South Asian smallholder forests and other tree-based systems: synthesizing LCLUC data and approaches to foster a natural climate solution that improves livelihoods.

Concept Note for Synthesis Workshop

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Introduction

Forests and other tree-based ecosystems play a vital role in sequestering CO2 emissions, making them indispensable components of climate change mitigation strategies targeting net-zero CO2 emissions (Mbow et al. 2014). Reflecting this significance, the Glasgow Pact from COP26, signed by over 100 countries, emphasizes the urgent need to halt and reverse global deforestation by the year 2030. High-biomass natural forests hold significant importance in the fight against climate change, making them primary targets for substantial public and private investments, especially in developing tropical countries. The leading international initiative for climate change mitigation in forests is REDD+ (Reducing Emissions from Deforestation and Forest Degradation), which primarily focuses on closed canopy tropical forests (Skole et al. 2021).

To achieve success in halting deforestation and forest degradation, it is imperative to implement robust monitoring systems that provide accurate measurement, reporting, and verification (MRV) of forest area and changes consistently across countries (Sexton et al. 2015). These high-quality monitoring systems play a crucial role in supporting conservation efforts. Deforestation and forest degradation, particularly in closed tropical forests, have long been the central focus of remote sensing global change research. However, recent findings challenge this narrative, revealing that landscapes worldwide are experiencing an increase in tree biomass, presenting crucial carbon sequestration potential (Zomer et al., 2016).

Scientific reports are drawing attention to a remarkable global trend in Land Cover and Land Use Change (LCLUC), indicating an increase in tree cover within smallholder agricultural landscapes. While forests worldwide face conversion and degradation, evidence suggests that tree cover outside of forests is experiencing rapid growth, particularly in developing countries and semi-arid agricultural regions. For instance, Brandt et al. (2018) observed elevated tree biomass around village areas compared to natural savannas in West Africa. These tree systems outside of forests (TOF) encompass diverse elements, such as agroforestry complexes, small-holder plantations, orchards, energy farms, woodlots, hedgerows, shelterbelts, scattered individual trees, and other woody perennial establishments within predominantly smallholder agricultural landscapes. Unfortunately, TOF is often overlooked in national tree resource monitoring efforts. As a result, data about this vital resource is scarce, with available information fragmented across various institutions and stakeholders involved in different types of TOF management.

Several studies have indicated that vast expanses of TOF and the observed increasing trend in their coverage can be attributed to intentional actions promoted and mediated by farmers. These deliberate efforts by farmers aim to harness both market and non-market benefits from ecosystem services, particularly those that enhance adaptation to the impacts of climate change (Miller et al. 2017; Mbow et al. 2014). Remarkable research conducted by Schnell et al. sheds light on the significant carbon storage capacity of TOF. In their study across six countries, they found that TOF holds a considerable amount of carbon. Astonishingly, in Bangladesh, the biomass in TOF was more than twice the total national forest biomass. A similar positive trend is observed in India, where the latest State of Forest Report by the Forest Survey of India indicates an improvement in tree cover outside official recorded forest areas, primarily on individual smallholder agricultural land. Notably, Africa's Sahel region demonstrates an impressive carbon sink since 1981, attributed to the expansion of woody cover outside dense forests (Sitch et al. 2015). These findings underscore the vital role that TOF plays in carbon sequestration and highlight the potential of individual efforts by smallholders to contribute significantly to climate change mitigation. If this pattern is widespread and can be further bolstered through policy and management interventions, it holds substantial implications for climate change mitigation and adaptation by enhancing carbon sequestration. This concept has garnered significant attention within international climate policy, termed "natural climate solutions." However, to fully realize its potential, comprehensive quantification and mapping of this land use and cover change are imperative.

Rethinking Natural Climate Solutions in South Asia

The World Agroforestry Center advocates that the "future of trees is on farms," reflecting a growing consensus among experts that while forests worldwide face conversion and degradation, tree cover outside of forests is potentially increasing rapidly, especially in developing countries and semi-arid agricultural landscapes. Many nations already incorporate TOF removals in their reporting on Nationally Determined Contributions (NDCs). Remarkably, 73% of all submitted NDCs include mitigation targets for land use, forestry, and agriculture, surpassing all other priority areas, including the energy sector (UNFCCC, 2021). Agroforestry, specifically, is identified in over 50% of all domestic NDC mitigation activities. Including TOF in the comprehensive portfolio of climate actions offers a compelling advantage, as it bolsters policies and measures for both future emissions reductions and current carbon removals. A stronger emphasis on TOF can significantly contribute to achieving net-zero goals by encompassing extensive landscapes across Asia, Africa, and Latin America. These landscapes hold the potential for significant atmospheric-carbon removal while directly enhancing adaptation, livelihoods, and promoting more stable income generation under climate-stressed conditions. Adopting a TOF strategy ensures that climate action participation is not limited to countries with high-carbon forests.

