 abstracts accepted for the conference. It constitutes a vivid illustration of the research developed by the program and its collaborative partners worldwide.

All the material and presentations over the course of the 10-day conference is freely accessible on the FTA website: <https://www.foreststreesagroforestry.org/fta-2020-science-conference-forests-trees-and-agroforestry-science-for-transformational-change/>

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

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