CGIAR Research Program on

Forests, Trees and Agroforestry

Revised Phase II Full Proposal 2017-2022

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1.0 CRP Narrative

1.0.1 Rationale and scope

Humankind has made significant progress towards achieving several of the Millennium Development Goals (MDG): poverty and hunger have been reduced, and nutrition and health have improved. The world attained the first MDG target (cut the 1990 poverty rate in half by 2015). Despite this, about 900 million people live at or below USD 1.90 a day and over 2.1 billion people in the developing world live on less than USD 3.10 a day. Some 795 million people do not have enough food to lead a healthy and active life. The vast majority of them live in developing countries, where 12.9% of the population is undernourished. Far too many people are still living in hunger[1] with far too little[2]. Therefore, there is still much to do about food security and poverty reduction in the global agenda known as the Sustainable Development Goals (SDGs).

Furthermore, most of the progress towards SDG 1 (No Poverty) and 2 (No Hunger) has been at the expense of natural resources[3,4]. Forests and trees have been particularly hit, destroyed for agriculture or degraded by suboptimal management[5,6]. Continuing this trend threatens the future of agriculture, and humanity itself. This is because, beyond the myriad of goods produced, forests and trees are also fundamental to sustaining food systems[7], ecosystem services[8]and mitigating or adapting to climate change[9]. Progress towards achieving the SDGs and the recently achieved Paris agreement on climate change requires the world to shift its historical development trajectory away from a 'doomsday scenario' or business as usual environmental degradation (Figure 1), where development continues at the expense of the environment.

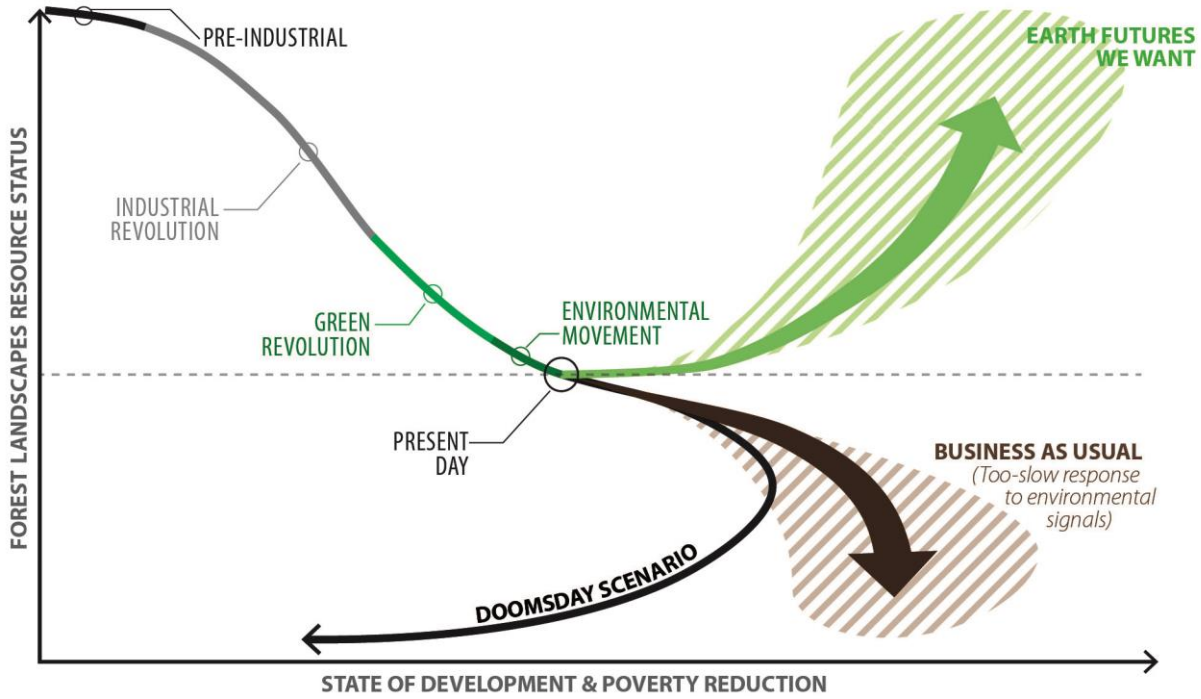


Figure 1. Potential future development pathways

Managed well, forests, trees and agroforestry (FT&A) systems offer a unique opportunity to contribute to the CGIAR Strategy and Results Framework (SRF) and the 17 SDGs because of their spatial extent, the range of goods or services they produce or maintain, and the number of people depending on such goods and services. An estimated 1.6 billion people depend in part or in full on forests and trees outside forest resources for their livelihoods[10]. More than 800 million people (30% of the global rural population) live on

9.5 million km^2 of agricultural lands (45% of the total area) with >10% tree cover; 180 million on the 3.5 million km^2 of agricultural lands with >30% tree cover; and about 350 million within or near 40 million km^2 of dense forests[11,12]. The estimated value of ecosystem services stemming from forests, trees and savannas represents more than USD 76 trillion, compared to USD 9 trillion for cropland[13]. Perennial tree crops and tropical forest products play a vital role in the livelihoods of hundreds of millions of households; they are also a primary source of export earnings and foreign exchange, representing hundreds of billions of USD for many countries, with important spillovers for local development.

We also believe there remains a significant performance gap in the way FT&A systems are currently managed and that we are far from achieving their full potential. The CGIAR CRP on "Forests, Trees and Agroforestry: Livelihoods, Landscapes and Governance" (FTA) fills a specific niche in the overall CGIAR portfolio as "*the only CRP that works on all aspects of the value and benefits of trees and forests for agricultural landscapes and agricultural sustainability (environmental, social and economic)*"[14]. It is complementary to the other Agri-food System CRPs (AFS-CRPs) for production systems and contributes to the Integrative CRPs (I-CRPs) for ecosystem services and climate change. The FTA's contribution includes conducting research that explores the central role that FT&A resources play in improving production systems, enhancing people's livelihoods and promoting the equitable distribution of benefits, all while protecting and enhancing the resource base through a better understanding of the interactions between productivity and ecosystem services in tree-based systems. Together with our partners, we will continue to generate integrated, high impact datasets about FT&A, relevant at local, regional and global scales, which we make accessible for sharing, interrogation or repurposing through our data-sharing platforms. *The range and depth of FTA's authentic and functional partnerships within the CGIAR are also a testament to its strategic centrality and relevance*[15].

We believe the doomsday scenario trajectory can be averted if decision-makers fully appreciate how much FT&A systems contribute to achieving the dual goal of prosperity and environmental sustainability. As noted by ISPC[16] "*the development of capacity to attain a balance of development with sustainability objectives as illustrated in FTA can have valuable strategic and operational lessons for the CGIAR more generally*". FTA is breaking new grounds scientifically in its work on this balance between development and sustainability and all the CRPs stand to benefit for this.

FTA II is built around 3 overarching hypotheses:

- **Governance hypothesis**: Public and private governance and institutional arrangements must be transformed and aligned to create the necessary enabling environment allowing FT&A systems to fully contribute to achieving the SDGs.
- **Livelihood hypothesis**: There is scope for major increases in income, food and nutrition security and resilience for at least 100 million people in the face of climate change, through more inclusive and gender equitable access to and better utilization and management of FT&A systems.
- **Trade-offs hypothesis**: To optimize benefits among diverse stakeholders at scales from the farm to the globe requires understanding and actively managing tradeoffs among the production of food, fiber, energy, water, other ecosystem services and the maintenance of biodiversity from forests and trees in landscapes.

We work across four main production systems (natural forests, plantations, pastures and cropping systems with trees) dealing with a number of globally or locally important commodities (timber, oil palm, rubber, coffee, cocoa, coconut, wood fuel, fruits, etc.) not considered by the other AFS-CRPs (as shown in Table 1 in Section 1.0.6). Tree crops produce important globally traded commodities including cocoa, coffee, coconut, rubber and oil palm that form the basis of smallholder livelihoods. Cocoa and coffee alone cover 20 million ha and are the mainstay of over 30 million smallholder households. Coconut is a critical source of income and nutrient-rich food for 50 million people. A large part of the world's oil palm production is produced by smallholders representing millions of smallholder growers. Recent global assessments suggest that up to 28% of household income is derived from forest resources for smallholders living at the forest margins[17].

More than 80% of rural people in the developing world still depend on fuelwood for cooking as well as warmth. The world is covered by approximately four billion hectares of forests, of which 93% are natural forest and 7% plantations[18]. Work under FTA is taking place in countries that together represent approximately 46% of global forest cover, including approximately 1.3 billion ha of closed forests – among which 400 million ha are designated for logging and 500 million ha of open and fragmented forests. In tropical countries, the gap between demand and supply is typically met through deforestation and land conversion, an option that will be closed off by "zero deforestation" pledges. Sustainable alternatives based on better forest management and plantations are needed. FAO[19] estimates that pastures are by far the largest agricultural use of land (26% of all land globally and >70% of agricultural land) and contribute to the livelihoods of 800 million people. Trees in pastures are ubiquitous in the Sahel and much of Latin America, and provide fodder and shade for animals as well as sustaining soil fertility and contributing to biodiversity conservation.

FTA II is very much an AFS-CRP, and will work with the other AFS-CRPs to look at innovative ways to harness the synergies between the different components of FT&A systems to close the yield gaps on smallholder farms and managed forests. But FT&A systems are much more than just another food production system. They are fundamental cornerstones of multi-functional landscapes, providing invaluable ecosystem services and supporting agriculture, livelihoods, biodiversity, health and well-being. '*FTA II, in many senses, appears to be a hybrid of the old "systems" CRPs with integrative and AFS-CRPs'* [15]. Our system approach is very much a landscape approach with multifunctional landscapes – where people interact through forestry, agriculture, fisheries, food and energy systems, water management, conservation, value chains and infrastructure, all at the core of the new climate and development agendas.

By nature of our concerns we work in many countries (see Figure 2), involving commodities and services representing very different situations, making FTA a large complex program that must operate at various scale using a landscape approach.

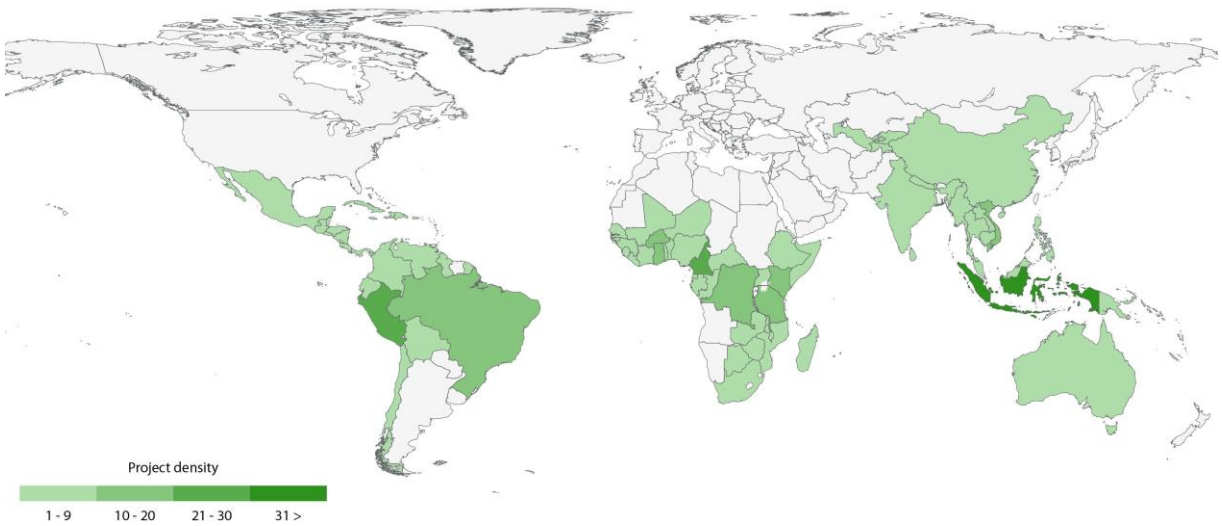


Figure 2. Number of projects per country 2016

"Landscape approaches" are now used by many major organizations and agencies specialized in food production and poverty alleviation thanks to the recognition that ecosystems and humans are integrated parts of complex social-ecological systems. These approaches are inherently complex and dynamic, as opposed to approaches with clearly -bounded spatial entities. People, in various forms of social organizations, shape the landscape and its natural resource base while their options are essentially bound by both the potential of the land and these resources as well as the prevailing natural resource governance

system. Changing the trajectory of a landscape implies a change in the behavior of the key actors within that landscape and thus requires the identification of successful leverage points and negotiated approaches.

The forest transition curve (Figure 3) provides a framework that helps us identify spatial and temporal patterns and drivers of tree cover change, as well as their consequences and stakeholders, options and alternatives, and institutions and incentives for leverage on tradeoffs. Changes in forest cover have multiple levels of causation ('drivers') and entry points for change at the landscape scale.

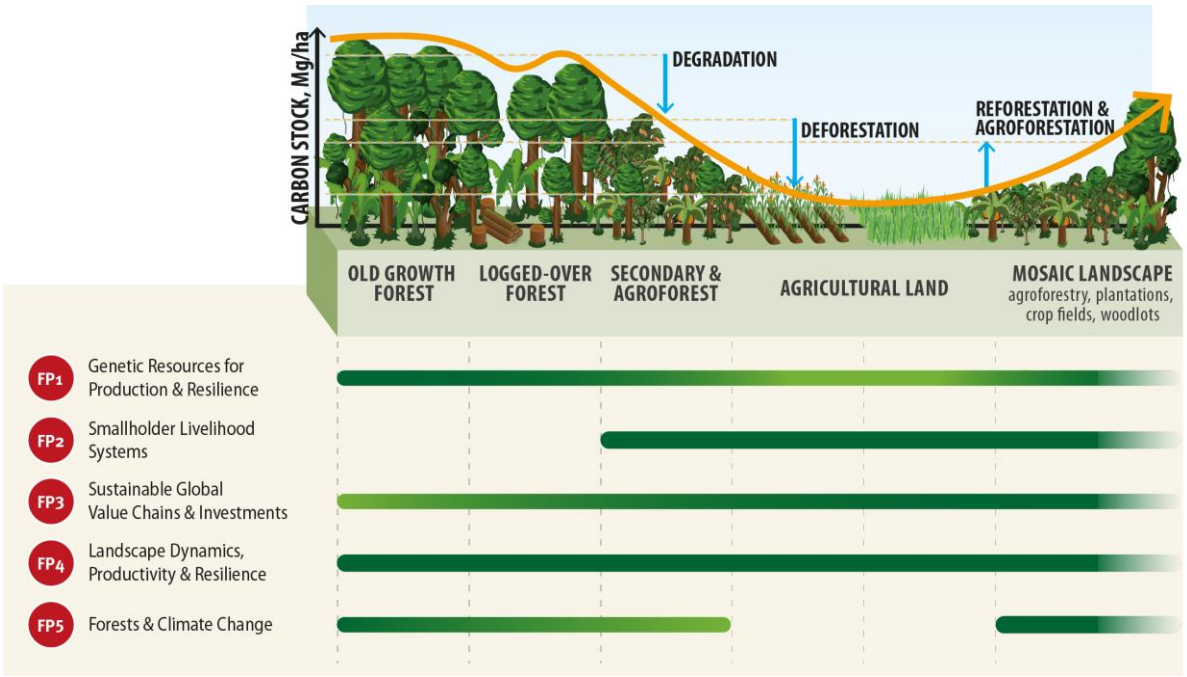


Figure 3. Forest and tree cover transition curve

At the national scale (Figure 4 left), the variation in reported forest cover is strongly associated with human population density. A single "country" point, however, includes a wide diversity at local scales (Figure 4 right); FTA also explores this within country diversity as a basis for analysis and policy/practice options and recommendations allowing the importance of contexts to be assessed.

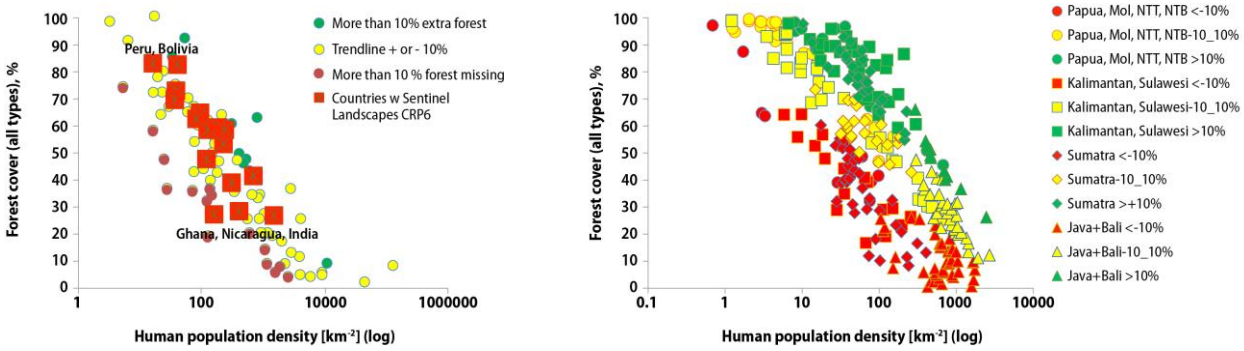


Figure 4. Variation in forest cover at the national (left) and subnational (right) scales in relation to human population density. Left global data set (see GLP news 2014); Right: 300 districts in Indonesia (update from Murdiyarso et al., 2005)

1.0.2 Goals, objectives, targets

Our overarching goal, as presented in Section 1.0.1, is to mitigate the impacts of the current suboptimal management of forests, trees and agroforestry (FT&A) resources, bringing evidence and science-based technologies and policy improvement at all levels.

Cost of suboptimal management of FT&A resources and FTA "value for money"

The latest estimated value of ecosystem services from tropical forests, trees and savannas represents more than USD 76 trillion, compared to USD 9 trillion for croplands[1]. In 2013, the TruCost[2] study documented costs to natural capital of the top 100 projects examined as USD 4.74 trillion, out of which USD 2.09 trillion related to sectors relevant to CGIAR and within its geographic scope. Projects directly related to FTA study topics represented USD 559 billion. After deducting the benefits from agricultural, forest and livestock rents in land replacing tropical forests, net annual losses are at USD 1.3 trillion[3]. This shows the magnitude of tropical ecosystem service losses through international trade created by the suboptimal management of FT&A resources.

By 2022, FTA will have worked directly with policy-makers in 25 countries to improve governance mechanisms, institutions and tools. Through collaboration with FTA, the public and private sector practitioners in these countries will also deliver more effective and equitable tree-related breeding, delivery, extension and pedagogical services. In the same year, FTA will also have worked directly with 20 multinational companies on improved business models and investment decisions, indirectly reaching approximately 500 private sector actors through five global, regional and national business platforms. These activities will benefit around 40 million smallholder households.

With about USD 500 million of public investment in the FTA program over a six-year time frame, we will provide USD 55 billion in avoided environmental externalities, a reduction of 0.2 gigatonnes (Gt) CO_2-e yr^{-1} in greenhouse gas emissions – equivalent to USD 70 billion in social costs[4] as well as improved livelihood options and food security to 31 million farm households through: (i) greater awareness of the functions, roles and values of FT&A capitals in the target regions; (ii) avoided damage by projects not implemented as public discourse takes FT&A values into account; (iii) continued learning on public policies and public-private partnerships that internalize the true costs to society of private decision-making, building on current successes, failures and lessons learned in REDD+ and payment for environmental services (PES) programs; (iv) innovation in practice, technologies to increase production; and (v) increased equity resulting from alternative arrangements for sharing access to resources, including better representation of women's interests.

FTA contribution to the SRF and SDGs

Our aspirational targets for 2022 summarizes FTA's contribution to the SRF (Table 1). These were first estimated in 2014 at each Flagship level in consultation with our key partners before being updated and aggregated at the FTA level based on experience during FTA Phase 1. Overall, FTA will continue to contribute to all three SLOs. While SLO 3 remains the main focus of FTA's efforts, the distribution of effort of 29%, 33%, 38% across SLO 1, 2 and 3 respectively shows a well-balanced program. The country breakdown of these targets is shown in PIM Table A. The numbers do not include the expected costs of the cross-cutting themes of the Support Platform. A complete and detailed explanation on how our targets have been defined including targeted population, FTA relevant research, FTA expected contribution, examples of past and current achievement and possible caveats is given in Annex 3.12.

Table 1. FTA aspirational targets for 2022.

SRF 2022 targets	FTA contribution	Financial resources needed 2017–2022 (USD *in millions*)
SLO1: Reduced poverty		**144**
100 million more farm households have adopted improved varieties, breeds or trees, and/or improved management practices	31 million more farm/smallholder households have adopted improved varieties, breeds or trees, and/or improved management practices	75
30 million people, of which 50% are women, helped to exit poverty	19 million people, 50% women, assisted to exit poverty	69
SLO2: Improved food and nutrition security for health		**124**
Improve the rate of yield increase for major food staples from current <1% to 1.2–1.5% year^{-1}	Improve the rate of yield increase by 0.1845%/year in FT&A systems	16
30 million more people, of which 50% are women, meeting minimum dietary energy requirements	17 million people, 50% women, meeting minimum dietary requirements or experience increased dietary diversity	108
150 million more people, of which 50% are women, without deficiencies of one or more of the following essential micronutrients: iron, zinc, iodine, vitamin A, folate and vitamin B12	N/A (although linked to above nutritional, poverty reduction and increased productivity targets)	-
10% reduction in women of reproductive age who are consuming less than the adequate number of food groups	N/A (although linked to above nutritional, poverty reduction and increased productivity targets)	-
SLO3: Improved natural resource systems and ecosystem services		**161**
5% increase in water and nutrient (inorganic, biological) use efficiency in agroecosystems, including through recycling and reuse	0.225% increase in either water or nutrient use efficiency is achieved	14
Reduce agricultural-related greenhouse gas emissions by 0.2 Gt CO_2-e yr^{-1} (5%) compared with business-as-usual scenario in 2022	FT&A GHG emissions reduced by 0.2 Gt CO_2-e yr-1 compared with the business-as-usual scenario	78
55 million ha degraded land area restored	30 million ha of degraded land area under restoration	39
2.5 million ha of forest saved from deforestation	2.5 million ha of avoided deforestation	30

FTA contributes to 9 SDGs, 12 IDOs and to 31 sub-IDOs with different levels of investment (Table 2). The focus on gender, youth and capacity development is strong with the cross-cutting Gender and Youth IDO and the Capacity Development IDO making up 11% and 12% of FTA's efforts, respectively. In addition, the nature of FTA research is such that a conducive policy environment will constitute a large part of FTA

efforts embedded in SLOs 1 to 3. In Table 2, the costs of the cross-cutting themes in the Support Platform have been included.