Among various Nature-Based Solutions (NBS), tree-based systems stand out as highly cost-effective, offering direct and immediate benefits to smallholder incomes through natural product value chains. Notably, they represent the most effective approach to scale carbon removal from the atmosphere. Millions of land managers are already employing traditional practices with tree-based systems, allowing for rapid and widespread adoption.

The proposed SARI synthesis project for South Asia aims to shed light on LCLUC patterns and processes within agricultural landscapes of smallholder tree-based systems, exploring their potential as natural climate solutions. This synthesis seeks to provide an observation-based evaluation of the extent to which these landscapes are expanding in terms of cover and biomass. Additionally, it aims to assess the

factors that contribute to the growth of tree and forest cover in South Asia, and how these improvements can enhance rural livelihoods.

The SARI South Asia Synthesis Consortium (SARI-SAS) has two primary objectives:

- Synthesize current and recent NASA research on LCLUC, aiming to deepen our fundamental understanding of the patterns and drivers behind these changes in the region.
- Translate the insights gained from fundamental science into evidence-based contributions that can inform crucial climate mitigation and adaptation policies in South Asia.

Amidst the growing urgency of climate change, new public-private partnerships are garnering significant capital investments for high-biomass forests. Notably, while initiatives like the Green Gigaton Challenge, the Lowering Emissions by Accelerating Forest finance Coalition (LEAF) and the new Architecture for REDD+ Transactions (ART) are spearheading efforts to address deforestation and promote sustainable forest finance solutions, the inclusion of TOF is becoming increasingly essential to enhance the relevance and effectiveness of climate investments. By incentivizing tree-based carbon removals in areas that directly impact people's livelihoods, TOF integration ensures permanence and scalability of these vital investments. The findings of this study thus hold significant importance for the international climate investment and climate change mitigation policy community, which actively seeks quantitative insights into TOF as natural climate solutions. The results are expected to serve as a valuable example for emerging Forest Landscape Restoration (FLR) programs. Moreover, they contribute to the evolving REDD+ agenda, fostering new perspectives on integrating Agriculture, Forestry, and Other Land Use (AFoLU) under a holistic landscape approach. Lastly, this work has the potential to positively impact agroforestry livelihoods, aligning with the objectives of international development communities and the Sustainable Development Goals (SDGs).

Scope of Activities

Centered in India but extending our analyses to the wider region, this ambitious project unites the Principal Investigators (PIs) of every ongoing LCLUC initiative in South Asia. Bolstered by a cadre of esteemed scientists and organizations from the region, the project forms the core of the SARI South Asia Synthesis (SARI-SAS) Consortium. Additionally, the Consortium will actively involve past PIs from the NASA LCLUC Program, further enriching the collective expertise.

The primary objective of the SARI-SAS consortium is to advance our understanding of the intricate processes, drivers, and impacts on carbon emissions and removals, ultimately unveiling new insights into the landscape-level drivers of biotic emissions and removals. To achieve this goal effectively, the consortium will concentrate on evaluating the significance of tree-based systems in non-forest landscapes, going beyond the well-understood forest estate. Specifically, the focus will be on atmospheric emissions and removals of carbon and the underlying processes that drive or mediate the increase of woody cover and biomass at the landscape scale.

In collaboration with the GOFC-GOLD program, the SARI-SAS Consortium is set to host an impactful thematic workshop in the SARI region in December 2023. This event will bring together Consortium members from both the US and the region, alongside regional and US participants, to explore and evaluate the current state of tree-based systems in SARI. Specifically, the workshop will focus on TOF,

agroforestry, smallholder plantations, and related themes, emphasizing their role as natural climate solutions for climate change mitigation and adaptation.

Central to the workshop's objectives is a comprehensive stock-taking exercise to assess the measurement capacities and advancements in tree-based systems within the SARI region. By examining the existing data and research, the workshop aims to produce insightful papers published in a Special Issue of a journal. These valuable contributions will form the basis for a Year 1 preliminary synthesis report, providing essential insights and potential pathways for implementing sustainable climate solutions.

Synthesis Workshop Activities and Deliverables

Here we broadly outline the structure of proposed activities leading up to the workshop.

Proposed Workshop Theme – Synthesis of scientific underpinnings to support climate change mitigation and adaptation through natural climate solutions with a special emphasis on tree-based systems particularly Trees Outside Forests (TOF)