Table 2. FTA contribution to sub-IDOs.

SDG	IDO		sub-IDO		FTA effort (USD *in millions*)	FTA effort (%)
SDG1 End poverty in all its forms everywhere	2	Enhanced smallholder market access	2.1	Improved access to financial and other services	14	2.9
			2.2	Reduced market barriers	8	1.8
	3	Increased incomes and employment	3.1	Diversified enterprise opportunities	9	2.0
			3.2	Increased livelihood opportunities	38	8.0
			3.3	Increased value capture by producers	19	4.0
			3.4	More efficient use of inputs	7	1.5
	4	Increased productivity	4.3	Enhanced genetic gain	7	1.5
			4.4	Increased conservation and use of genetic resources	7	1.5
			4.5	Increased access to productive assets, including natural resources	14	3.0
SDG2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture	5	Improved diets for poor and vulnerable people	5.2	Increased access to diverse nutrient-rich foods	23	5.0
	7	Improved human and animal health through better agricultural practices	7.1	Improved water quality	3	0.7
SDG15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and	8	Natural capital enhanced and protected, especially from climate change	8.1	Land, water and forest degradation (including deforestation) minimized and reversed	55	11.6
			8.2	Enhanced conservation of habitats and resources	4	0.9
			8.3	Increased genetic diversity of agricultural and associated landscapes	4	0.7
	9	Enhanced benefits from ecosystem goods and services	9.1	More productive and equitable management of natural resources	12	2.6

SDG	IDO		sub-IDO		FTA effort (USD *in millions*)	FTA effort (%)
halt biodiversity loss			9.2	Agricultural systems diversified and intensified in ways that protect soils and water	12	2.5
			9.3	Enrichment of plant and animal biodiversity for multiple goods and services	3	0.6
	10	More sustainably managed agroecosystems	10.1	Increased resilience of agroecosystems and communities, especially those including smallholders	20	4.3
			10.2	Enhanced adaptive capacity to climate risks	23	4.9
SDG13 Take urgent action to combat climate change and its impacts	A	Mitigation and adaptation achieved (climate change)	10.3/A1	Reduced net greenhouse gas emissions from agriculture, forests and other forms of land use	34	7.2
			A3	Improved forecasting of impacts of climate change and targeted technology development	9	1.9
			A4	Enhanced capacity to deal with climatic risks and extremes	4	0.7
SDG5 Achieve gender equality and empower all women and girls	B	Equity and inclusion achieved (gender and youth)	B1	Gender-equitable control of productive assets and resources	28	6.0
			B2	Technologies that reduce women's labor and energy expenditure developed and disseminated	6	1.3
			B3	Improved capacity of women and young people to participate in decision-making	20	4.2
SDG16 Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build	C	Enabling environment improved (policies and institutions)	C1	Increased capacity of beneficiaries to adopt research outputs	4	0.8
			C3	Conducive agricultural policy environment	26	5.5

SDG	IDO		sub-IDO		FTA effort (USD *in millions*)	FTA effort (%)
effective, accountable and inclusive institutions at all levels						
SDG17 Strengthen the means of implementation and revitalize the global partnership for sustainable development SDG4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	D	National partners and beneficiaries enabled (capacity development)	D1	Enhanced institutional capacity of partner research organizations	20	4.2
			D2	Enhanced individual capacity in partner research organizations through training and exchange	15	3.1
			D3	Increased capacity for innovation in partner research organizations	7	1.4
			D4	Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	18	3.7
				TOTAL	471	100

1.0.3 Impact Pathway and Theory of Change

FTA's theory of change (Figure 1) is a live and dynamic framework that will continually evolve as an integral element of the overall research portfolio. It describes how FTA will (1) undertake high quality FT&A research in collaboration with partners and other stakeholders to (2) co-generate relevant, credible and legitimate knowledge that (3) informs and facilitates improved policy and practice and institutional change, which (4) contributes to the delivery of positive, equitable and inclusive development and environmental outcomes, including those associated with CGIAR's SRF (see below). The theory of change specifically builds on FTA's previous achievements and is a product of the corresponding structured learning, reflection and refinement that took place during CRP I.

Grounded in the literature, experiences from both within and outside CGIAR, and key lessons from FTA's successes in influencing policy and practice, our theory of change is founded on five interrelated principles:

1. **Co-learning**. Investing in meaningful stakeholder and partner engagement and the "co-generation" of knowledge and evidence throughout the research cycle – as opposed to one-way, supply-driven "research dissemination" – significantly increases the likelihood of research relevance, use and, ultimately, developmental impact.
2. **Interdisciplinarity**. Interdisciplinary and transdisciplinary research approaches are generally more effective in addressing the complex – often "wicked"[1] – grand challenges, such as those associated with FT&A.
3. **Inclusivity**. New scientific knowledge and evidence will translate into both greater and more inclusive, equitable and sustainable development impact if focused efforts are undertaken to investigate and ensure that the differential needs and priorities of specific groups of end-users and beneficiaries (e.g. women, youth and the poor and marginalized) are addressed throughout the research cycle – and with their own knowledge systems recognized as important points of reference.
4. **Focus on end-user needs.** The translation of scientific knowledge and evidence into improved policy, practice and institutions is greatly accelerated and enhanced if complemented with (a) targeted capacity development; (b) the explicit comparison of the existing local, public/policy and science-based knowledge systems related to the specific questions; (c) the packaging of generated knowledge into actionable recommendations, decision-support tools (where a single decision-maker is involved) and negotiation support (where multiple stakeholders are expected to have different perspectives and interests); and (d) structured processes to enable stakeholders to meaningfully engage with scientific data and evidence.
5. **Adaptive management**. Monitoring and evaluating progress along well-defined knowledge-to-outcome pathways and – *critically* – meaningfully informing management decision-making based on the resulting data and learning will further significantly facilitate the translation of quality FT&A science into equitable and inclusive developmental impact.

At the very foundation of FTA's theory of change lie its five Flagships (described in Section 1.0.6), which are joined together by its Support Platform (SP). The latter, in particular, will play a critical role in supporting and facilitating the successful operationalization of the five above principles. In particular, it will (1) support FTA research teams to mainstream gender, youth and other inclusion issues meaningfully into research projects, e.g. via gender and inclusion analysis (Section 1.0.4 and Section 1.0.5); (2) apply relevant Monitoring, Evaluation, Learning, and Impact Assessment (MELIA) tools and approaches to support the larger program and project teams to engage in continuous, evidence-informed learning and self-reflection, thus improving research design and effectiveness in achieving outcomes and impacts (Annex 3.6); (3) support the packaging and communication of FTA-generated insights and complementary communications and outreach activities for ease of understanding and uptake by decision-makers and practitioners (Section 1.0.14); and (4) further facilitate scaling through capacity development (Section 1.0.10) and the brokering of strategic partnerships (Section 1.0.8). See Section 1.0.6 for further details.

While carrying out high-quality research in their respective areas will be core to the work of each Flagship, so too will the successful development and execution of targeted engagement strategies. This will take place throughout the research project cycle, right from the research concept stage through to the generation and dissemination of results and beyond. It is clear that FTA's development impact will be greater if it targets and strategically engages with those actors who wield the most significant decision-making power and influence in the research domain in question. Given that FTA's target audience and end users traverse different scales and geographies, FTA's SP will further support the FPs, other FTA research teams, and even specific projects to undertake stakeholder mapping and power analysis, with a view toward developing targeted engagement plans.

FTA's primary targeted engagement strategies are listed in Figure 1, and those specific to each Flagship are presented in their respective nested theories of change in relevant sections of FP narrative. Despite the uniqueness of each FP's and project's engagement strategy, common examples include: (1) collaboration with partners that influence policy articulation; (2) setting up and facilitation of evidence and data sharing platforms and communities of practice; (3) partner and stakeholder capacity development; (4) knowledge "co-production" initiatives with international, national and private sector partners; and (5) engagement in development projects while embedding research within them[2]. However, further refinement will be undertaken for each specific project initiative and closely linked to FTA's MELIA system (see Annex 3.6).

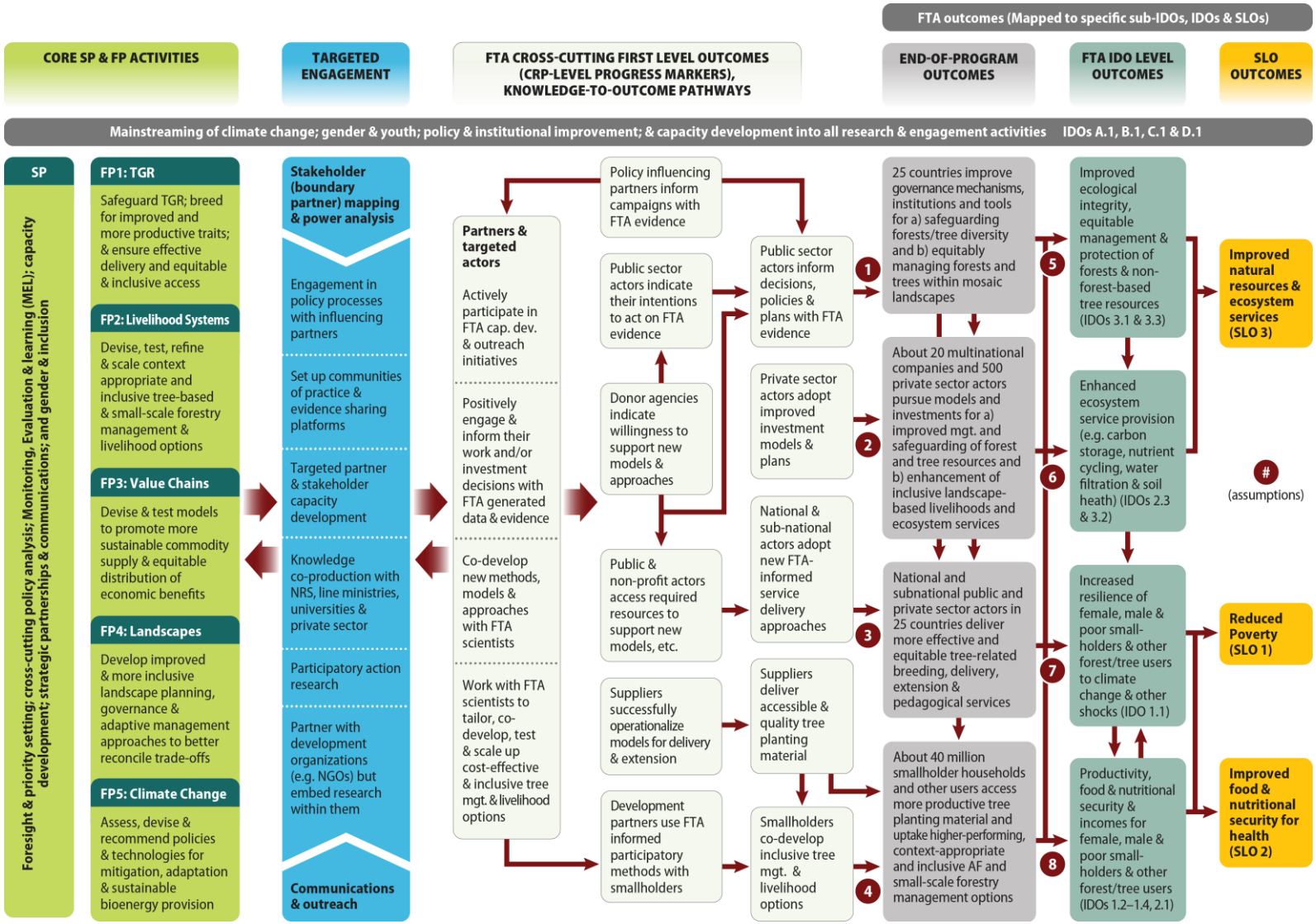


Figure 1. FTA's Theory of Change

Just as each FP and project stakeholder engagement strategy will be unique, so too will their knowledge-to-outcome pathways. FTA operates in complex systems, with long and non-linear impact pathways, multiple actors and long time-lags. Often, researchers do not have access to the necessary networks and/or possess the capacity to reach intended end-users. Therefore, FTA will partner with various intermediaries and boundary organizations. Following the approach of Outcome Mapping[3], these have been specified for each FP (see ToC section for each FP) and will be further refined at the project level. As described in Annex 3.6, much of FTA's MELIA efforts will focus on monitoring and reviewing the behavior of all boundary partners (including FTA scientists) against expected progress markers. Where progress is less than expected, the research initiative's stakeholder engagement tactics and/or strategies will be adjusted accordingly. This will be part-and-parcel of FTA's iterative approach to results-based management (RBM) in general and efforts to continuously accelerate and enhance the CRP knowledge-to-outcome pathways in particular.

FP- and project-specific refinement withstanding, Figure 1 depicts some of the primary knowledge-to-outcome pathways that will be pursued under FTA. As already noted, one of the key strategies to facilitate the uptake and use of FTA research – and which will cut across all the FPs – will be to directly collaborate with key public and private sector actors. Such deep engagement is recognized to significantly promote research uptake and use[4]. This will be combined by targeted and demand driven capacity development and multi-stakeholder processes, such as the Stakeholder Approach to Risk-informed and Evidence-based Decision-making (SHARED), to aid decision-makers and other stakeholders to meaningfully engage with and use FTA-generated knowledge and evidence. This – coupled with strategic collaboration with policy influencing partners – is expected to promote the integration of FTA-generated knowledge and evidence in policy and practice decision-making, as well as the pursuit of more sustainable and equitable business plans among targeted private sector partners.

Given that FTA will engage significantly with donor agencies, this is further expected to facilitate the unveiling of resources required for public and non-profit organizations (e.g. line ministries and NGOs) to effectively execute FTA co-developed, improved, and more inclusive service delivery and extension models and approaches. This, coupled with engagement with development partners, is intended to culminate in meaningful work with smallholders and other forest/tree users to pursue more cost-effective and equitable tree- and forest-based management and livelihood options.

The interaction between FTA's strategically prioritized research and targeted stakeholder engagement efforts are ultimately expected to generate four key end-of-program outcomes (EPOs), which are, again, interrelated and mutually reinforcing. The first pertains to improved governance arrangements, mechanisms and tools, while the second and third focus on more sustainable and equitable FT&A investments and improved service delivery, respectively. The final EPO focuses on improved access and uptake among smallholders and other local FT&A users. The four EPOs are mapped to 31 sub-IDOs, as presented in Table 1a.

Table 1a. Mapping of FTA's End-of-Program Outcomes (EPOs) to the Sub-IDOs

FTA EPO	Mapped Sub-IDOs
1. 25 countries improve governance mechanisms, institutions and tools for a) safeguarding forests/tree diversity and b) equitably managing forests and trees within mosaic landscapes	***2.1*** *Improved access to financial and other services* ***2.2*** *Reduced market barriers* ***3.1*** *Diversified enterprise opportunities* ***3.2*** *Increased livelihood opportunities* ***3.3*** *Increased value capture by producers* ***3.4*** *More efficient use of inputs* ***4.3*** *Enhanced genetic gain* ***4.4*** *Increased conservation and use of genetic resources* ***4.5*** *Increased access to productive assets* ***5.2*** *Increased access to diverse nutrient-rich foods* ***7.1*** *Improved water quality* ***8.1*** *Land, water and forest degradation minimized and reversed*
2. About 20 multinational companies and 500 private sector actors pursue models and investments for a) improved mgt. and safeguarding of forest and tree resources and b) enhancement of inclusive landscape-based livelihoods and ecosystem services	***8.2*** *Enhanced conservation of habitats and resources.* ***8.3*** *Increased genetic diversity of agricultural and associated landscapes* ***9.1*** *More productive and equitable management of natural resources* ***9.2*** *Agricultural systems diversified and intensified in ways that protect* ***9.3*** *Enrichment of plant and animal biodiversity for multiple goods and services* ***10.1*** *Increased resilience of agro-ecosystems and communities* ***10.2*** *Enhanced adaptive capacity to climate risks* ***10.3/A.1*** *Reduced net GHG emissions from agriculture, forests, etc.* ***A.3*** *Improved forecasting of impacts of climate change and targeted technology development* ***A.4*** *Enhanced capacity to deal with climate extremes*
3. National and sub-national public and private sector actors in 25 countries deliver more effective and equitable tree-related breeding, delivery, extension & pedagogical services	***B.1*** *Gender-equitable control of productive assets and resources* ***B.2*** *Technologies that reduce women's labor & energy expenditure developed & disseminated* ***B.3*** *Improved capacity of women and young people to participate in decision-making* ***C.1*** *Increased capacity of beneficiaries to adopt research outputs* ***C.3*** *Conducive agricultural policy environment* ***D.1*** *Enhanced institutional capacity of partner research organizations* ***D.2*** *Enhanced individual capacity in partner research organizations* ***D.3*** *Increased capacity for innovation in partner research organizations* ***D.4*** *Increased capacity for innovation in partner development organizations and in poor and vulnerable communities*
4. About 40 million smallholder households and other users access more productive tree planting material and uptake higher performing, context appropriate and inclusive AF and small-scale forestry mgt. options	

Successfully achieving FTA's EPOs is expected to contribute to the realization of four primary higher-level outcomes that correspond to the SRF's IDO level. These are presented in Table 1.3b, together with the specific IDOs they have been mapped to. Finally, Figure 1.3 shows that the work of FTA is expected to ultimately make a meaningful contribution to each of the SRF's three System Level Outcome (SLOs).

Table 1b. Mapping of FTA's IDO-level Outcomes to the IDOs

FTA IDO-level Outcomes	Mapped IDOs
1. Improved ecological integrity, equitable mgt. and protection of forests and non-forest-based tree resources	**3.1** Natural capital enhanced and protected especially from climate change **3.3** More sustainably managed agro-ecosystems
2. Enhanced ecosystem service provision (e.g. carbon storage, nutrient cycling, water filtration and ⇧ soil heath)	**3.2** Enhanced benefit from ecosystem goods and services. **2.3** Improved human and animal health through better agricultural practices
3. Increased resilience of female, male and poor smallholders and other forest/tree users to climate change and other shocks	**1.1** Increased resilience of the poor to climate change and other shocks
4. ⇧ Productivity, food and nutritional security and incomes for female, male and poor smallholders and other forest/tree users	**1.2** Enhanced smallholder market access **1.3** Increased incomes and employment **1.4** Increased productivity **2.1** Improved diets for poor and vulnerable people
Cross-cutting Outcomes	**A.1** Mitigation and adaption achieved **B.1** Equity and inclusion achieved **C.1** Enabling environment improved **D.1** National partner and beneficiaries enabled

The translation of an activity or lower level result into a higher level result in FTA's ToC (represented by numbers in Figure 1) is dependent on a number of key assumptions holding true. Table 1c presents these assumptions, the level of assumed risk that they will not hold true, and the action that FTA will take to monitor and mitigate the risk. It is important to acknowledge that the level of risk will vary significantly by country and even within countries.

Table 1c. Key Assumptions, Risks and Mitigation Measures

ToC link	Key Assumptions	Risk Rating	Risk Monitoring & Mitigation Measures
1	Policy and decision-makers find FTA's knowledge and evidence credible and relevant. Absence of significant perverse incentives and/or power vested interests in maintaining the status quo.	Medium	FTA MELIA team to periodically monitor with scientists and ensure this is a focus of selected CCEEs and other types of evaluations. Revising of FTA engagement strategies and tactics undertaken as necessary.
2	Willingness of and incentives for targeted private sector actors to do business differently.	Low-Medium	FTA MELIA team to support FP4 team to monitor, with strategy and/or tactic adjustment as necessary.
3	Positive NRS & line ministry receptivity; pre-requisite capacity & infrastructure exits that can be developed.	Medium	FTA MELIA team to work with scientists to periodically monitor and management to act accordingly.
4	Targeting is inclusive and appropriate; extension system tailors innovations to differing contexts and groups. Smallholders find it worthwhile to invest in the complementary management practices & livelihood options.	Low-Medium	MELIA team to support FP1-2 to assess during impact assessments & evaluations, with management acting on recommendations as necessary.
5	Adopted governance arrangement, mechanisms and tools are intrinsically effective AND properly implemented.	Medium-high	FTA MELIA team to monitor with scientists and ensure this is a focus of selected CCEEs and other types of evaluations, with FTA engagement strategies and tactics undertaken as necessary.
6	Scale and extent of FT&A protection, enhancement and promotion is of sufficient scale to generate significant ESS.	Medium	MELIA team to support FTA scientists to assess during impact assessments and evaluations, with research prioritization and/or engagement being adjusted as necessary.

ToC link	Key Assumptions	Risk Rating	Risk Monitoring & Mitigation Measures
7	Options to improve resilience and agro-ecosystem health are adopted and sufficiently efficacious in scaling context. Climatic and other shocks to which targeted farming systems are subjected are not exceptionally severe.	Medium	MELIA team to support FTA scientists to monitor and assess during impact assessments and evaluations, with research prioritization and/or engagement being adjusted as necessary.
8	Food produced (or purchased with increased income) is of sufficient quantity and quality and is actually consumed. Additional income generated is significant and stable enough to bring smallholders out of poverty.	Medium	FTA MELIA to evaluate with impact assessments, with learning fed back into FTA research and scaling prioritization

1.0.4 Gender

The gender research strategy: A focus on transformative gender research

The FTA gender strategy (2013) outlined the critical roles both women and men play in managing forests, agroforestry and tree genetic resources across the developing world, illuminating the missed opportunities to generate knowledge that can guide the redress of gender inequities in accessing resources and benefits.

During phase I, the strategy was implemented through a multi-pronged approach, focused on four components: (i) capacity development of scientists and partners in gender concepts, frameworks and methods; (ii) strategic gender research across forests trees and agroforestry (FTA) themes and CGIAR Research Programs (CRPs), and targeted support for gender analysis across Flagship Projects (FPs); (iii) adaptive learning and gender responsive M&E; and (iv) knowledge-sharing across specified themes of tenure, forest use and management, climate change and value chains.

The coordinated implementation of the strategy in participating Centers has built a strong network of gender expertise and increased recognition that addressing gender dimensions is key to achieving development outcomes and better science quality. Tailored support in gender analysis across FPs has influenced the FTA research agenda and supported achievements in addressing key institutional and cultural contexts that determine gender inequity.

A key example of such achievements is the work on the gender implications of REDD+ schemes in countries such as Brazil, Cameroon, Indonesia, Tanzania and Vietnam, and in Vietnam and Indonesia, where these recommendations have informed national guidelines and policies.

Another example is the gender work on forest use and management that create new spaces for women's participation and build understanding between women and men about the benefits of inclusiveness in forest management across different geographies and contexts including Uganda and Nicaragua, India and Malaysia, Kyrgyzstan and Burkina Faso.

The gender theme in FTA Phase II will prioritize a transformative approach to gender equality by focusing on analyzing structural barriers and drivers of change in tree-based and forested landscapes, and how these affect men and women's capabilities to: (i) control assets and resources; (ii) value and distribute unremunerated labor; and (iii) meaningfully participate in decision-making at the household and community levels.

The research proposed complements the articulation of gender dimensions undertaken within each of the FPs by exploring the gender norms, institutions and power relations that are structural barriers to gender equality. Gender research and mainstreaming in FTA will link with the PIM-led gender platform to enhance synergies and amplify contributions to the achievement of the CGIAR gender IDO 'Equity and inclusion achieved' (Figure 1).

Studies under this theme will take place in geographies relevant to the FPs where partnerships can be leveraged to inform policy and practice. Research outputs will contribute to the CGIAR gender IDO.

Using a triangulation of methodological approaches, diagnostic and action research will address the following research questions:

1. What are the effects of different sector policies in creating constraining or enabling environments for women's access to and control over forests, trees and other productive resources?

Some countries in the tropics have gender-specific policies, but these are often in conflict or inconsistent with other sectoral policies, creating disincentives for women to get involved and benefit from forestry and agroforestry interventions. For example, family laws often have strong provisions for women's rights over assets acquired during marriage. But social and credit policies limit women's access to credit, as women are not often regarded as household heads and land allocation policies generally award land titles only to men.

Hypotheses: Policies are an integral part of the contextual conditions that affect the capacity of different actors to participate and capture benefits from the management of forests and tree-based production landscapes. Improved synergies among sectorial policies in the target countries can create incentives for women to get involved and benefit from forestry and agroforestry interventions.

Specific outputs include a multi-country comparative report of sector and gender-specific policies and recommendation on ways to harmonize those policies.

2. What types of institutional arrangements promote meaningful participation of men and women in decisions related to forest restoration and management? Under what conditions does such participation translate into more equitable benefit-sharing and sustainable NRM?

A growing body of research highlights the role of gender in shaping access, management and use of forest resources and their associated benefits[1]. Women generally face greater constraints than men in their ability to make decisions around natural resource management (NRM) resulting from gender norms and technological biases, among others; this hinders their participation in formal decision-making forums such as forest user groups or in household-level decision-making processes. Studies show that increasing women's participation in forest user groups and decision-making often results in improved incomes from forests and improvements in the management of forest resources, at the community, household or farm level[2].

Hypotheses:
(i) The active participation of women and marginalized groups in forest and NRM is mediated by the interaction of gender-based constraints and interests. Appropriate mechanisms can promote greater gender equity and social inclusion in forest governance institutions. (ii) Women's participation and decision-making can lead to more sustainable local tree management practices and improved livelihood outcomes.

Expected outputs include: protocols for engaging women and marginalized groups in community forestry institutions and in restoration; data sets on gendered constraints and interests in forest management and restoration; locally-defined, community-level institutions, policies and strategies that enhance women's participation in forest management and restoration.

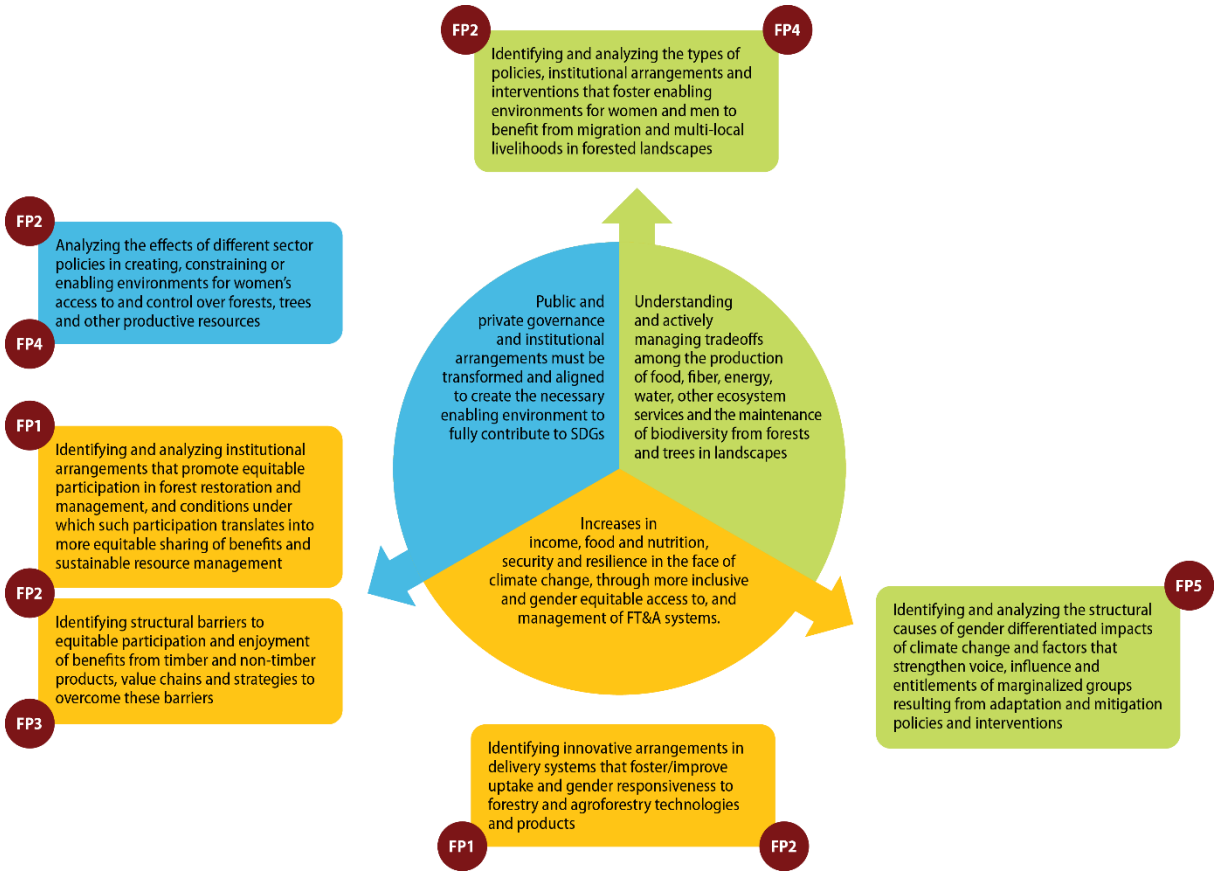


Figure 1. Gender research in the Forests and Agroforestry Agri-food Systems Research Program.

3. What are the structural causes of gender differentiated impacts of climate change, and what factors strengthen the voice, influence and entitlements of marginalized groups resulting from adaptation and mitigation policies and interventions?

Strategies to mitigate the impacts of climate change depend on management of the world's forests and tree resources, with implications for the diverse, numerous populations who depend on them. Men and women face varying challenges and opportunities to mitigate and adapt to climate change impacts due to gender-differentiated roles and responsibilities. Fewer women than men can access productive resources such as land, technology and financial and extension services. Societal roles contribute to the development of gender-differentiated risk perception and knowledge of FTA resource management, with implications for smallholder adaptation strategies.

Hypotheses: (i) Climate change policies and interventions that address gender inequalities can promote equitable benefit distribution, harness producers' innovative capacities and create long-term, positive mitigation and adaptation effects. (ii) Policies can anticipate risks and reverse harmful inequalities when they are informed by understanding of socially differentiated interests and needs, and when they incorporate mechanisms for meaningful participation of marginalized groups in decision-making processes in their development and implementation.

Expected outputs include: regional and national-level policy recommendations and learning platforms on gender equity in REDD+ processes, and socially differentiated analyses of climate change impacts on men's and women's livelihood strategies in relation to forest and tree resources.

4. marginalized groups face in different FTA business models and value chains across different institutional, economic and cultural contexts? What types of strategies, institutional arrangements, interventions and safeguards should be used to improve gender responsiveness of FTA value chains and business models? How can potential synergies be amplified – and trade-offs mitigated – between the gender responsiveness and the environmental and economic sustainability of such business models?

There is an urgent need to reduce deforestation and forest degradation while meeting a growing global demand for food, feed and fiber. In order to enhance their uptake and sustainability, public and private governance arrangements aimed at reducing the adverse environmental impacts of FTA value chains and business models will have to address issues of economic viability and social inclusion and equity. While gender roles and relations often structure the extent and nature of women and men's engagement with FTA value chains, systematic sex-disaggregated data on male and female participation, activities and benefits is scarce. As various private initiatives are gaining traction, discussions about their potential gendered impacts is limited. There is a need for further research on how gender norms and relations structure women and men's engagement with FTA value chains in various contexts, as well as understanding what kind of institutional arrangements foster gender-inclusive participation.

Hypotheses: (i) Gender norms structure the extent and nature of women and men's participation in FTA value chains. (ii) Gender-blind policy interventions and business models can exacerbate gender inequalities. (iii) Gender-responsive interventions and business models improve gender equality and may offer synergies for enhancing their environmental and economic sustainability.

Expected outputs include: sex-disaggregated data sets on participation and gendered constraints in various FTA value chains and policy options for more gender-responsive value chain governance.

5. What is the impact of gender differences in patterns of migration and mobility (male-led, women-led, mixed-gender) on women's voices and influence in forest governance? Which types of policies, institutional arrangements and interventions foster enabling environments for women and men to benefit from migration and multi-local livelihoods in forested landscapes?

Forest and tree-based landscapes are changing due to high levels of internal and transnational migration. But the literature portrays peoples' relations to forests as geographically bounded. Understanding how different groups of women and men in varying forested landscapes are affected by economic migration will ensure that policies, interventions and advocacy on migration, forest governance, smallholder livelihoods and gender equality are more effective at empowering women. The following research questions will contribute to the goals of FP2.

Hypothesis: In the highly globalized world that forested landscapes are a part of, women are increasingly migrants, left behind, and/or both. These are likely to have different and contrasting consequences for women's empowerment, work burden and social capital.

Expected outputs include consolidated country-level analyses and a stakeholder workshop to disseminate results and validate findings.

6. What type of extension arrangements will improve the uptake and gender responsiveness of forestry and agroforestry technologies and planting materials and create opportunities for women's empowerment?

While extension services play a critical role in: NRM, agricultural development for food and nutrition security and for improving productivity and livelihoods, they do not adequately serve rural women[3]. Little attention is given in extension to empowering women. Overcoming gender bias requires attention to what stands in the way of equitable service provision, rather than trying to increase extension contacts with women[4].

Hypothesis: Extension and delivery approaches that seek to transform gender roles and promote more gender-equitable relationships between men and women will achieve more equitable participation in household agricultural decision-making and improve uptake of forestry and agroforestry technologies.

Expected outputs include: data sets on the effect of various extension and delivery approaches on women's empowerment, and options to integrate gender transformative mechanisms in extension and delivery systems.

Theory of change/Impact pathway

The CRP gender research strategy contributes to the IDO 'Equity and inclusion achieved', and to sub-IDOs 12.1 and 12.3 through an integrated approach that combines at least two impact pathways:

Pathway 1. Informing policy-making to address institutional barriers to women's control over and access to FTA resources and their benefits

In collaboration with a wide network of boundary partners, we will create knowledge hubs and hold workshops to identify the entry points for affecting policies and institutions, and promote uptake of research findings. Boundary partners (policy-makers, practitioners, advocacy organizations) will be equipped with: (i) greater evidence on the relationship between forests and women's empowerment and options for reforming policies, institutions and interventions to foster women's empowerment and sustainable forest management; (ii) evidence on the disconnect between sectoral policies that affect men and women differently and options for creating enabling policy conditions for women to benefit from forests, trees and agroforestry resources; and (iii) improved information on how gender shapes forest/tree-based livelihood strategies, adaptation to climate change and benefit-sharing in REDD+ schemes and mitigation measures.

Pathway 2. Enhancing women's participation in decision-making on management of forests and agroforestry landscapes through action research

Innovative methodologies involving women and men, with an emphasis on the most vulnerable community members, will improve awareness, develop capacity and increase gender-balanced influence in joint forest management. They will involve women and vulnerable groups more actively in agroforestry and restoration and will focus on helping them to enhance their role in NRM decision-making. This will open up a space for women's wider decision-making at the household and community levels. These represent a key channel for strengthening women's voices and promoting their interest in and claims for priority forest resources and related income.

The above impact pathways rest on three key assumptions.

- Partnerships built in Phase I will continue and increase their engagement; the entry points identified to influence policies and institutions will ensure uptake of research findings.
- Evidence on the relationship between sustainable forest management and tree-based livelihood strategies and the empowerment of women and other vulnerable groups will influence the design/reform of policies, institutions and interventions.
- Improving awareness, capacities and more gender-balanced participation in forest and NRM, will help women's access and control over forest and tree-based resources and related income.

These assumptions will be monitored throughout the implementation of Phase II and will be continuously reflected on to adjust our approach, if and when needed.

Reinforcing gender mainstreaming

Building on progress made in Phase I, the strategy will focus on:

- **strengthening capacities for gender analysis**, to equip scientists and partners with the latest thinking on gender through:
    - a fellowship program for junior scientists across the FTA FPs to deepen understanding of contemporary issues around gender in NRM
    - periodic workshops to raise awareness among scientists about basic concepts and approaches to gender integration in NRM.

- **developing learning and knowledge-sharing platforms** to share data, information and evidence-based strategies on gender and forestry issues, and mobilizing partnerships that influence policy and action
- **supporting the integration of gender dimensions in monitoring and evaluation frameworks** to: (i) gather best practices and evidence for impact of research towards achieving the equity and inclusion IDO; and (ii) generate gender relevant information in the CRP ToC and impact pathway
- **leveraging inclusive partnerships** to broaden the social networks on gender to inform research priorities and goals, develop institutional capacities and communicate results for advocacy and scaling-up impact
- **providing support to HR units** by training and developing gender-responsive workplace policies.

Monitoring progress in gender research and gender integration

Monitoring will be done by: (i) gender integration in research and action across FP portfolios; and (ii) contribution of strategic gender research to transformative outcomes on equity and inclusion in particular FPs.

In (i), the Gender Equality in Research Scale (GEIRS) will be used to monitor and track gender integration in relevant FPs. Application of the tool will facilitate assessment of the application of gender analyses and collection of sex-disaggregated data, and will identify projects that will require support from the GIT.

In (ii), the GIT will work closely with the monitoring and impact assessment team to conduct impact studies on selected projects. Selected studies will examine gender-differentiated impacts and gender relations in forests and agroforestry landscapes. The focus of the studies will be: (i) to identify which types of interventions foster greater equality between men and women of different ages and socio-cultural backgrounds in forests and agroforestry landscapes; and (ii) to monitor contributions towards sub-IDOs 1 and 3.

1.0.5 Youth

Along with forest transitions, livelihood opportunities and the ambitions and interests of new generations also change. Both positive and negative aspects of change are generally linked to intergenerational shifts as motivators. Explicit consideration of such links across age and gender helps to understand current bottlenecks for young people to engage in new FT&A-related opportunities.

To better understand and address those bottlenecks, the second phase of FTA proposes a strategy for youth engagement in forest and tree-based productive landscapes (Annex 3.5 Youth Strategy). Overall, the strategy develops two strands of research. One strand will generate evidence and propose options to address the structural and institutional factors that constrain youth participation in tree and forest product value chains and non-farm entrepreneurial activities. It will also look at limits to youth access to productive resources, including land, financial services and information. The other strand will focus on aspects related to the aspirations, interests, skills and knowledge of young men and women in tree-based livelihood activities. This includes addressing the most appropriate tools and approaches to motivate youth and develop their capacities to participate in decision-making processes in natural resources management, agribusiness models, forest product value-chains and business opportunities in delivery systems.

The strategy will be implemented through FTA Flagships by developing research questions that contribute to the two proposed strategic strands, and by directing specific efforts to meaningfully involve youth in capacity development and knowledge-sharing activities to facilitate change. Information on specific research questions, sites where research will take place, partnerships and the organizational arrangement needed to develop the youth component can be found in Annex 3.5 Youth Strategy.

1.0.6 Program structure and Flagship Projects

The major external elements that guided content priority setting (Annex 3.18) and the shaping of FTA II were the new CGIAR SRF and its targets, the portfolio approach developed in Windsor, the vanishing of System CRPs, and important new developments in the international agenda (Aichi targets, Sustainable Development Goals, New York Declaration on Forests, Bonn Challenge, Paris climate agreement).

Responding to the FTA I evaluation[1] and comments on FTA II pre-proposal[2], we structured the program into five Flagship Projects and one cross-cutting Support Platform. This new structure is generally similar to that of FTA I for two reasons: it avoids major disruption of an intrinsically very successful program, and it ensures consistency with the internal organization of the main FTA partners. However, it also incorporates important changes: 1) creation of a cross-cutting support platform to improve prioritization, impact at scale and social inclusion; 2) creation of a Flagship on tree genetic resources linking with the Genebanks and Genetic Gain platform; 3) positioning of part of the tenure work in PIM reinforcing cross-CRP collaboration; 4) merging the two CoA of the Flagship on forest management and restoration into other Flagships (forest management in Value chains; restoration in Landscapes); 5) emphasizing productive elements of FT&A systems: smallholder livelihood systems using multiple products; global value chains and high-value tree crops; forest management, timber and biodiversity.

Each FP is built around a set of critical issues affecting FT&A production systems or the capacity of FT&A services to support food systems, as well as global sustainability (see Table 1 for an illustration of the various production systems and commodities). This set of FPs allows us to divide a complex continuum (multiple commodities, multiple actors and entry points, and multiple scales) into manageable, meaningful units that interact both within FTA and across CRPs. FPs are both solid constructs in their own right and work coherently with each other to integrate relevant results. In this way, FTA will contribute to the system-level outcomes in the context of our three overarching hypotheses (Section 1.0.1). Flagships interact with each other by exchanging results, knowledge, information and material as illustrated in Figure 1.

To realize the potential of FT&A production systems and maintain future options, **Flagship 1 'Tree genetic resources to bridge production gaps and promote resilience'** works toward safeguarding existing genetic diversity, seeks new solutions for critical steps in the domestication and improvement of priority tree species; investigates delivery pipelines for improved germplasm relevant to addressing the constraints for trees on farms to make desirable impacts in FP2, while also supporting delivery systems for landscape restoration initiatives within FP4.

Food security, nutrition and income for more than 100 million poor smallholders can be improved through better management of FT&A resources underpinning their livelihood systems. **Flagship 2 'Enhancing how trees and forests contribute to smallholder livelihoods'** is researching forest-based and high-value tree crop production systems to increase smallholder incomes and support sustainable agricultural intensification. FP2 interfaces with all other FTA FPs and with AFS-CRPs (RICE, WHEAT, MAIZE, RTB and Livestock), CCAFS on adaptation, and WLE on the role of trees in sustaining soil health.

FT&A systems are increasingly affected by global trade, foreign investment and transnational public/private regulations. **Flagship 3 'Sustainable global value chains and investments for supporting forest conservation and equitable development'** contributes to developing public and private governance arrangements, business models, and finance options to enhance a sustainable supply of commodities (cf. Table 1) and reduce pressures on forests, supporting their long-term conservation, while expanding the inclusion of smallholders and SMEs. FP3 provides an interface to PIM and CCAFS while informing FP2, FP4 and FP5 on global policy and market dynamics, people- and environment-friendly business models and "zero-deforestation" commitments.

We must understand what really matters at the landscape scale, in terms of patterns of change, trade-offs between, and consequences for ecosystems services supporting the production systems, landscape diversity and governance. **Flagship 4 'Landscape dynamics, productivity and resilience'** addresses these issues

through landscapes that represent broad agro-ecological zones, ensuring an interface with WLE, A4NH and PIM and with FP5 on climate-water interactions. FP4 clarifies the wider context in which the livelihood options of FP2 are tested and further developed, safeguarding biodiversity conservation with FP1. On the interface with FP3 we study trade-offs: how concerns of end users along value chains of tropical commodities are modifying trade as a driver of tree cover change.