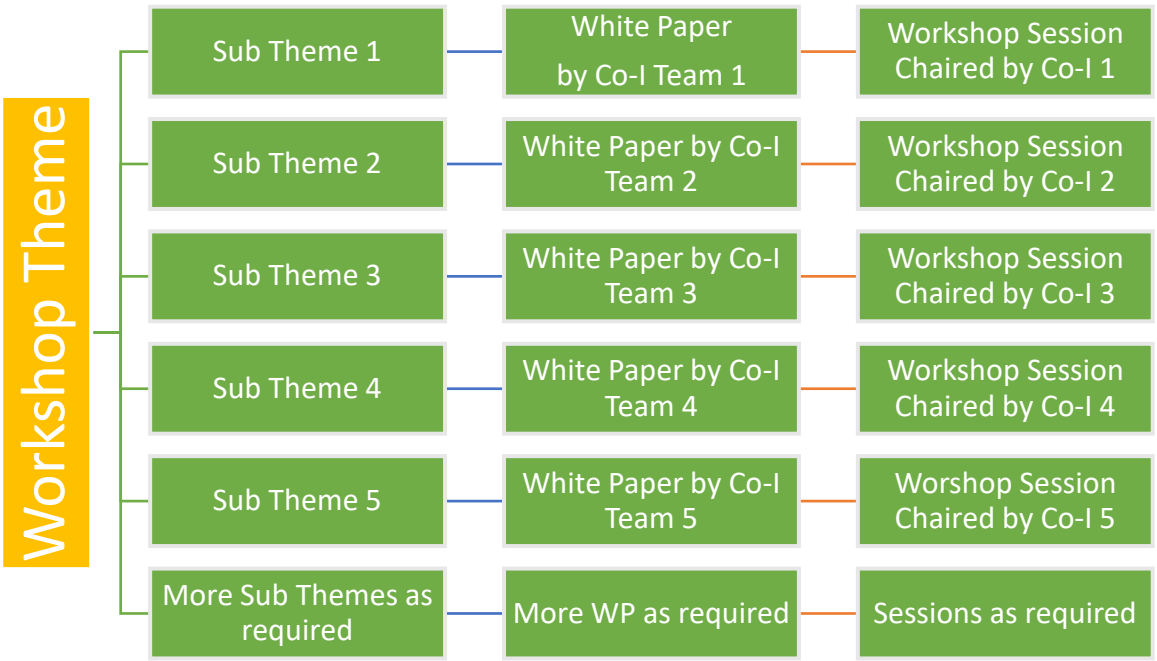

Figure 1 Flowchart exhibiting SARI Workshop Plan of Action

Activity 1 - An Inventory of LCLUC Projects in SARI South Asia

The cornerstone of having the planned workshop is the development of a comprehensive inventory of existing LCLUC projects. This inventory will provide a detailed summary of each project, encompassing its status, major findings, utilized data, methodologies, identified drivers, and fundamental discoveries. By consolidating this information, we aim to lay a solid foundation for a robust meta-analysis that encompasses the current state of knowledge on forest conversion and regeneration rates across the entire SARI region. Additionally, this meta-analysis will investigate the underlying process-drivers of land cover change, unraveling invaluable insights into the dynamic landscapes of South Asia.

Activity 2 – Dataset Preparation and Web-GIS Integration

To ensure a robust and comprehensive analysis, our project is focused on meticulous dataset preparation. We will begin by gathering remote sensing datasets, including medium-resolution data from project participants and other public sources. These datasets will form the foundation for our remote sensing analyses, providing valuable insights into land cover and land use changes. A second crucial data effort will involve producing downscaled social and economic indicators to the village cluster scale. By incorporating fine-grained socio-economic data, our synthesis analysis will gain a deeper understanding of the interplay between human activities and landscape dynamics**.**

Activity 3 – Working Analyses on Drivers and Processes

Our research endeavors aim to conduct two insightful working analyses, drawn from the current literature on land cover change drivers and processes. These analyses will delve into specific sub-elements, focusing on drivers related to incomes and livelihoods, ecosystem services benefits, and institutions/governance. By scrutinizing these key aspects, we seek to gain a deeper understanding of the dynamic relationship between human activities and land cover change.

Analysis Stream 1: Drivers Related to Incomes and Livelihoods

This analysis will explore the intricate links between land cover change and the socio-economic aspects of communities. By examining how changes in land use and cover affect incomes and livelihoods, we aim to uncover patterns and trends that illuminate the role of human activities in shaping landscapes.

Analysis Stream 2: Ecosystem Services Benefits and Institutions/Governance

In this analysis, we will delve into the complex interplay between land cover change, ecosystem services, and institutional and governance structures. Understanding how decisions made by various institutions and governance mechanisms influence land use and cover is vital for effective and sustainable land management.

Activity 4 – Co-Is develop White Papers before workshop based on working analyses and choice of sub-theme under Analysis stream 1 or 2

As a crucial preparatory step for the workshop, our research endeavors are directed towards the creation of White Papers by Co-Is for chosen sub-themes. The White Paper will encompass a meticulous evaluation of forest cover change trends, as well as trends related to tree-based systems outside of forests. To ensure accuracy and relevance, our study will heavily rely on LCLUC data and reports from the Forest Survey of India, including its recent assessments of TOF cover area.

Activity 5 – Year 1 Synthesis Report from Workshop Sessions chaired by Co-Is

Based on activities 1-4, our upcoming workshop will bring together Consortium members from both the US and the region, alongside regional participants. Sessions to be chaired by Co-Is (Figure 1) based on their focus areas and a year 1 synthesis report would be prepared which shall be presented at one of the regular NASA Science Team meetings.