Deforestation and forest degradation are responsible for 60% of tropical land-use emissions. FT&A systems offer actionable solutions to the challenge of climate change and represent the only carbon sink opportunity in the context of the Paris Agreement's ambitious goals. **Flagship 5 'Forests and climate change: Climate change mitigation and adaptation opportunities in forests, trees and agroforestry'** researches policies and technologies for mitigation, adaptation and sustainable bioenergy provision and their implementation in climate-smart landscapes, and provides knowledge and tools for the assessment of policy performance. FP5 closely coordinates with CCAFS (see Annex 3.7 for details). FP5 is designed to interface with FP2, FP3 and FP4, by incorporating zero-deforestation options from FP3 into its work on low carbon development; by delivering climate change policy options to be integrated into landscapes in FP4; and by providing climate change adaptation options for inclusion in the broader adaptation context of FP2.

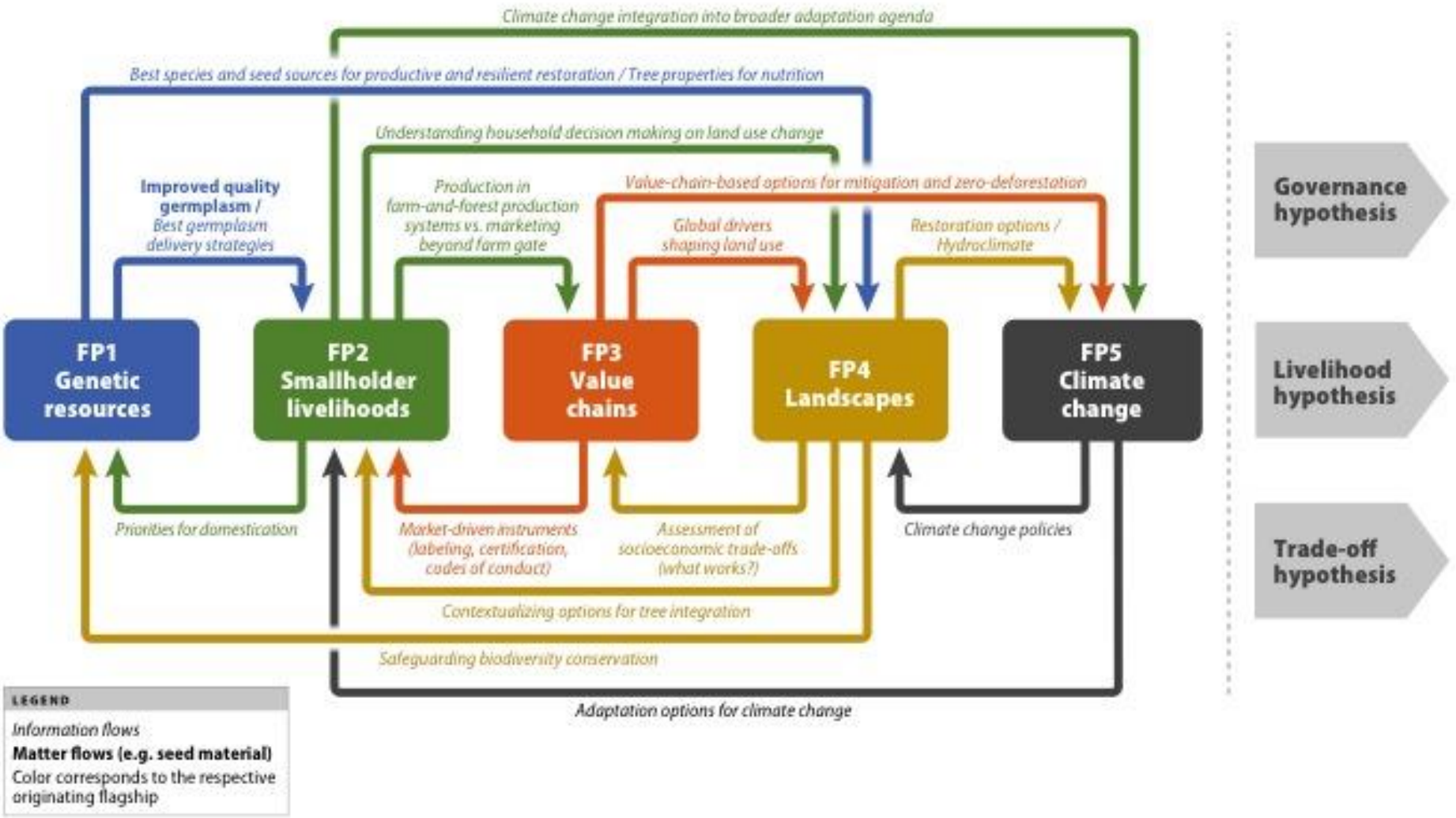


Figure 1. Interdependencies among FTA Flagship Projects

The crosscutting Support Platform (SP) **'Delivering Impact and Inclusion'** contributes in making the FTA program more than the sum of its Flagships by revising theories of change, delivering *ex-ante* assessment and foresight, bringing together results from Flagships through systems' analysis and focusing on scaling up FTA outcomes and impacts. The SP ensures that 1) outputs are gender and youth-sensitive and when possible effect transformation gender equality; 2) capacity exists to co-develop and use these outputs; 3) we engage in continuous interaction, learning and self-reflection to improve coherence, research design, engagement and outcomes; and 4) we implement activities necessary to achieve impact at scale. The SP collaborates closely with all other FPs to identify research questions and geographic coverage and with other CRPs (CCAFS, PIM and WLE) on foresight, gender, youth, big data and capacity development (See Annex 3.15).

We use all avenues for interfacing and coordination between FPs, including: 1) various FPs working on the same commodities (e.g. timber, cocoa, oil palm) from diverse entry points and impact pathways; 2) co-location of activities in Sentinel Landscapes; 3) co-location of research activities in site integration countries; 4) identification of emerging themes (e.g. eco-labeling or certification) that concern several FPs; and 5) bilateral projects connecting work across multiple FPs in a given geographical context. For example, the AgFor project in Sulawesi (Indonesia) now in its final stages operated on the FP2-FP4 livelihoods-landscape interface, but also included work on tree options for diversifying cacao agroforestry (FP1). The project helped understand the links to global value chains (FP3), explored climate change adaptation options (FP5) as part of the wider changes that farmers face, helped to further our understanding of the dynamics and diversity of gender relations at the forest-farm interface, and contributed to local policy reform and tenurial agreements between forestry authorities and farmers.

Our structure allows FPs to work both as stand-alone unit and coherently with each other, building on each other's work as also exemplified in the contribution to FTA targets (Annex 3.12).

Table 1. Production systems and commodities within FTA

Production systems	Commodity	FP1	FP2	FP3	FP4	FP5
Natural forests - savannas	Timber	Safeguarding and promoting sustainable use of genetic resources within interacting *in-circa-ex situ* conservation systems. Maintenance of option values for production of a range of tree resources (food and feed trees, timber, other NTFPs and wood-fuel) in off-forest settings.	Smallholder income from fallow management and development of silvopastoral systems across savannas	Implications of adoption of sustainability standards in sustainable forest management Impacts of regulations in importing countries (e.g. FLEGT, Lacey Act) on timber supply in producer countries Options to increase timber supply based on more intensive management systems	Effects of all changes in forest and tree cover on the provision of ecosystem services, through modification of pathways of water flow and its net effect on buffering floods and droughts, effects via biodiversity; management swing potential (footprints per unit product), as basis for eco-certification and differentiation in value chains. Effects of landscape mosaic diversity on nutritional diversity	How sustainable timber production can support carbon sequestration (mitigation; REDD+) and non-carbon benefits (e.g. income generation under REDD+); land use, development and conservation policies
	NTFP	Promoting natural regeneration and where relevant, invigoration of poor trees will be promoted.	Development of NTFP markets and equitable access to them by women and men.	Options of business models that improve value capture by smallholders, and access to financial resources		Income generation under REDD+
	Wood fuel	Development of tree planting material delivery systems.	On-farm supply of fuel as part of sustainable intensification and development of sustainable charcoal production systems			Policies and practices for smallholders and production on degraded lands; biofuel analysis and policies at large; food-fuel nexus debate and recommendations for sustainable production

Production systems	Commodity	FP1	FP2	FP3	FP4	FP5
Plantations	Timber	Safeguarding of perennial crop resources, including commodity crops and a wide range of other planted species. Application of combinations of new and established domestication approaches to invigorate and enhance productivity and quality of commercial crop germplasm. Development of delivery systems to supply a range of high quality, site- and purpose matched tree planting material.	Smallholder income from timber in woodlots and trees integrated in farm production practices	Financial flows and investment models shaping processes of plantation development Social, economic and environmental impacts of plantations expansion Options of business models to improve greater social inclusion with a greater involvement of women Policy and market incentives and disincentives for adoption of sustainability standards Impacts of regulations and sustainability standards, and private commitments in the adoption of improved production and supply chain management	*Idem. +* Opportunities for high Land Equivalent Ratios (and thus 'land sparing') in timber + food crop systems *Idem. +* Technical options for diversified small holder oil palm in landscape mosaic context	How sustainable timber production can support carbon sequestration and non-carbon benefits (e.g. income) Land use, development and conservation policies Land use change and deforestation mapping Estimation of emission factors Tree crops as adaptation measures
	Oil palm		Oil palm intercropping options			
	Cocoa		Rejuvenation strategies	*Idem.+*	*Idem.+*	

Production systems	Commodity	FP1	FP2	FP3	FP4	FP5
			and sustainable agroforestry options	Options on business models that support creating shared value	Landscape level opportunities for oil palm + cacao systems	
	Coffee		Climate adapted options for smallholder coffee agroforestry	Improved finance schemes to support improvement of production practices	*Idem.+* Hydrological effects of different coffee production systems on steep slopes	
	Rubber		"Green" rubber production practices, for sustaining ecosystem service provision	*Idem.+* Options for developing voluntary standard systems for green rubber production systems with greater social benefits	*Idem.+* Historical research on the 'jungle rubber' systems, combining high biodiversity with acceptable returns to labor	
	Fruits		Increasing smallholder income from high quality fruit production and better marketing.			

Production systems	Commodity	FP1	FP2	FP3	FP4	FP5
Cropland system with trees	Rice	Development of more optimal genetic-level species interactions between tree species and other annual crops in production systems (community genetics) to help improve land equivalence ratios. Development of delivery systems to supply site- and niche- matched tree planting material that supports annual crop production and restoration of degraded agricultural landscapes.	Development of rice agroforestry practices focusing on trees underpinning soil health, water and nutrient cycling in sub-Saharan Africa and Asia			Agricultural expansion as a driver of deforestation. Emission factors needed to estimate emissions when forests are replaced by agriculture.
	Maize		Development of maize agroforestry practices focusing on trees underpinning soil health, water and nutrient cycling in sub-Saharan Africa.		Opportunities for high Land Equivalent Ratios (and thus 'land sparing') in timber + food crop systems	
	Wheat		Development of wheat (and teff) agroforestry practices focusing on impacts of trees on crop physiology to close yield gaps.			
	Soy		Options for enhancing market access and prices achieved by smallholders from selling beans in Zambia	Public and private arrangements to improve supply chain governance and intensification Impacts from adoption of voluntary standard systems in production and sustainable sourcing		

Production systems	Commodity	FP1	FP2	*FP3*	FP4	FP5
Pasture systems with trees	Meat	Development of more optimal genetic-level species interactions between tree species relevant for pasture systems. Domestication of new perennial fodder crops.	Use of trees to reduce heat stress in cattle and supplement animal diets including trade-offs between production goals and other ecosystem service provision, particularly biodiversity conservation.	*Idem.+* Innovative policy and market approaches to incentivize adoption of more intensive cattle ranching under more integrated land use and production systems	Biodiversity and connectivity aspects of silvopastoral systems.	Agricultural expansion as a driver of deforestation. Land use change and deforestation mapping.
	Fodder	Development of delivery systems to supply perennial fodder planting material matched to livestock production system needs.	Development of commercial markets for tree fodder and integrated systems of fodder production involving trees.			

1.0.7 Cross-CRP collaboration and site integration

Collaborations across CRPs

Building on the progress made in FTA I (i.e. collaboration with CCAFS and WLE, as well as pilots with A4NH and PIM), FTA II has a greater focus on formal collaboration across CRPs in order to achieve the portfolio approach promoted in the guidance document. All five FTA Flagship Projects (FPs) and the Support Platform (SP) have links with other CRPs.

Proposed interfaces ("Provide and Receive") between FTA II Flagships and other CRPs are detailed in the Table 1 of Annex 3.7 with specifics provided in the Flagship narratives. We see interfaces with the four integrating CRPs (all FTA FPs and the SP), the gene banks and genetic gain platforms via Flagship 1 (Tree Genetic Resources) and several other agri-food system CRPs (maize, rice, wheat, DCL, livestock) via FP2 (Smallholder livelihoods).

In Table 2a of Annex 3.7, we provide examples of collaboration with A4NH, CCAFS, PIM, WLE, DCL, livestock, maize, wheat, rice and the gene banks.

Site integration (country collaboration)

FTA strongly supports the CGIAR country collaboration process.

We are coordinating the site integration efforts for Cameroon (ICRAF-led) and Burkina Faso (CIFOR-led) and have held national consultations. We have been pioneering, with CCAFS and WLE, a country-wide consolidation in Burkina Faso with some promising outcomes[1] and overall good potential for replication in most countries. We are currently in discussions to take the lead on site integration in Cameroon, where all FTA members are well represented.

FTA staff actively participated in several of the national consultations organized by the coordinating Centers in 2015 and 2016 (Democratic Republic of the Congo, Ethiopia, India, Nepal, Nicaragua, Vietnam). We, like PIM, favor pursuit of national integration or country collaboration through participation of CGIAR in existing coordination mechanisms rather than the establishment of separate ones. The details can be found in Table 2b of Annex 3.7.

Indonesia is not one of the 20 countries for site integration, but it is the world's fourth most populous country and tenth largest economy, with 14% of GDP from the agricultural sector (world's largest palm oil producer, second or third largest for timber, pulp and paper, rice, cocoa, coffee and rubber) and the sixth largest greenhouse gas emitter. It is therefore a significant country for CGIAR. FTA's work there is significant and FTA stands willing to contribute or lead any site integration efforts in the country.

Sentinel Landscapes

We also bring to the table (via CoA 4.1 Landscape observatories: Forests, trees, farm and settlement dynamics) the Sentinel Landscape network and data. This cluster of activities is designed to maximize its interactions with all other parts of FTA and other CRPs that require data on tree cover change and countries that have commitments to the Aichi targets of the CBD, Bonn Challenge and associated reporting obligations. The observatory function of monitoring change in 10 landscapes selected to represent five major agroecological zones will continue the ***'Sentinel Landscapes'*** of Phase I, and plan for a second characterization around five years after the initial one. It links between wider agroecological zone concepts and the observatories, supporting analysis of representativeness and extrapolation domains of site-based studies across FTA. Details about the role of Sentinel Landscapes in FTA II can be found in the FP4 (landscape) narrative, and a description of the datasets currently being collected, variables monitored, and related parameters and progress to date are in Annex 3.19.

[1] Using future scenarios to design policy and research together in Burkina Faso. http://tinyurl.com/o9p9w7n

1.0.8 Partnerships

FTA delivers international public goods (IPGs) – high-quality publications; tools and methods; datasets; options for policy reforms and strengthening institutions – that requires working with partners in different capacities and at varying levels of intensity (see Annex 3.2).

Managing partners play roles in FPs and CoAs leadership and/or have a significant investment in FTA II. They include three external organizations (CATIE, CIRAD, INBAR and TBI) and three CGIAR Centers (Bioversity, CIFOR and ICRAF). The FTA's restructured managing partnership represent the world largest gathering of publicly funded institutions concerned with the sustainability of FT&A systems and committed to deliver IPGs.

Contributing partners play a significant role in achieving our goals but do not participate in FTA management. Global contributing partners include ARIs (IIASA, ZEF, several major universities), CGIAR Centers (CIAT), and international organizations (FAO, UNEP, World Bank, IUCN), and offer cutting-edge science and modeling capacities, complementary expertise or geographies. At country level we continue investing significant resources working with **NARES** (e.g. FOERDIA, Indonesia; KARI and KEFRI, Kenya; IRAD, Cameroon and EMBRAPA, Brazil) and with the relevant ministries and government agencies of priority countries.

Our collaborations with **global agribusiness** (e.g. Mars, Nestlé, Unilever), **financial institutions** and **business platforms** offer ways to improve the sustainability of FT&A production systems that contribute to the livelihoods of millions of farmers associated with large-scale agriculture and national and global value chains. Through engagement with our **knowledge-sharing partners**, we will continue to share results and lessons learned with potential users through classical dissemination activities and direct engagements with development or policy partners.

FTA's **comparative advantage**, besides being the world's largest partnership on FT&A resources, rests in its capacity to work across continents in a wide range of countries, ecosystems and species. FTA partnership[1] is seen as a "neutral" research organization with complementary areas of expertise and is therefore strategically suited to work across governments, NGOs and the private sector. National partners feel that FTA partnership plays an important role as 'hubs' for global research information and good practices that can be shared at national and subnational levels[2]. FTA links global initiatives to ground-level needs and actions, which national research organizations often cannot do as part of their mandate and because they have relatively limited familiarity and access to international processes. FTA's network of decentralized locations working closely with local partners offers important platforms for site integration. **Sentinel Landscapes** are unique places where extensive baseline data concerning all relevant dimensions of forest and tree-based systems are collected and monitored rigorously and regularly to implement trans-disciplinary research as part of a global comparative network that seeks to compare and contrast – and thus to understand and address – the complexities of natural resource management issues at the landscape level. They provide platforms for co-location of research for interested CRPs and allow for evaluation of changes (e.g. in FTA I, CATIE used the Nicaraguan-Honduran Sentinel Landscape to develop new cross sectoral R&D – 'climate-smart territories' – with CCAFS, WLE and DCL.

Of the W1/W2 funding for research, more than 50% is allocated to CGIAR Centers other than the Lead Center and to the external managing partners. Of the overall FTA budget approximately 25% is contracted to external partners.

1.0.9 Evidence of demand and stakeholder commitment

Links to global and regional initiatives

The FTA portfolio is largely shaped by demands and priorities expressed through a number of key international initiatives. Our participation in the Collaborative Partnership on Forests allows us to interface closely with the 14 global institutions that have a significant mandate on forests, as well as to provide research inputs on global issues: e.g. UNFF Non-Legally Binding Instrument on All Types of Forests; IUCN on forest landscape restoration; CBD on sustainable use of forest biodiversity; UNFCCC on international climate regime (REDD+) negotiations; World Bank on its Forestry Action Plan.

FTA has strong linkages to regional integration bodies and initiatives (e.g. CAADP, APAARI), and has both received and provided substantial input to the implementation of programs overseen by these multi-national actors: COMESA (Regional Forestry Strategy and Action Plan); EAC and SADC (Regional Forest Law Enforcement Governance and Trade Program); COMIFAC and ECOWAS (Strategic Convergence Plans); African Union (Africa Forestry and REDD+ frameworks). We support forest genetic resources networks in Asia, Africa and Latin America (APFORGEN, SAFORGEN and LAFORGEN, respectively), which are linked to national governments and play a major role in promoting implementation of the FAO Global Plan of Action for the conservation and sustainable use of forest genetic resources.

Country level

Our work is in demand with the relevant ministries and agencies as well as several CSOs and NGOs (e.g. World Vision International, Evergreen Agriculture Partnership, WWF). The Peruvian ministries of environment and agriculture asked our advice on policy related to cocoa agroforestry and fast-growing timber from fallows. At their request, we contribute to ongoing policy dialogues in Central Africa and South America to improve incentive systems for smallholder engagement in domestic timber markets; on REDD+ in Peru, Vietnam, Guyana and Ethiopia; and on tenure reforms in Uganda and Nicaragua. We work with the Indonesian Ministry of Environment and Forestry on their climate agenda, interacting on the establishment of carbon and land use reference levels and of a national carbon accounting system.

Development banks and donors

IFAD invited us to become core partners in a GEF-funded USD 100 million integrated agriculture pilot project involving 12 countries in sub-Saharan Africa. The European Commission invited us to design and manage a capacity development/land-use management program worth EUR 24 million in the Democratic Republic of the Congo based on previous achievements. We are developing for UKAID a community of practice on translating research and knowledge into action in the climate and environment sector for various UK-based agencies.

Private sector

A SME in Vietnam picked up a new technology we developed to market *Son Tra* in non-perishable forms. Unilever came to FTA for support in developing *Allanblackia* as a resource for vegetal oil, and a first product hit Swedish supermarket shelves last fall. In Côte d'Ivoire, Mars Inc. supports the genome sequencing of agroforestry trees, the Global Conservation Strategy for Cacao, and improved markets and production technologies. We also collaborate with business sustainability platforms (e.g. the Sustainable Agriculture Initiative, Consumer Goods Forum, Investment Forum).

Evidence of demand for FTA products is summarized in Table 1.

Table 1. Downloads and page views of FTA products

Product	Link	Downloads	Sessions	Views	Unique visitors	Datasets
Publications						
FTA publications	-	>1,500,000	-			-
Data repositories and platforms (since creation)						
CIFOR dataverse (2015)	http://data.cifor.org/dvn/	838	3,833	7,285	3,087	336
ICRAF dataverse (2012)	https://dataverse.harvard.edu/dataverse/icraf	>92,000				2,414
Portals (2015 data)						
Landscape portal	http://landscapeportal.org/	2,100,000			35,202	1,500
Terra-I	www.terra-i.org	4,629	14,845		9,372	
Global Forest Watch	http://www.globalforestwatch.org/	*	20,474		**	
CartoChaco	http://www.globalforestwatch.org/	*	6,584		5,969	
InfoAmazonia		*	**	82,000	**	
Peru Min of Env	http://infoamazonia.org/es/	3,263	2,139		501	
MAAP PROJECT***	http://geoservidor.minam.gob.pe/intro/	*	**	47,000	**	
Toolboxes (since creation)						
FCC toolbox (2011)	www.cifor.org/fctoolbox		10,179	19,779	10,700	
GCS REDD Map (2013)	www.cifor.org/gcs/redd-map		2,836	5,117	2,280	
SWAMP toolbox (2015)	www.cifor.org/swamp-toolbox		1,309	2,812	893	
IPN toolbox (2015)	www.cifor.org/ipn-toolbox		1,124	2,462	810	

*Terra-I data is not downloaded from this site, only viewed in interactive map viewer
** This data is not collected (but should be in the future)
*** From Matt Finer, mfiner@amazonconservation.org

1.0.10 Capacity development

1. CapDev role in the impact pathways			
For FTA's impact pathways, capacity development acts as an enabler at each stage of discovery, piloting and scaling. At the discovery stage, capacity to frame right research questions, choose appropriate methodologies and collect and analyze data is required, which is achieved through developing individual capacities in partner research organizations through developing future research leaders. At the same time, FTA's research in development and co-learning with development partner paradigms requires capacity to frame credible and relevant science from which development partners' knowledge needs are met. This is achieved through engaging development partners at relevant scales right from the beginning in an action research mode. For the proof of concept stage, FTA delivers tested methodologies, frameworks and approaches in the form of learning materials and delivery approaches. For scaling up and out, FTA develops capacity to innovate by strengthening relevant innovation/multi-stakeholder platforms and communities of practice.			
2. Strategic CapDev actions (Note: FTA will only monitor high intensity elements)			
Element	Intensity of implementation of chosen elements (expect no more than 3-4 would be high)	Give an indication of how chosen elements will be implemented (Note: see full plan in Annex 3.3)	Note any Indicators – from CapDev Indicators document or other – that could be used to track progress and contribution to CapDev sub-IDOs
1. Capacity needs assessment and intervention design strategy	Medium	FP2 intends to systematically assess capacity needs of its multi-stakeholder platforms and design interventions based on those assessments	Number of CRP managing partners adapting and using methodologies and approaches
2. Design and Delivery of innovative learning materials and approaches	High	FTA FPs will design and pilot test learning materials with target audiences at different levels (community, landscape, national and global) for new or adapted approaches, tools, frameworks, and business models, and work with capacity development boundary partners for scaling capacity development interventions	Number of targeted users and organizations include learning materials and approaches into their CapDev processes; number of frameworks/models approaches adopted/adapted by targeted organizations
3. Develop CRPs and Centers' partnering capacities	Low		
4. Developing future research leaders through fellowships	High	All of FTA's FPs will engage MS and PhD students to scientists from partner organizations to enhance the research skills of young scientists in developing countries to conduct innovative research, particularly in new conceptual and methodological approaches and using new and/or participatory methods relevant for addressing complex issues. FP1 and FP3 will particularly run academies for advancing scientific skills.	1. Number of ISI publications co-authored by students and young scientists 2. Number of funded research proposals involving fellows, post-docs, and alumnae of FTA
5. Gender sensitive	Medium	FP5 will integrate gender	Proportion of women among students

approaches throughout capacity development		explicit criteria into sustainability standards (e.g. RSPO), and criteria for assessing private commitments. It will also strive to achieve a balance between men and women young scientists	and post-docs involved in FTA research Gender-sensitive sustainability standards proposed by FTA used/adapted/included into monitoring tools accepted and used by respective organizations
6. Institutional Strengthening	High	FP1 will collaborate with networks and institutions for the development of National Plans of Action for safeguarding TGR. FP3 will strengthen multi-stakeholder platforms and business fora (FSC, RSPO, ISPO, GTPS, TFA 2020), FP3 and FP4 particularly work with national and/or subnational agencies (e.g. landscape managers and policy implementers)	Number of networks who institutionalize their standards based on FTA recommendations; and proportion of communities of Practice/Multi-stakeholder platforms inspiring innovation in FTA research, practice and policies
7. Monitoring & Evaluation of capacity development	Medium		FTA's MELIA framework incorporates CapDev
8. Organizational development	Low		
9. Research on capacity development	Low		
10. Capacity to innovate	High	FP1, FP 2, FP3 work on strengthening multi-stakeholder and innovation platforms through linking public and private actors' efforts to build complementary institutional arrangements to tackle specific governance puzzles, for example, oil palm governance in Indonesia and SMEs development in the cacao sector in Peru	Impact resulting from adoption of innovation: Indicators to be picked up in broader CRP impact assessment

Budget and resource allocation (The CRP should demonstrate that budgets allocated for CapDev have a credible share of the total CRP budget [e.g. around 10%] though amounts may vary in individual Flagship budgets) IMPORTANT: Please indicate in Table 3 of the PIM the investments of each FP on the Capacity Development sub-IDOs.

Budget for CRP	USD 58.9 million						
Budget for Flagships/other:	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**Supp. Platform**
	7.0	10.0	16.8	9.6	8.3	N/A	7.2

1.0.11 Program management and governance

The governance and management structure for FTA II is fully compliant with the Fund Council-endorsed IEA Review of CRP Governance and Management and summarized in Figure 1.

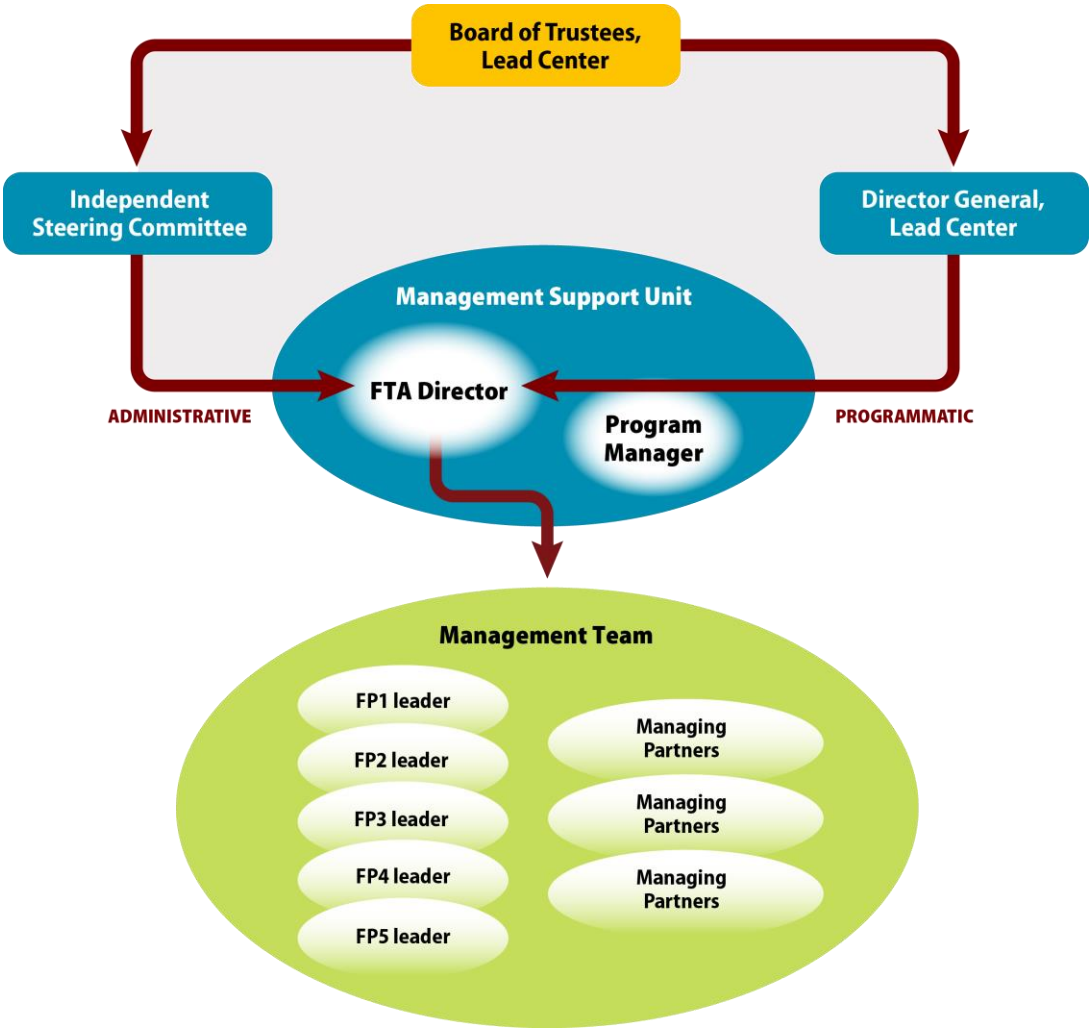


Figure 1. Program governance and management

Governance bodies

Fiduciary and programmatic responsibility for FTA lies with the **CIFOR Board of Trustees** (BoT) with CIFOR as Lead Center. A dedicated FTA session is organized during each biannual CIFOR BoT meeting in which the Chair of an **Independent Steering Committee (ISC)** reports and makes recommendations to the BoT for decisions. The ISC, active since June 2015, is composed of eight members: four independent members with no conflict of interest with FTA partners, three representatives of managing partners (DG Lead Center, one CGIAR and one non-CGIAR representative) and one Ex-officio member (FTA Director). The chairperson of the steering committee is one of the independent members. S/He reports to the Lead Center BoT. The ISC meets twice a year in coordination with CIFOR BoT meetings. The ISC ToRs are provided in Annex 3.8. The ISC is playing a major role in advising the CIFOR BoT on strategic programmatic issues (e.g., active portfolio management, strategic allocation of Window 1 and 2 funds) and in assessing the performance of the FTA Director.

Management bodies

At the date of submission, the DDG-Research of CIFOR is the acting **FTA Director** as the position is under recruitment. The successful applicant must show a strong record in managing large complex projects in multicultural environments and have a relevant multidisciplinary scientific background[1]. Following the guidance document, the FTA Director reports administratively to the Lead Center DG and programmatically to the ISC. The **FTA Director** leads a **Management Team (MT)** composed of a maximum of 10 members, including Flagship leaders and principal investigators of managing partners who do not lead a Flagship. The MT meets face-to-face at least once a year, but preferably twice (if funding is available), and via teleconferencing facilities once a month. The agenda of MT meetings is developed by the FTA Director with input from MT members. The ToRs of the current MT are provided in Annex 3.8, and will be amended if required by the FTA II governance bodies. The FTA Director is supported in his/her duties by a small **Management Support Unit** consisting of one program coordinator and modest administrative and communications support. **Flagship Leaders** are senior researchers (from CGIAR or non-CGIAR participating partners) with a strong publication record who have demonstrated their ability to successfully deliver expected development outcomes or impacts and to lead complex multi-partner teams or projects. They must also be able to fundraise and attract strong partners. The current ToRs for Flagship Leaders are provided in Annex 3.8.

Mechanisms for working effectively across FTA include monthly meetings of the MT (teleconferencing and at least two face-to-face meetings); regular meetings at CoA, Flagship and CRP levels (including one science conference every two years); e-groups to foster strong interactions throughout the program; communities of practice run in close collaboration with partners under the guidance provided in SP; co-developed joint annual program of work and budget (POWB); and shared senior staff across Flagships. In addition, FTA's progress in delivering outputs and outcomes is regularly and systematically monitored at the CoA and FP levels by the MT and the FTA Director via half-yearly traffic light reports, to ensure that scientific synergies across CoA and FP are fully realized and that scientists strive to improve research efficiency. The individual performance assessment of the FP Leaders needs to take into consideration the results of this monitoring. FTA I leadership is working on a process to formalize this as a means to further increase motivation and achievement within FTA. The implementation of a performance-based allocation of W1/W2 funds within FTA, which started in 2016, is a further mechanism that focuses the work of all scientists in the same agreed upon directions.

Composition of senior leadership (CVs in Annex 3.8)

At the time of submission, the main actors of the governance and management of FTA II are:

- Lead Center Board Chair: John Hudson
- Lead Center Director General: Peter Holmgren
- ISC Chair: Anne-Marie Izac
- FTA Director: position advertised for recruitment in 2016; Acting Director Robert Nasi (CIFOR)

Flagship leaders:

- FP1 Tree Genetic Resources: Ramni Jamnadass (ICRAF)
- FP2 Livelihood Systems: Fergus Sinclair (ICRAF)
- FP3 Value Chains: Pablo Pacheco (CIFOR)
- FP4 Landscapes: Meine van Noordwijk (ICRAF)
- FP5 Climate Change: Christopher Martius (CIFOR)

Support Platform:

- Gender, Youth: Margaret Kroma (ICRAF)
- Foresight-MEIA: position advertised for recruitment; acting Daniel Suryadarma (CIFOR)
- Capacity Development: Mehmood Hassan (ICRAF)
- Data for Impact: Anja Gassner (ICRAF)

1.0.12 Intellectual asset management

As the lead Center, CIFOR ensures that intellectual assets (IAs) produced under FTA are managed in compliance with the CGIAR principles on the management of intellectual assets (CGIAR IA principles) and CIFOR IA management policy for effective dissemination of its research outputs and maximize global impact. Hence, the following principles, as described in the CGIAR IA principles are adopted as guidance on IA management for FTA:

- **International public goods**
  FTA research results and development activities are regarded as international public goods and FTA is committed to widespread diffusion and use to achieve the maximum possible access, scope of impact and sharing of benefits to benefit the poor, especially farmers in developing countries.
- **Partnerships**
  Partnerships are critical to ensuring access to the best knowledge and innovation, harnessing efficiencies in product development and achieving maximum impact through effective delivery and deployment.
- **Sound management of IA and IPR**
  FTA research results will be managed with integrity, fairness, equity, responsibility and accountability in all of the locations in which FTA operates.
- **Maximizing global accessibility and impact**
  All IAs produced under FTA are managed in ways that maximize their global accessibility and ensure that the results lead to the broadest possible impact on target beneficiaries in furtherance of the CGIAR vision with prompt dissemination of research results.

The outputs of FTA include: policy briefs, guidelines, decision-support tools, working papers, data sets, publications and other knowledge and information related products. To ensure global access in line with CGIAR IA principles and CIFOR IA management policy, FTA publications are disseminated through open access (OA) that is governed by the CGIAR open access and data management policy and CIFOR OA policy.

One of CIFOR's FTA CGIAR partners, ICRAF, will work with national partners in tree germplasm improvement programs under FTA; such collaboration may also include public-private partnerships and issues of acquisition, protection and management of plant variety rights may arise. However, the decisions and process of acquiring and granting of these rights shall be made in accordance with the CGIAR principles on the management of IA and terms of the standard material transfer agreement (SMTA) under the International Plant Treaty with the ultimate goals of improving the germplasm and enhancing the scale and/or scope of impact on target beneficiaries, to achieve the CGIAR vision.

Complete information on the strategy for IA management of FTA is available in Annex 3.10.

1.0.13 Open access management

In line with the open data initiative, FTA aims to make research outputs on FT&A systems more available, citable, discoverable, interpretable, reusable and reproducible. In FTA I, together with partners, we generated a rich trove of multi-location, multi-disciplinary, and long-term data and associated information, which we make accessible for sharing, interrogation or repurposing through our data sharing platform. This is in adherence to the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) and thus can easily be linked to the new CGIAR initiative on Big Data Analytics. Through a community of practice, drawing on FTA research staff with a strong competence in research methodologies and longstanding field experience both from participating Centers and key partners, we place specific emphasis on ensuring that all primary data that our projects collect are of high value to FT&A and follow sound design principles.

As of 2015, 80% of all FTA publications are open access. We expect to reach 100% in 2017. In addition, FTA is currently developing an open data platform based on big data principles linked to Dataverse and Dspace. The platform will allow the public to visualize, analyze and collaborate using available FTA data. The platform will be ready for beta testing by late 2017.

To accommodate knowledge discovery, the supporting platform will be optimized as a solid infrastructure to improve access to scientific information and its long-term preservation. The platform will also support the development and evaluation of technologies and tools for data collection and management, data analytics and collaborations, which will enable discoveries and innovation. Annex 3.9 provides additional details

1.0.14 Communication strategy

The CRP-FTA communications strategy leverages Centers' and Flagships' existing strengths for engagement, knowledge sharing and visibility, supported by a central communications platform. The strategy components are therefore embedded throughout the program, to best use opportunities, areas of expertise and spheres of access for creating and maintaining uptake pathways, in accordance with the Theory of Change. Flagships will take the lead in engaging with policy and practice partners, and an FTA Communications Coordinator, working in collaboration with Centers' and partners' communications infrastructure, will adopt an integrated approach to sharing information about FTA research, engagement and other activities among Centers, CRPs, partners and broader audiences.

This model connects Centers' established channels and networks, primarily through the FTA Communications Coordinator. The FTA Communications Coordinator (i) uses FTA platforms to direct audiences to relevant libraries, databases and platforms; (ii) uses various communications tools (e.g. stories, websites, social media, fact files, events) to share knowledge on the program and its results at both CRP and Flagship levels, in collaboration with individual Centers; and (iii) serves as a hub for sharing information among Centers, partners and other CRPs (e.g. via FTA website, newsletter). The Communications Coordinator also circulates FTA visibility guidelines for all, so Centers can make FTA more prominent.

The tools and approaches used, and their contribution to achieving FTA's communications goals at both Flagship and CRP levels, are detailed in Annex 3.11.

The FTA Communications Coordinator is hosted by CIFOR, the CRP's lead Center, to take advantage of CIFOR's high-performing multimedia and library services teams.

Of the annual budget of USD 300,000, 34% will support FTA communications coordination directly, with the remainder split among Centers for activities focused on FTA knowledge sharing and visibility.

1.0.15 Risk management

FTA Lead Center CIFOR maintains as part of its Risk Management Policy a risk register that is updated yearly with the support of the CGIAR Internal Audit Unit. Other participating partners also have their own internal risk management policies that complement the actions taken at FTA level. Complementing this Centers-based comprehensive risk assessment, we developed the following risk table (Table 1) in the original FTA proposal in 2011.

Table 1. FTA risks and related management options in 2011

Risk	Risk management
Insufficient funding to match needs and expectations	Funding commitments by donors secured by CGIAR in advance of start of CRP6 Effective fundraising by individual participating Centers and through coordination and synergy between participants Early recognition of potential funding shortfalls, and prioritization of activities to minimize risks to accomplishing CRP6 objectives
Partner non-performance in managing program activities, generating sound data, analysis, outreach or financial management	Management Support Unit (MSU), assisted by staff in each participating Center and partner organization, provides adequate monitoring and evaluation, early detection of problems, and technical and managerial support Independent Steering Committee approved (Feb. 2016) a new performance based allocation rule for W1/W2 funding
Lack of clarity of research boundaries	Carefully articulated research proposal, and annual work plans, agreed to by all partners Steering Committee provides effective oversight of research strategy M&E provides effective feedback to choices of research as well as achievement of performance objectives
Suboptimal coordination of research activities	Independent Steering Committee provides effective oversight of research activities and supports coordinating role of MSU Regular MT meetings ensure a continuous monitoring of research and provides a venue for monitoring and improving coordination
Difficulty of measuring impact	Achievable targets and impact pathways identified and agreed, and sound methodologies employed at outset of activities to capture data Results from Impact Assessment studies inform process of measuring impact, providing for adaptive improvement of impact measurement

These above risks remain valid but we have been able to mitigate the potential negative impacts of most of these by putting in place the relevant governance structure and compliance monitoring (see sections on governance and management, IA, etc.). We have also considerably improved our business and management processes including performance allocation of W1/W2 funds and mapping of bilateral projects to FTA.

The top remaining risks and proposed risk mitigation measures are outlined in Table 2.

Table 2. Current FTA risks and management options

Risk	Explanation	Risk management
W1/W2 budget changes imposed by CO or donor decisions	Between October 2014 and January 2016, our W1/W2 budget has been brought down from USD 29.8M to USD 14.5M with major rectifications made more than 10 months in the financial year.	It is extremely difficult to manage pre-emptively such changes. A reduced allocation at the beginning of the year is one way but this has some significant impacts on our ability to commit to partners.
Delayed transfer of W1/W2 funds	While the drastically reduced W1/W2 allocation for 2015 has been received in full in 2015, there have been significant delays in receiving the funds in prior years 2011-2014. This has meant that FTA partners have significantly pre-financed the activity based on proposed allocations that have constantly changed and reduced.	CRP management has allocated 75% of W1/W2 allocation in the absence of firm commitments of funding to mitigate risk of reductions until the point allocations are firm. Despite this, Center reserves have been drastically reduced in the last couple of years due to deficits incurred due to last-minute reduction of W1/W2
Possible W1/W2 funding interruptions	Working on a 6-year framework program with 3-year budgeting tranches create some significant risks of interruption of W1/W2 funding during transitions between funding tranches and puts the CRP at risk of non-delivery or of creating significant opportunity costs, especially regarding cross-cutting themes such as gender integration, communications, monitoring, evaluation and impact assessment.	All partners are aware of poor stability of W1/W2 funding pipeline and will hopefully be able to respond relatively quickly with stepping up efforts to raise bilateral funding to close gaps. However this remains a significant risk that is difficult to manage effectively.
Reduced ability to deliver due to uncertainty in funding and constant change	Funding uncertainty and constant change in the CGIAR has made the institutions a less attractive employer. In the long term this can lead to reducing ability to deliver fully on expected results.	As above.
Increased volatility and unrest in many countries of our active portfolio	The years 2014 and 2015 have seen a significant increase in volatility and unrest around the world. This affects current and future FTA activities in some important countries (Cameroon, Central African Republic, DR Congo, Burkina Faso, Mali) by i) increasing potential risk to researchers, ii) making work more difficult or costly, or iii) rendering it impossible to travel to research sites.	Increased emphasis on safety and security and duty of care. Continual monitoring of situation in countries where we work.

1.1 CRP Budget narrative

1.1.1 General information

CRP Name	Forests Trees and Agroforestry
CRP Lead Center	CIFOR

1.1.2 Summary

Flagship Name	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
FP1-Tree Genetic Resources for production and resilience	11,671,235	12,147,335	12,655,434	13,197,951	13,777,508	14,396,948	77,846,410
FP2-Enhancing trees and forest contribution to smallholder livelihoods	16,698,876	17,476,293	17,920,908	18,474,414	18,729,180	19,472,990	108,772,660
FP3-Sustainable global value chains and investments	12,375,091	12,920,740	13,493,671	14,095,250	14,726,906	15,342,508	82,954,167
FP4-Landscape Dynamics, productivity and resilience	17,863,554	18,393,603	18,941,325	19,516,433	20,120,297	20,760,103	115,595,315
FP5-Climate change mitigation/adaptation opportunities in forests&agroforestry	12,868,110	13,438,410	14,025,422	14,677,199	15,347,398	16,036,941	86,393,479
Management & Support Cost	1,766,000	1,794,980	1,824,829	1,855,574	1,887,242	1,919,859	11,048,484
Strategic Competitive Research Grant	0	0	0	0	0	0	0
	73,242,865	76,171,360	78,861,589	81,816,820	84,588,530	87,929,350	482,610,516

1.1.3 CRP funding plan

Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	11,000,000	11,490,680	12,005,314	12,545,083	13,111,226	13,705,042	73,857,346
W3	0	0	0	0	0	0	0
Bilateral	62,242,865	64,680,680	66,856,274	69,271,736	71,477,303	74,224,307	408,753,168
Other Sources	0	0	0	0	0	0	0
	73,242,865	76,171,360	78,861,588	81,816,819	84,588,529	87,929,349	482,610,510

Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2(Assumed Secured)	11,000,000	11,490,680	12,005,314	12,545,083	13,111,226	13,705,042	73,857,346
W3	0	0	0	0	0	0	0
Bilateral	47,890,166	16,600,131	5,876,033	3,468,125	2,000,000	0	75,834,455
Other Sources	0	0	0	0	0	0	0
	58,890,166	28,090,811	17,881,347	16,013,208	15,111,226	13,705,042	149,691,800

Funding Gap	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0
Bilateral	-14,352,699	-48,080,549	-60,980,241	-65,803,611	-69,477,303	-74,224,307	-332,918,713
Other Sources	0	0	0	0	0	0	0
	-14,352,699	-48,080,549	-60,980,241	-65,803,611	-69,477,303	-74,224,307	-332,918,710

Narrative: At the time of redaction, early 2017 we have a gap of about 20% but we are confident being able to achieve the level of funding required in 2017 as we currently have around USD 20 million in high probability proposals in the FTA bilateral pipeline.

1.1.4 CRP management and support costs

FTA management and support costs are set at approximately USD 1,800,000, and have two components:

- An annual flat allocation of USD 100,000 to each partner for covering the basic costs of participation in the program (staff, meetings, travel, etc.). This might be revised depending on the number of core partners and the level of funding available.
- An average annual budget of approximately USD 1,000,000 managed by the Lead Center for the operations of the Management Support Unit detailed in the table below for 2017. The MSU budget increases approx. by 3% per year

Category of expenditure	USD
FTA Director (full time)	290,000
DDG-Research Lead Center (1 month)	45,000
DDG-Operation Lead Center (1 month)	45,000
Program coordinator (full time)	120,000
Secretary (half time)	15,000
Consultants	60,000
Steering Committee	60,000
Travel	70,000
Meetings	60,000
Research Support Costs	75,000
TOTAL direct costs	**840,000**
Overhead	126,000
TOTAL MSU	**966,000**

1.1.5 CRP financial management principles

1) W1/W2 allocation process for 2017

The minimum amount of w1-2 required for 2017 in order to properly run FTA II as a whole program and not a collection of bilateral projects has been estimated by the team at USD 18,455,000. The amount available based on the Table 2 is USD 11,000,000. This amount has been transparently allocated using a minimum fixed allocation as we estimated it was not possible to run properly a FP without a minimum of USD 1,600,000. If more W1/W2 is available, then we will revert to our initial idea of a base allocation and a variable allocation based on based on the actual bilateral funds invested into the FP and composed of a variable allocation to non-CGIAR partners capped at USD 200,000 and of a variable allocation to CGIAR partners

FIXED ALLOCATION

- Each core partner receives a flat allocation of USD 100,000 to cover the basic costs of participation in the program (staff, meetings, travel, etc.) – this is included in the management costs together with the costs of the Management Support Unit.
- Each Flagship receives an allocation of USD 1,846,800 to cover scientific coordination and management
- The lead Center has a budget of USD 966,000 (in 2017) for Management Support Unit operations
- The cross-cutting themes of the Support Platform SP (Gender, Youth, MELIA, Communication, Site Integration) receive USD 1,730,000 that is redistributed (together with the expected bilateral) equally in each FP

For the following years of the program this base distribution will be reviewed based on the performance of each partner and FP based on a set of criteria agreed by the Independent Steering Committee (document available on demand) in 2016.

Area	Indicator	Weight	Assessment period	Source of verification
Science efficiency	W1/W2 $ by non-refereed publication	1	Last 3 years	Publication list provided by Centers and FP
	W1/W2 $ by refereed publication	1		
Delivery	$/green or yellow outputs as in operational plan	2	Last 3 years	Traffic light reports and financial reports
Outcomes / Impacts	Progress towards outcomes, as ranked by the ISC independent members, from 1 to 5	2	Last year	Narrative provided by FP with associated evidence
Leveraged funds	Amount of W3-bilateral leveraged by W1/W2	2	Last 2 years	Consolidated financial reports

2) Budget ownership of the Flagship leaders (tracking, reporting, revising, etc.)

FP leaders are in full control of their budget within the constraints set up by the annual allocation approved by the Lead Center Board of Trustees and proposed by the Independent Steering Committee. They are provided the necessary financial information by partners and are responsible for the consolidation at FP level for reporting. Budget revisions are discussed within the management team and a consensus approach is taken to consider for the possible spillover effect of budget changes in one FP on the others.

3) Rules and expectations around annual variances for Flagship and participating partners budgets

Each year, based on the amount of bilateral registered in the FTA database and on the financing plan provided by the CGIAR system office, the Management Team proposes to the Independent Steering Committee a revised allocation of the W1/W2 funds for the year using the rules in place for performance management and making sure not to hinder the operations. The ISC review and amend the proposal and submit it to the Lead Center Board for decision. Annual budget variances of 10% for individual activities and line items funded by W1/W2 will be allowed for partner and Flagship budgets; any variance beyond these limits will require explanation and approval by CRP management and the ISC. It is recognized that W1/W2 funding may be associated with significant uncertainty regarding its timing and level, in which case this variance requirement may be relaxed by the CRP management with ISC approval. W3/bilateral budget and expenditure is subject to its own contractual requirements

4) Expected major capital investments

It is not possible to answer this at this stage for the whole budget, but one can safely assume that if there are such capital investments they are likely to be done using bilateral or W3 funding. Capital investments are

realized at partner levels in any case (the CRP cannot buy equipment) and are fully depreciated following the rules in place in each partner institution.

1.1.6 Budgeted costs for certain key activities

	Estimate annual average cost (USD)
Gender	9,000,000
Youth (only for those who have relevant set of activities in this area)	2,900,000
Capacity development	9,800,000
Impact assessment	2,600,000
Intellectual asset management	350,000
Open access and data management	2,000,000
Communication	8,200,000

The above amounts (snapshot of online tool) are including the planned expenditures of the FP and of the Support Platform

1.1.7 Other

The level of ambition of FTA requires mobilizing approximately USD 62–74 million in bilateral and Window 3 funds annually. This calls for flexibility to address the priorities of funders in terms of country focus and thematic interest.

Window 1 and 2 funds at the CRP level are used primarily to support fundamental elements of the program:

- Basic funding for allowing participation of the core partners to the various coordination, planning and reporting activities and Management Support Unit (see Section 1.1.3)
- **Supporting platform on delivering impact and inclusion**: This platform gathers the various cross-cutting concerns: Gender, Youth, Communication/Outreach, Data for Impact, Capacity Development, Site Integration, Monitoring Evaluation Learning and Impact Assessment. Regarding the SP, the ISPC wrote "The opportunities to leverage additional funds may be limited for this key component program, and in those respects, the budget for this FP may be too small and it also probably merits priority for W1/W2 funds going to FTA". Note that we did manage to secure a significant amount of bilateral funds to complement the basic W1/W2 funding.
- OA/OD and IA implementation

Window 1 and 2 funds at the FP level (see also specific sections in FP narratives) are used primarily:

- To strategically leverage bilateral funding likely as basket funds, in a way that different sources of bilateral funds contribute to the same major project goals, this in order to build a program that is consistent and that can deliver its expected objectives across the different geographies in which we are planning to do our work
- For "innovative" research lines (assuming co-funding requirements by bilateral funders can be met in other ways) while development outcomes oriented in part of FP are expected to be primarily funded by bilateral sources (within the geographical priorities of investors).

A reduction in W1/W2 fund availability will therefore primarily affect the innovative research lines, the important cross-cutting issues and the basic functions of the CRP.

2. Flagship Projects

2.1. Flagship 1 Tree genetic resources to bridge production gaps and promote resilience

2.1.1 Flagship Project Narrative

2.1.1.1 Rational and Scope

The effective use of tree genetic resources (TGR) to bridge production gaps, ensure profitability and for the essential global diversification of production options as highlighted by GAPAD[1] provides important opportunities to improve livelihoods and sustain ecosystems, and is a crucial part of reversing current cycles of land degradation and deprivation (Dawson et al. and Thomas et al. in[2]). However, the role of TGR in the provision of tree products and services has often been undervalued (Loo et al. in[2]). This has resulted in the cultivation of trees not matched to context, with poor yields and low-quality traits. Opportunities to prevent deforestation and landscape degradation, and to stop narrow agricultural intensification and dietary homogenization, have therefore been lost.

Flagship 1 addresses the under-recognition of the importance of TGR for productive and sustainable landscapes; the lack of coordination and appropriate investment in relevant research; and the inadequate models, tools and support mechanisms for effective testing and upscaling. Activities on **safeguarding** genetic diversity, **domestication** and planting material **delivery** are newly located within a single Flagship, whereas they were previously spread across different components of FTA Phase I, which resulted in a lack of effective integration. Safeguarding research ensures the proper characterization and continued availability of the fundamental resources – the trees – that support agroforestry and restoration planting, while protecting the utility of existing tree populations through their proper genetic management. Domestication research is concerned with the use of large gene pools to support significant genetic gains in tree traits that are important for product and service provision, matched to the production systems and landscapes of growers (Table 1). Research on delivery systems ensures that high quality, needs-matched, tree planting material reaches growers efficiently, to support wide-scale adoption of product and service options. By together drawing on recent methodological advances in each of these three areas, effective coordinated approaches are mainstreamed to provide a route to greater impact.

The enabling environment for coordinated research on TGR has recently become more favorable. First, the findings of the first *State of the World's Forest Genetic Resources* report (SOW-FGR)[3] brought the importance of TGR safeguarding for the 3000+ trees used by humans to wider attention. Awareness was reinforced by recent Action Plans for TGR conservation[4], and by prominent concerns of the pitfalls of small founder tree populations for disease susceptibility under climate change (Alfaro et al. in[2]). Second, recent community genetic research has revolutionized our understanding of the role of TGR in environmental service provision, showing that genetic diversity can be as important as species diversity[5]. This research has provided insights into species interactions that can be used to force positive relationships between genetic diversity and yield in agricultural systems not achievable naturally[6]. Third, greater awareness of climate change has reestablished the importance of resilience that can be supported by diversity breeding and decentralized participatory domestication approaches which consider production traits enhanced by genetic variation, and which use local landscape-level deployment to maintain planting material diversity[7]. Fourth, a greater focus on dietary quality has raised the profile of 'orphan' crops including nutrient rich tree foods in food production[8]. If the massive extant genetic variation of these crops is translated through increased recommended investments in domestication[9] into productivity, quality and profitability gains, they can compete with crop staples (Figure 1). Fifth, renewed investments in forest restoration[10] rely for success on access to site-matched tree planting material, and provide new opportunities to realign existing suboptimal

delivery systems. Recent landscape research has also indicated the tree traits that can be manipulated at the genetic level to improve restoration success[11].

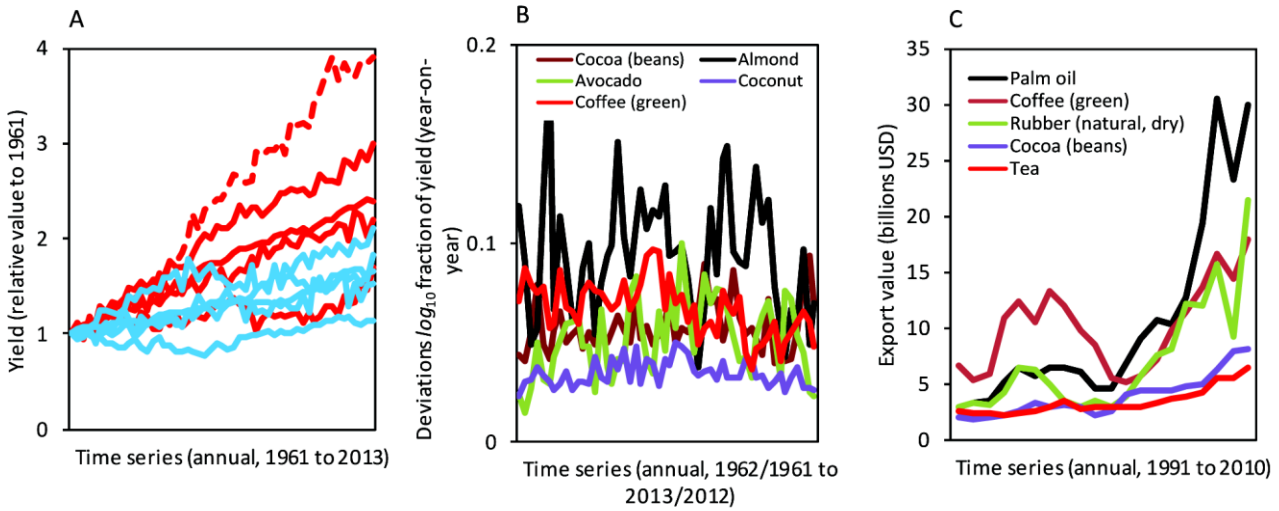


Figure 1. Supporting data for Flagship 1, extracted from FAOSTAT databases. A, 50-year yield time series for 10 crops with large increases (red) or decreases (blue) in their relative contributions as human foods[9]. The red dashed line is the exceptional case of oil palm. Most crops with a large increase in relative importance have doubled in yield over the period. With suitable investment, such gains should be readily achievable for new and orphan tree crops, allowing them to successfully compete in agricultural landscapes; B, Yield stability time series (as A) for five fruit tree crops with > 10% dependence on animal pollinators. Year-on-year instability can be high, but can be reduced by appropriate breeding/selection, choice of propagule type and system- and landscape-matching; C, 20-year export value time series for five formally-bred tree commodity crops. Data indicate high and increasing values, justifying investment in new, and further investment in existing, tree crops.

Table 1. Supporting data for Flagship 1, compiled from indicated sources (Sections 2.1.1.1 and 2.1.1.2)

Topic	Data
Trait improvement through domestication	(Section 2.1.1.1) Level of improvement depends on trait, propagule, production context and method of evaluation. Genetic gains can be high because of large gene pools and limited histories of domestication of many trees. Timber yields have been raised by a factor of two for several trees[12], with similar gains possible for fodders[13]. Significant gains in growth form for timbers and palatability and protein content for fodder trees are also attainable. High yield and food quality (e.g. vitamin, fiber) variation is observed in indigenous fruit trees and in tree commodity crops, although gains in yield are particularly sensitive to production context (e.g. because of pollination requirements)[14]. Cost: benefit analysis shows that investments in genetic improvement can be greatly outweighed by the extra value of the gains achieved (e.g. the case of acacia improvement in Vietnam, where a ratio of 1: >50 was estimated[15]).
Immediate beneficaries Flagship 1	(Section 2.1.1.2) Conservative numbers for beneficiaries draw on experiences among others with: the Mars-funded Vision for Change project to rehabilitate cocoa production with improved planting material in Cote d'Ivoire that, to date, has reached > 10,000 farmers[16]; rural resource center activities that support domestication and market access that serve > 10,000 households in Cameroon (and raise revenues for tree nursery practitioners); scalability projections for the Technologies for African Agricultural Transformation initiative (TAAT) for particular tree crops; and the experiences of the AgFor project in Indonesia, where > 15,000 individuals were trained in tree nursery management and propagation, and where > 500,000 residents benefited from improved access to quality tree seedlings produced in farmers' nurseries[17].
Long-term indicative economic value of domestication and delivery	(Section 2.1.1.2) Value represents an estimate for an extended 10-year intervention period, based on: an assumed year zero economic value of a range of tree commodity crops/products and other existing and new perennial crops/products/services that the program works on directly or influences of 200 billion USD annually (reasonable considering Figure 1C); a baseline of 1% year-on-year increases in productivity/quality of these tree crops/products/services is increased to 1.2% through program intervention, starting in the 1st year and being sustained (and accumulating) over the period (based on large gene pools from which selection can take place and improved technologies for capturing variation; larger gains are frequently attainable); and a baseline of a 1% yearly farmer replacement rate of improved tree planting materials that result from domestication activities is improved year-on-year by 0.5% over the intervention period, starting in year 1 and accumulating. Replacement rates are currently low in part because of ineffective delivery systems as well as the long time to maturity and longevity of many trees, which gives scope for considerable improvement, although effective intervention faces many challenges
Economic value of safeguarding	(Section 2.1.1.2) There are few economic analyses of the value of safeguarding TGR. Of the cases available, coffee is the best example[18]. Analysis of the value of wild coffee genetic resources in Ethiopian forests for three future breeding purposes indicated a net present value of 420 million USD, based on 30-year discounting period, a discount rate of 10%, a 15-year period for successful breeding into cultivars and a 20% adoption rate for improved cultivar planting. Similar analyses although not currently available are required for other tree gene pools, especially of high value species. An obvious candidate is cacao, with its high market value, the need to upgrade production to respond to low yields and pest and disease losses, and current reliance on a relatively narrow genetic base in breeding

2.1.1.2 Objectives and targets

Objectives

Availability and access to quality tree-planting materials suited to location and purpose are serious global constraints to tree planting. Narrow agricultural intensification coupled with loss and degradation of natural forests leads to ecologically impoverished landscapes with low productivity, as well as lost opportunities, besides threatening TGR. Flagship 1 research addresses these challenges by co-developing effective and affordable methods, technologies, gender-responsive guidelines, decision-support tools and proofs of concept in partnership with relevant institutions and networks. By applying optimal combinations of TGR safeguarding measures specific to ecological, geographical and societal contexts, by combining new and already available tree domestication approaches, and by developing context-specific delivery systems for the best available planting materials, livelihoods, and productive and resilient ecosystems, are supported – and current declines are reversed.

Outcomes and Targets

By 2022, Flagship 1 will increase capacity, share data and make recommendations for positive change or improvement in policies and institutions. Allocation of the three main Flagship 1 outcomes to funding windows is shown in Table 2. These outcomes contribute to Sustainable Development Goals 2, 13 and 15. Targets for Flagship 1 by 2022 are shown in Table 3.

Table 2. Outcomes by windows of funding

Outcomes	Amount needed (million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
1. (Safeguarding) Managers and policy-makers adopt effective monitoring methods, tools and practices to mitigate threats to valuable TGR, and implement suitable safeguarding strategies in line with international initiatives, such as the Global Plan of Action for Forest Genetic Resources and the Global Strategy on Conservation and Use of Cacao Genetic Resources	23	19	0	81
2. (Domestication) Agricultural and horticultural research and development partners adopt cost-effective domestication approaches for priority tree species, based on impacts and maximizing efficiency, and considering trade-offs involved in intensification, while paying attention to smallholder breeders' rights	23	19	0	81
3. (Delivery) National governments, extension services and private partners adopt cost-effective and equitable tree-planting material delivery approaches, with attention to appropriate international and national policies governing material transfer/use agreements and using the most appropriate decision support tools, to supply high-quality site-appropriate tree-planting material to smallholders and other growers	23	19	0	81
Total	**69 million**	19%	0%	81%

Table 3. Targets by 2022

Activities	Targets
Safeguarding	Support for implementation of global and regional strategies for TGR conservation in Latin America and Africa; support for *circa situ* safeguarding of TGR of 10 globally-important and 100 regionally-important food or income-generating tree species; tools and approaches for reducing the impacts of threats such as illegal logging and over-grazing in place in five key countries; on-line status and threat assessment tools for 100 species in Latin America and 100 in Africa used by managers to develop national conservation strategies; effective, efficient and equitable approaches and policy recommendations for TGR conservation developed for 10 priority species in target countries in each of three continents; training materials, characterization methods, policies and indicators of status and threats adopted in 10 countries
Domestication	Guidelines and decision-support tools on domestication approaches adopted by national research partners in at least 10 countries, with national and private sector breeders, on user-prioritized species; genomic data and assembled germplasm collections/panels fully developed and used in breeding strategies for five important food tree crops; stakeholders testing at least 10 more potential 'varieties' of trees across agro-ecological zones; public and private partners engaged in tree domestication activities to reach identified needs with incipient cultivars for at least three more tree species
Delivery	National extension partners, private companies and others involved in agroforestry and restoration initiatives in 10 countries have adopted best practices for sourcing planting material; national partners, on protected public land, have established new breeding/production seed orchards for 20 tree species globally; policy-makers have incorporated appropriate certification standards into delivery systems in five countries; farmers have adopted user-friendly online and mobile phone decision support tools to support tree planting choices in conjunction with market information services in five countries; national extension partners have determined and adopted improved context-specific delivery approaches for priority tree species in 10 countries, with the roles of the various actors involved properly aligned; changes in policies and strategies by national governments and implemented by national extensions services have resulted in entrepreneurial suppliers becoming more engaged in delivery (supplying at least 20% more material than 2016 levels) in five countries

Within the timescale of FTA Phase II, we estimate the number of smallholders benefiting directly from Flagship 1 activities due to improved access to resources through safeguarding as more than 500,000, with more than 1 million additional community beneficiaries (such as forest harvesters). We estimate the numbers positively affected directly by domestication activities that extend beyond smallholders to wider rural stakeholders to be similar. We anticipate the numbers of smallholders benefiting directly from Flagship improvements in planting material delivery systems to be 2 million or more, while more than 10 million will benefit from more effective restoration supported by improved delivery (Table 1). A longer-term (after 10 years) indicative value of interventions in economic terms and with effects amplified through wider adoption of the theory of change is estimated as an annual benefit following program intervention of ~USD 230 million in today's prices (Table 1). This does not account for reduced losses in genetic diversity through safeguarding that support options for future production by TGR incorporation into breeding and selection programs, which would increase the value of the intervention further, as illustrated by an analysis of wild coffee genetic resources in Ethiopia that indicated a net present value of ~USD 420 million (Table 1).

Links to IDOs and SDGs

Three Clusters of Activity (CoA) constitute the research program of Flagship 1. The CoAs contribute to the CGIAR's SRF sub-IDOs as follows:

- CoA 1.1 (safeguarding): sub-IDOs **4.4**, 5.2, **8.2**, 8.3, 9.2, **9.3**
- CoA 1.2 (domestication): sub-IDOs 1.2, 2.2, 3.1, 3.2, 3.4, **4.3**, 4.5, **5.2**, 8.3, **9.1**, **10.2**
- CoA 1.3 (delivery): sub-IDOs 1.2, 3.1, 3.2, **3.4**, **4.5**, **8.3**, 9.1, 10.1, 10.2, 10.3.

Bold indicates sub-IDOs of highest importance, described in Table 4 along with allocations of Flagship 1 investments.

Table 4. Investments by sub-IDOs

Sub-IDOs	Amount needed (million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
4.4 Increased conservation and use of genetic resources	6,9	19	0	81
8.2 Enhanced conservation of habitats and resources	4,1	19	0	81
9.3 Enrichment of plant and animal biodiversity for multiple goods and services	2,8	19	0	81
4.3 Enhanced genetic gain	6,8	19	0	81
5.2 Increased access to diverse nutrient-rich foods	2,8	19	0	81
9.1 More productive and equitable management of natural resources	2,1	19	0	81
10.2 Enhanced adaptive capacity to climate risks	2,1	19	0	81
3.4 More efficient use of inputs	6,8	19	0	81
4.5 Increased access to productive assets, including natural resources	3,5	19	0	81
8.3 Increased genetic diversity of agricultural and associated landscapes	3,5	19	0	81
A.3 Improved forecasting of impacts of climate change and targeted technology development	3,45	19	0	81
A.4 Enhanced capacity to deal with climatic risks and extremes	3,45	19	0	81
B.2 Technologies that reduce women's labor and energy expenditure developed and disseminated	3,45	19	0	81
B.3 Improved capacity of women and young people to participate in decision-making	3,45	19	0	81
C.1 Increased capacity of beneficiaries to adopt research outputs	3,45	19	0	81
C.3 Conducive agricultural policy environment	3,45	19	0	81
D.4 Enhanced institutional capacity of partner research organizations	3,45	19	0	81

2.1.1.3 Impact pathway and theory of change

Flagship 1's theory of change is illustrated in Figure 2. Through co-research and co-development of decision support tools and by capacity building, stakeholders are better able to define priorities, select methods and improve and implement practices and policies for TGR safeguarding within and in addition to wider forest, woodland and tree conservation measures. These stakeholders include national agricultural, forestry and horticultural research institutions, policy-makers, national planning agencies, global conservation organizations, community forestry groups, local authorities, and the private sector. Through similar approaches and the adoption of model domestication pathways and decision support tools, stakeholders are able to more widely and effectively promote and apply new approaches to tree genetic improvement in combination with well established existing methods to realize faster, more targeted and better sustained genetic gains for a wide range of tree species during domestication, suited to production and landscape contexts. More efficient and inclusive tree planting material delivery options and support tools, developed through co-research and through engagement with policy-makers, the private sector, government extension services, national tree seed centers and business development NGOs, enable the upgrading and commercialization of input suppliers, including women and youth enterprises. These suppliers are then able to more effectively provide growers with a range of more productive, diverse and/or site-matched tree planting materials that provide better options than existing materials. These measures support incomes that encourage a general reinvestment in farming and forest management. Through co-research with national partners, a better understanding of how, when and where domesticated resources and otherwise appropriately chosen planting material contribute to the provision of environmental services leads to more sustainable TGR management guidelines for adoption through national policy-makers. This knowledge also reveals important traits that inform domestication. Improved planting material inputs increase the range, yield and quality of tree products available for rural women and men and their households, supporting their incomes and diets, and enhancing the success of restoration initiatives. As farmers and traders further integrate improved tree products into value chains with the support of small and medium enterprises (SMEs) and larger commercial companies, peri-urban and urban consumers benefit through increased availability at reduced unit production costs and hence at lower consumer prices, enhancing the range of accessible products. Among other benefits this supports dietary diversity. Central to the theory of change is the assumption that all stakeholders are able to recognize the value of TGR, and therefore support pathways to impact. An important role of Flagship 1 is therefore to characterize and demonstrate this value, which is often not immediately apparent, and how it can be captured and mobilized.

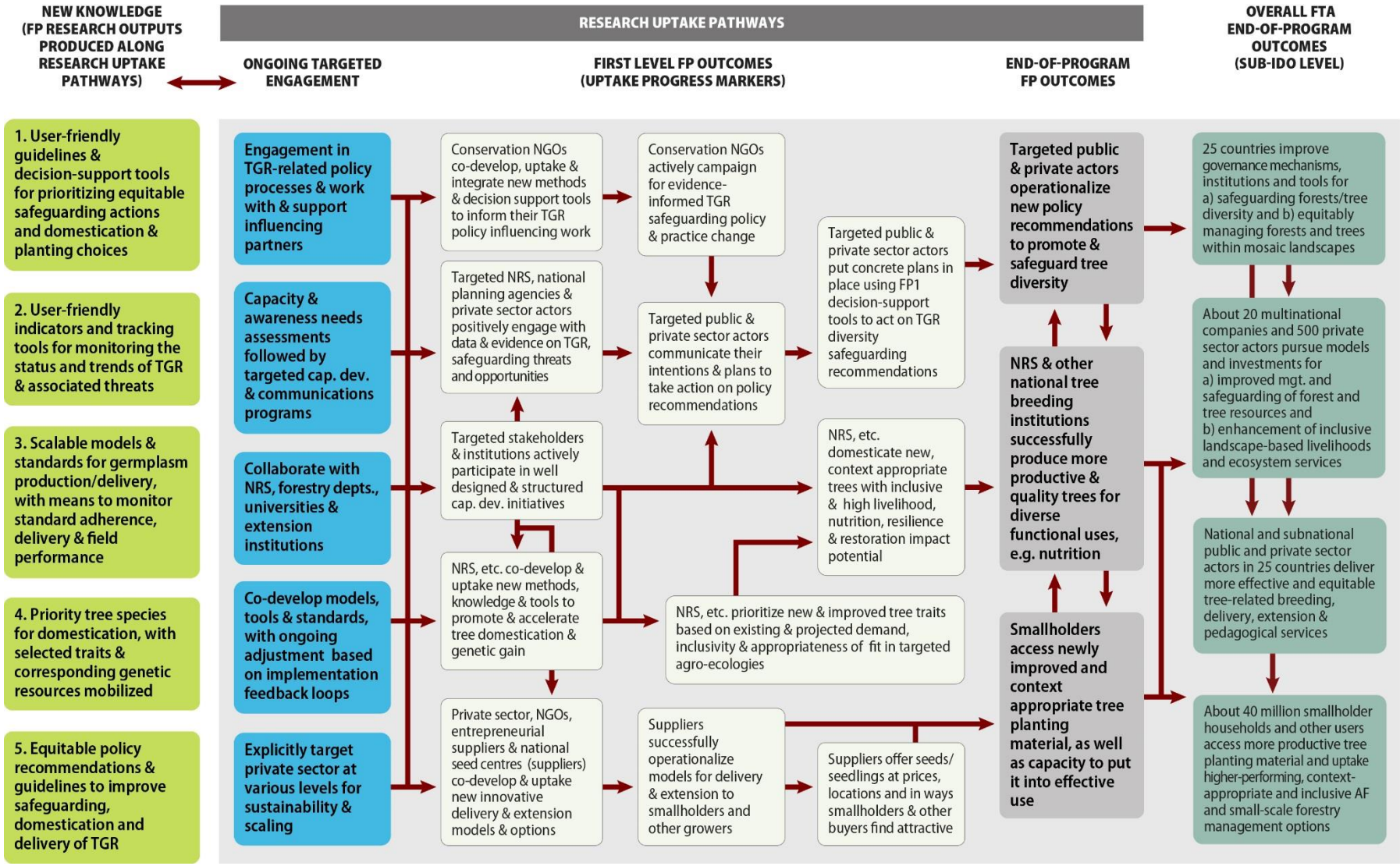


Figure 2. Theory of change for Flagship 1

Reaching impact through linkages with other Flagships, CRPs and platforms

The research of Flagship 1 targets, develops and ensures appropriate delivery options for the most basic input – tree planting material well matched to production and landscape contexts – that is promoted by other FTA Flagships. Each of the three elements of Flagship 1 are therefore clearly represented in all four of FTA's key end-of-program outcomes. Interactions between Flagship 1 and other FTA Flagships are summarized in Table 5 and Figure 3. Flagship 1 impacts are determined primarily through close interaction and research co-investment with Flagships 2 and 4; these relay positive effects to Flagships 3 and 5, respectively (Indicated in Table 5 in bold). Interactions with other CRPs and platforms requiring further exploration within FTA Phase II are also indicated.

Table 5. Summary of interactions with other FTA Phase II Flagships, CRPs and platforms

Component	Contributions of FP1 to…	Contributions from Flagship, CRP, platform to FP1…
FTA Flagships		
FP2 (livelihood systems)	**Improvements in tree characteristics that support sustainable intensification in a range of production systems and at various spatial/temporal scales, e.g. through enhancing mixed species LER**	**Development of appropriate planting material delivery options for different production contexts; effective/equitable approaches for up-and out-scaling TGR interventions (e.g. participatory domestication); joint testing of domestication traits in multi-species systems**
FP3 (value chains; mediated through FP2)	A range of planting material options for higher-quality tree products and more useful services with greater market value, suitable for incorporation into, and the diversification of, value chains	Selection/prioritization of market-determined species and traits for tree domestication; options to integrate tree-planting material into product/service markets, including public-private partnerships/SMEs; market-based certification approaches for safeguarding TGR
FP4 (land-scapes)	**Planting material options better matched to a range of landscape/ ecological niches, supporting restoration; more optimal (genetic) management of landscapes to support products, services and resilience**	**Development of appropriate planting material delivery options for different landscape configurations; joint testing of different/evolving landscape configurations on TGR across scales, and the effectiveness of particular environmental service rewards for TGR safeguarding; prioritization of tree traits to support landscape resilience**
FP5 (climate change; mediated through FP4)	Site-matched, 'future-proofed' tree-planting material, with high adaptive capacity and greater mitigation opportunities (e.g. carbon sequestration and biofuels)	Important tree traits for adaption and mitigation, including new trait combinations for novel environments; climate models to indicate planting domain shifts under future climates
SP (impact & inclusion)	Indicators, tools and capacity training to monitor and evaluate FTA II success from the context of the value of TGR in supporting productivity and sustainability	Development of key indicators for measuring impacts and demonstration of value of TGR to stakeholders; adaptive learning to guide future research directions and support TGR mainstreaming within the wider FTA

Component	Contributions of FP1 to…	Contributions from Flagship, CRP, platform to FP1…
CRPs		
A4NH (with FTA II Flagship 4)	More nutritious, productive and production system- and site-matched tree foods aligned with the prioritized needs of communities	Prioritization of relevant traits for food tree domestication to support nutritional quality and diversity, within tree food and annual food crop portfolios
CCAFS	Tools for tree-site matching under future climates, based on key tree traits	Models to help FP1 study tree distributions and determine tree-planting material delivery systems to meet future site-specific climates
PIM	Key adoption, impact and policy concerns for TGR and related technologies	Framework for TGR tenure, ownership and governance issues; effective and cost-efficient policies, strategies and extension approaches for facilitating uptake of planting material
Livestock	Cross-transfer of domestication tools and delivery systems, especially for animal forages	Important tree traits to maximize positive interactions in mixed livestock production systems; threats to TGR safeguarding
All AFS CRPs	Nexus for FTA II-wider AFS CRP learning; models for genome-environment marker-assisted selection and focused trait identification using natural plant populations; lessons for annual 'orphan' crops delivery; information on tree-crop interaction traits (with FTA II FP2)	Models for domestication and planting material delivery to be adapted to the specific context of tree species, key traits, products and services; opportunities for exploring positive tree-crop interactions by focusing on key interaction traits (with FTA II FP2)
Platforms		
Big data	Tree genomic data, for exploration of synteny with crops (e.g. legumes); geo-referenced species, vegetation and risk assessment maps; modeling approaches to support analytical capability	Methods for comparative analysis of genomes, distributions and interactions, supporting safeguarding priorities, trait capture and climate-smart delivery approaches
Genetic gains	Models for genome-environment association analysis based on natural plant populations (as under 'all AFS CRPs'); case studies where large gains possible through platform use	Links with experienced scientists, outsourced services and range of tailored solutions for the use of advanced genomic methods in TGR domestication, especially relevant for the African Orphan Crops Consortium (AOCC)[19]
Genebanks	Context-specific information on the relevance of complementary safeguarding approaches, exploring positive and negative interactions between methods; identify gaps in *ex situ* collections; feedback, perspectives and context for ABS arrangements (Policy Module)	Characterization of TGR supports the prioritization of safeguarding *in* and *circa situ* and of candidate material for domestication; raw material for domestication; phytosanitary support to tree-planting material delivery systems; framework for dealing with ABS of domesticated and wild tree resources (Policy Module)

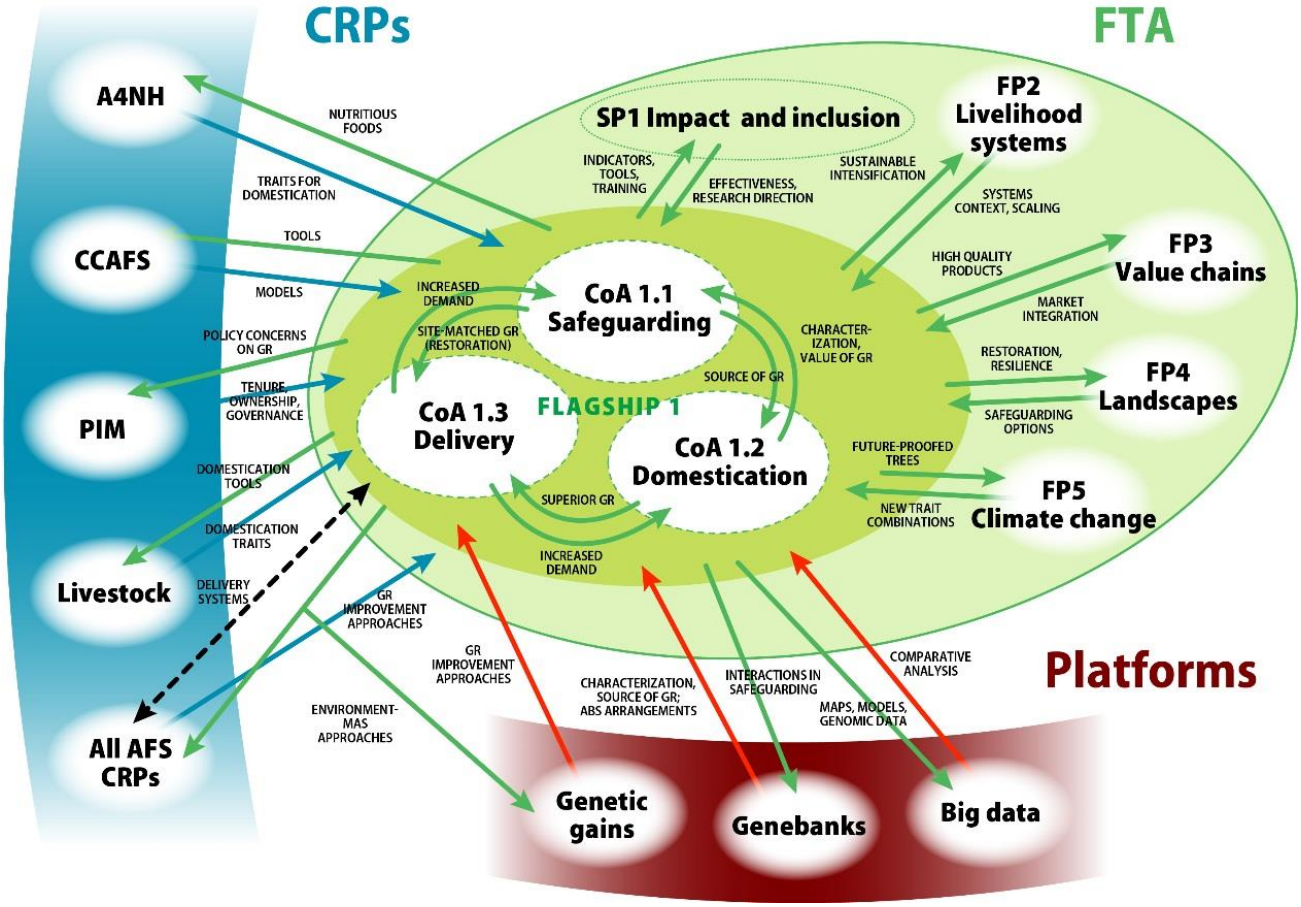


Figure 3. Linkages with other FTA Flagships, CRPs and platforms, including nested linkages between Flagship 1 clusters. Major impacts for Flagship 1 within FTA are mediated through Flagships 2 and 4.

Developing a theory of place for Flagship 1

The development of Flagship 1's theory of place (Figure 4) involves Flagships 2 and 4 in particular. Geographic foci of CoA 1.1 are genetic diversity hotspots where important TGR exist and where resources are threatened, within the range of landscape configurations of Flagship 4. CoA 1.2 activities focus on priority tree species determined by local women and men, market needs and other important factors such as 'researchability' and tend ot be more localised in distribution. CoA 1.3 locations are chose for their value in 'proof of concept' testing for up and out-scaling according to Flagships 2 and 4, in addition to cognizance of the locations of other large-scale agroforestry/restoration initiatives. For CoA 1.3, Flagship 4 provides a framework of landscape configurations for different planting material delivery systems. CoA 1.3 not only considers the priority species of CoA 1.2, but a diverse portfolio of species for production and restoration.

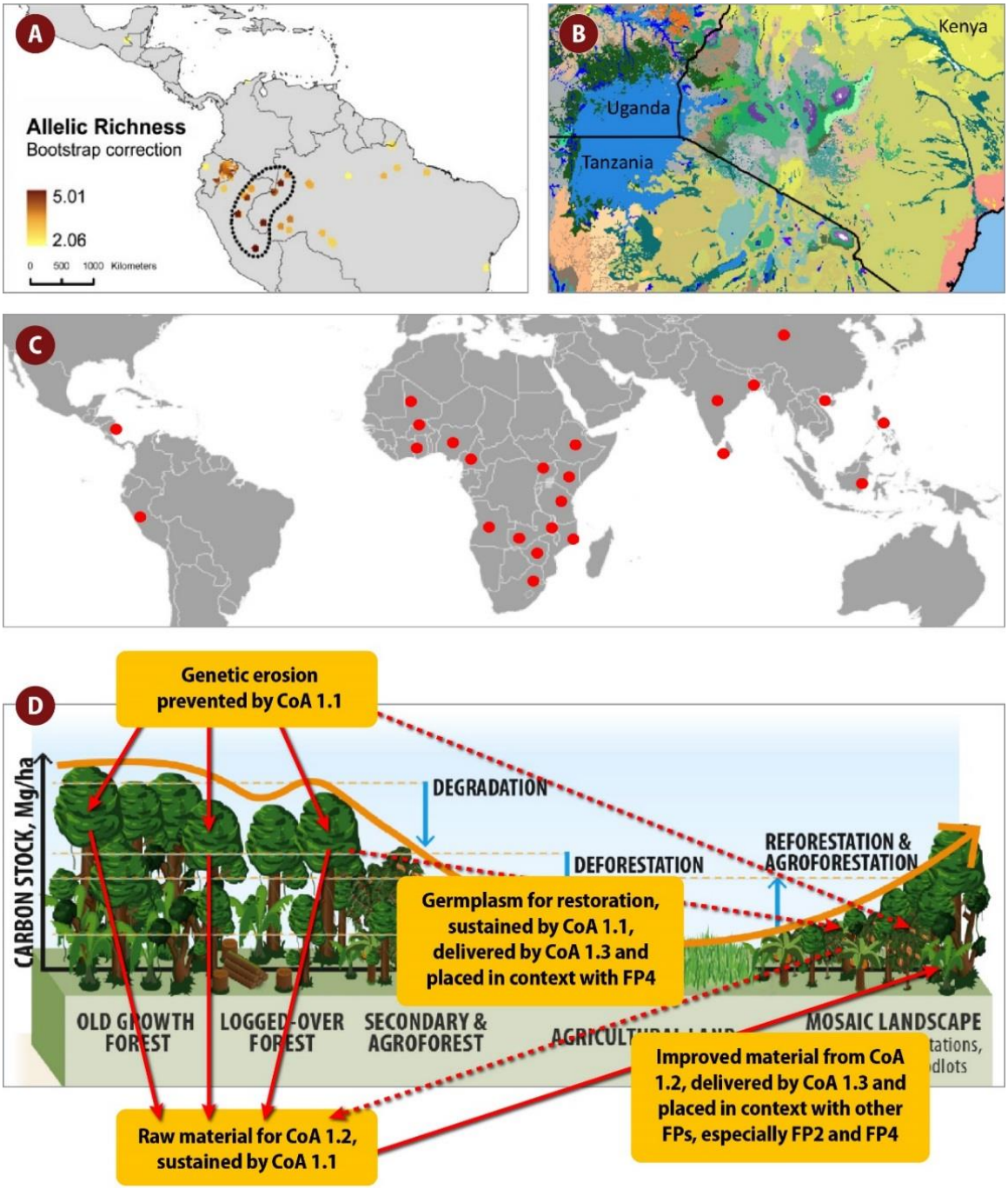


Figure 4. Elements of the theory of place for FP1. A, Genetic diversity hotspots in cocoa in the Amazon, based on molecular markers, indicating priorities for safeguarding purposes (dashed enclosure; CoA 1.1); B, High resolution vegetation map for eastern Africa (extracted snapshot) informing what trees should be planted where in the region for delivery purposes (different colors indicate different vegetation types; CoA 1.3), guiding plantings initiatives. Superimposed on other spatial data sets, maps such as A and B support the 'when' as well as the 'where' of the up- and out-scaling of plantings relevant for other FTA Flagships; C, Countries with tree domestication activities (CoA 1.2) under FTA Phase I are indicated by red circles. Species worked on, with common names, example countries and their key use(s), include: *Allanblackia parviflora* (allanblackia, Ghana, fruit for edible oil), *Allanblackia stuhlmannii* (allanblackia, Tanzania, fruit for edible oil), *Dacryodes edulis* (safou, Cameroon, fruit), *Docynia indica (son tra, Vietnam, fruit), Gliricidia sepium* (madre de cacao, Indonesia, shade and soil fertility replenishment), *Guazuma crinita* (bolaina blanca, Peru, timber), *Prunus africana* (African cherry, Cameroon, medicine) and *Sclerocarya birrea* (marula, Malawi, fruit); D,

Placing the three Flagship 1 CoAs within the context of the forest transition curve of FTA illustrates the linkages between them.

2.1.1.4 Science quality

Flagship 1 is concerned with salience, combining novel with well-established methods where this advances the ability to address strategic issues for TGR, particularly in bridging knowledge gaps for key bottlenecks to reach improved development outcomes and impacts. We start with a range of important tools and the knowledge framework generated under FTA Phase I. For safeguarding, for example, a number of innovative spatial datasets were derived, including MAPFORGEN[20] and vegetationmap4africa[21]. Work on genetic diversity indicators also revealed more practical and affordable measures (Graudal et al. in[2]), while a greater understanding of the possible interactions between TGR safeguarding options and past and contemporary land- and resource-use patterns was obtained, which guide conservation and sustainable use practices across different settings within the context of wider conservation actions[22]. For domestication, a wealth of experience in methods for different product and service requirements was obtained. Allanblackia, a new fruit tree domesticate that reached the market with food oil, was an important case study that involved the development of a novel public-private collaborative platform to support domestication with market integration. The approach is currently being applied to other indigenous fruits such as safou in Central Africa and son tra in Asia. Considerable new experience was also gained in decentralized participatory tree domestication approaches, especially in Central Africa[23], that achieve positive outcomes for livelihoods, nutrition and the social standing of participants, their households and communities, and which encouraged the development of new enterprises to undertake domestication and deliver new fruit tree varieties[24]. For delivery, innovative characterization of current delivery systems has led to the development of more effective approaches to allow different stakeholders to align their objectives and to work together positively to reduce the costs for suppliers and growers in sourcing planting material, with particular emphasis given to the role of small entrepreneurial suppliers[25].

In FTA Phase II, earlier outputs and outcomes will be extended in scope based on lessons learned (Section 2.1.1.5) and newly developing approaches and knowledge. Innovative tools and approaches will be applied and improved in the following ways (relevance to particular CoA indicated):

- By the application of new thinking on appropriate TGR safeguarding approaches that challenge ‘conventional wisdom’ on the benefits of cultivation and the linkages between safeguarding settings in different contexts (CoA 1.1)[26].
- By mainstreaming of advanced, geo-spatial methods of threat mapping and gap analysis in combination with local ‘gendered’ knowledge, to support partners in determining safeguarding priorities for TGR (CoA 1.1, building on Phase I maps[20,21]).
- By further development and testing of novel hand-held media tools of vegetation and other map resources to support both safeguarding (CoA 1.1) and planting material delivery for trees with the right products/services for particular production systems/landscapes (CoA 1.3)[27].
- By the application of in-house next generation sequencing facilities working in collaboration with other institutions, breeder networks and global bioinformatics support to facilitate new approaches to the domestication of priority trees, through the AOCC initiative (CoA 1.2)[19].
- By the application of new statistical methods to combine genomic and interpolated environmental information to test potential and limits for marker-assisted selection for environmental adaptation, including with regard to anthropogenic climate change (CoA 1.2).
- By further exploring the production system and landscape contexts of up and out-scaling of decentralized participatory domestication approaches for tree products and services that consider consumer and private sector concerns (CoA 1.2)[28].
- By integrating genomic-environmental data sets with participatory domestication, to facilitate the deployment of TGR more closely adapted to a wide range of different production and landscape contexts (CoA 1.2 and 1.3).

- By option testing of new, inclusive and context-tailored entrepreneurial support models for tree-planting material delivery systems for smallholders and restoration practitioners, with the use of innovative Before-After-Control-Impact experimental designs that have not yet been applied to the sector (Graudal et al. in[2]) (CoA 1.3).
- By applying new ensemble climate modeling approaches that determine probability-based delivery/suitability domains for tree planting to a much greater range of trees (CoA 1.3), making available the developed packages to the ecological research community for wider application.
- By further developing flexible and resilient approaches for tree planting material supply in the context of anthropogenic climate change effects for landscape restoration[29], based on considerations of both genetic and species suitability, phenotypic plasticity and emerging knowledge on current practice (CoA 1.3).

Competitive advantage

Endnote-listed references that include the Flagship 1 team indicate that the program brings together leading global researchers. A recent publication highlight was a special edition of *Forest Ecology and Management* on TGR edited by Flagship 1 staff, with many co-authored contributions, which contained some of the most downloaded articles for the journal in the following year[2]. Another recent highlight was the SOW-FGR[3], which was supported by Flagship 1 staff at FAO's request in the form of data collection, advice, review, writing of chapters and of thematic studies[11]. This last initiative was illustrative of the ability of Flagship 1 to bridge research, development and policy concerns, with a 'research for development' team that deliberately integrates science with practice, and which is capable of large program management and delivery (see appended CVs and Table 6).

A summary of various online resources involving the current Flagship 1 team produced under FTA Phase I is given in Figure 5, illustrating high annual use of products and indicating the visibility of the staff involved in research and development communities. A co-authored statistical software suite (vegan), for example, has been cited more than 8,400 times in the scientific literature[30], and has had more than 350,000 installations. Staff have wide experience of research in different geographic areas and at various scales, and in working with a wide range of stakeholders, collaborating with well-established key partners globally (see Section 2.1.1.7). The ability to bridge communities provides context and realism to research, and supports progression into impacts, as do important contributions and leadership in policy discussions globally on TGR[4]. Of key importance, the teams' researchers have the detailed understanding of tree biology needed to underpin effective research.

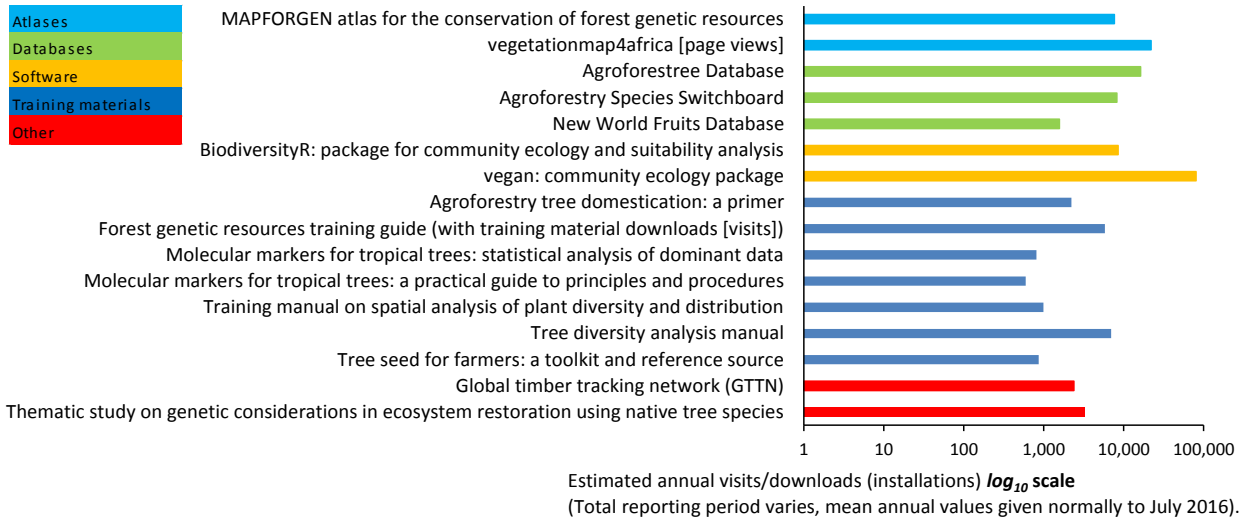


Figure 5. Annual reads and downloads/installations of various online outputs of the Flagship 1 team. Note the log_{10} scale on the *x* axis.

Table 6. Key scientists and development practitioners for Flagship 1 (alphabetic **surname** order)

Name, institution	**Specific skills**	**H**	**Total Citations**	**Rank CGIAR** (if CGIAR)	**Position in FP1**	**FTE**
David **Boshier**, Univ. Oxford	Conservation ecologist	19	2,070	-	CoA 1.1 support, conservation	0.20
Richard **Coe**, ICRAF (ILRI, Reading)	Statistical expert	27	3,899	55	FP1 support, statistics	0.20
Jonathan **Cornelius**, ICRAF	Forest genetics and management	20	1,837	120	FP1 support, strategy	0.3
Ian **Dawson**, ICRAF (& JHI)*	Genetics and genetic resource specialist	26	2,003	101	FP1 support, strategy	0.65
Jerome **Duminil**, Biover. Int*	Forest geneticist	12	1,168	139	CoA 1.1 (sci.)	0.20
Steve **Franzel**, ICRAF	Agricultural economist	35	4,745	45	FP1 support, economics	0.20
Lars **Graudal**, Univ. Copenhagen (& ICRAF)*	Development practitioner, ex-Director Danida Seed Centre	10	586	-	CoA 1.3 lead	0.80
Rhett **Harrison**, ICRAF	Conservation, forest ecologist	22	2,242	95	CoA 1.1 (senior sci.)	0.30
Chris **Harwood**, CSIRO	Tree breeder	20	2,076	-	CoA 1.2, 1.3 support, domestication, delivery	0.20
Ramni **Jamnadass**, ICRAF*	Genetic resources specialist	20	1,838	119	FP1 Leader	0.80
Wanjiru **Kamau-Rutenberg**, AWARD*	Gender expert, AWARD Director	n/a	n/a	-	FP1 support, gender issues	0.15
Roeland **Kindt**, ICRAF*	Ecologist	23	12,053	12	CoA 1.3 lead support	0.80
Roger **Leakey**, ITF	Domestication expert, ex-Director research ICRAF	48	7,350	-	CoA 1.2 support, domestication	0.20
Judy **Loo**, Biover. Int.*	Forest geneticist	16	914	171	CoA 1.1 lead	0.75
David **Neale**, Univ. California Davis **	Tree genomics expert	n/a**	> 10,000	-	CoA 1.2 support, genomics	0.10
Jim **Roshetko**, ICRAF	Delivery specialist	18	1,389	130	CoA 1.3 (senior sci.)	
Zac **Tchoundjeu**, ICRAF*	Domestication specialist	32	3,478	64	CoA 1.2 lead	0.90
Evert **Thomas**, Biover. Int.*	Ethnobotanist	15	580	234	CoA 1.1 (sci.)	0.70
Barbara **Vinceti**, Biover. Int.*	Conservation specialist	16	2,629	87	CoA 1.1 lead support	0.50
Jianchu **Xu**, ICRAF	Agroforestry-landscape ecologist	33	8,290		CoA 1.1, 1.3 (senior sci.)	0.30

*Scientific leaders for FP1 whose CVs have been provided. ** Not on Google Scholar.

2.1.1.5 Lessons learned and unintended consequences

Combining safeguarding, domestication and delivery research into a single Flagship is a means to effectively apply lessons from FTA Phase I. These include:

Safeguarding: combining varied information sources allows rapid out-scaling of spatially explicit safeguarding tools. Calculating 'option values' for TGR is crucial and these need to be combined with genetic diversity indicators, perceived values, and threat and distribution information, to prioritize safeguarding. Interactions between TGR safeguarding methods for *in*, *circa* and *ex situ* environments need to be explored further in a range of landscapes, to develop environmental reward systems specifically targeted to TGR.

Domestication: Experience in domestication methods, including the decentralized participatory approach, shows that such interventions are most successful when part of a suite of measures that encourage general upgrading of farm practices, including support for soil fertility replenishment[31]. Domestication approaches shared with public and private partners including SMEs can be applied to a wide range of tree products and services. Specifically considering the role of women allows skewed benefits to be more effectively addressed.

Delivery: Planting material delivery approaches for annual crops require specific adaption for application to trees. Lessons on effective stakeholder interactions need to be appropriated to realize 'proofs of concept' and impacts. Integration of delivery models into value chains with tree product markets is required, working with SMEs[32] through approaches such as participatory domestication, which requires scaling out from Central Africa. Particular attention is needed to strengthen weak extension services that are a bottleneck in adoption.

Placing TGR in context: TGR must be considered in the context of inter-specific diversity. Appropriate safeguarding systems for TGR enhance, and ameliorate loss, of inter-specific diversity as well as of genetic variation. Better domestication approaches can support, maintain and enhance positive interactions between species. More optimal delivery systems result in a wider range of tree species being planted, which supports overall diversification. Understanding the interactions between intra- and inter-specific diversity is important for placing TGR in the context of all other FTA Flagships.

We seek to avoid the following key potential unintended consequences of TGR research:

- That policy measures put in place to safeguard TGR, including access and benefit-sharing (ABS) arrangements to benefit local communities, and high option values for TGR, result in limited access to TGR for research and hinder the distribution of superior material for use by farmers and other tree growers.
- That domestication and market expansion result in a trend to monoculture in production, rather than desired diversification, reducing service provision and increasing production risks.
- That enhanced delivery for planting material results in new species assemblages that interact negatively in production systems (e.g. introducing weeds and diseases), causing declines in productivity and resilience rather than gains.
- That the increased profitability of production resulting from domestication and improved planting material delivery leads to the clearance of forests for tree cultivation and/or reduced attention to the management of natural resources, as a less-important source of product.

Examples of collaboration to avoid these potential consequences include: encouraging open ABS arrangements that support communities but do not unduly hamper innovation; and resisting trends to monoculture by exploiting genetic resources to maximize land equivalence ratios in mixed production systems.

2.1.1.6 Clusters of activity (CoA)

Formulated based on global and national priorities, the CoA of Flagship 1 on safeguarding (CoA 1.1), domestication (CoA 1.2) and delivery (CoA 1.3) research represent the core interdependent elements in effective management and use of TGR. Progress in each is needed to reshape current suboptimal mainstream practice that negatively affects development. The priority for safeguarding research stems from the recent SOW-FGR recommendations; for tree domestication research from levels of improvement and the high investment returns possible with the proper use of gene pools that increase production options (Table 1); and for delivery research from the widespread failure of current delivery mechanisms to support tree planting matched to site and purpose, along with the recognition that institutional reorientation and other measures can result in much improved practice, as demonstrated in the crop sector. The purpose of research in Flagship 1 is to address the key 'need to know' strategic elements of research to improve current outcomes (W1/W2 funding), providing lessons that can then be tested and applied more widely through development in practice that feedbacks to strategy (W3 funding).

The positionings and inter-linkages between CoA were outlined earlier in Figure 3 and, with reference to the forest transition curve of FTA, in Figure 4D. In more detail, the safeguarding research of CoA 1.1 helps to describe, and support the availability of, the TGR that are the raw material for tree domestication activities in CoA 1.2. Similarly, well-described and safeguarded TGR are important sources of site-matched planting material for restoration activities, supported through the delivery pathways developed by CoA 1.3 research. At the same time, the domestication research of CoA 1.2 helps characterize important genetic traits and patterns of intra-specific variation important for safeguarding activities in CoA 1.1. Domestication research defines the values of particular TGR for providing important products and services, supporting safeguarding and defining priority areas for conservation based on a utilitarian justification of use value. With regard to CoA 1.3, CoA 1.2 research supports the devleopment/selection of superior planting material that is then delivered by the cluster. Finally, the realization of impact through the delivery of site-matched and/or genetically improved planting material to growers through CoA 1.3 supports the importance of domestication research in CoA 1.2 and of the TGR retained through the safeguarding of Cluster 1.1. The relationships between CoA 1.2 and CoA 1.3 in addressing production- and ecosystem service-provision gaps through both up-scaling and out-scaling are illustrated in Figure 6.

The hypotheses and assumptions behind research for each of Flagship 1's CoA are given in Table 7.

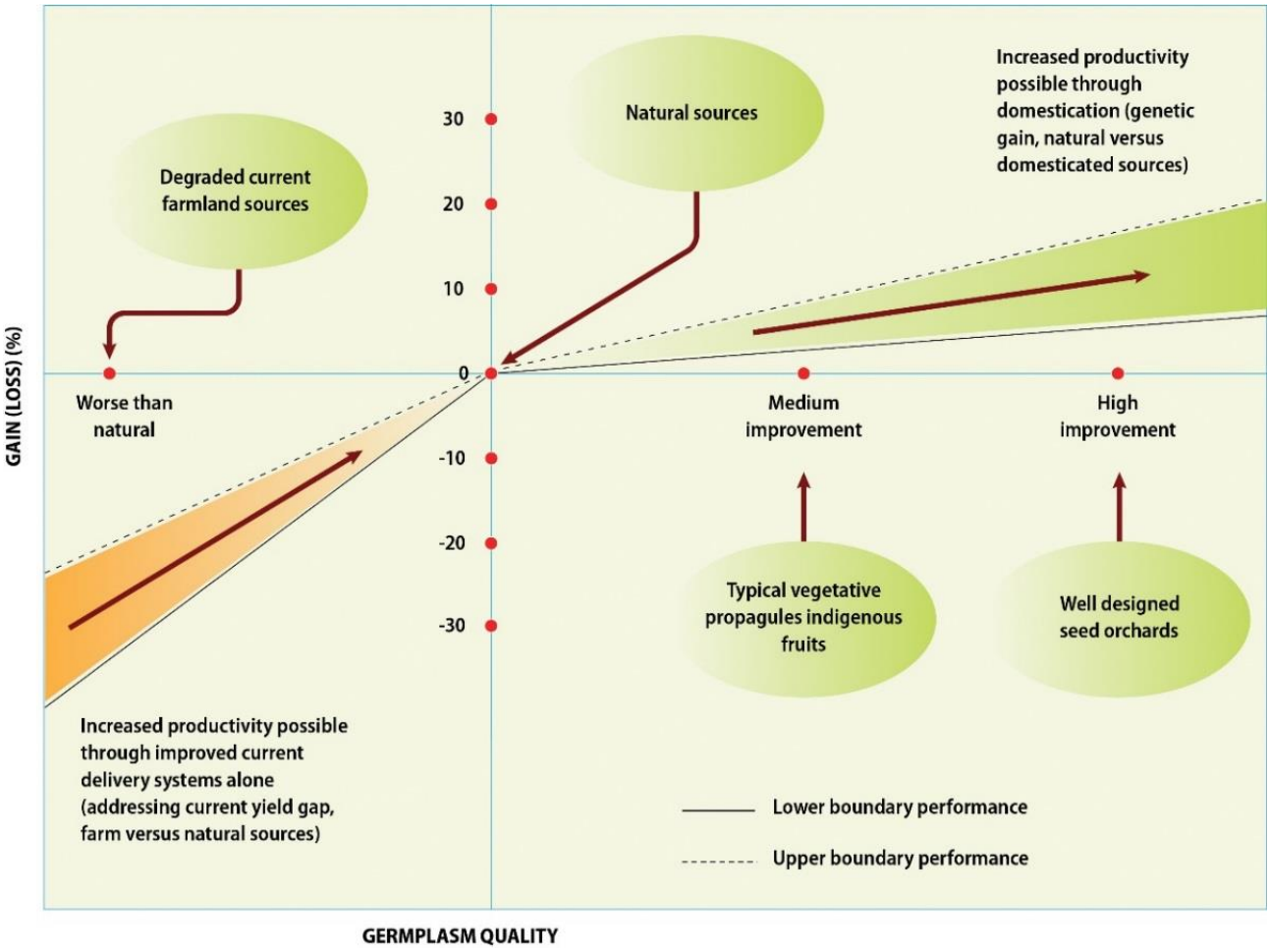


Figure 6. Schematic illustrating the gains in performance available through changes in the planting material sources used by smallholders. Initial productivity gains are frequently possible just by improvements in delivery systems that allow sub-optimal degraded material (compared to existing natural, unimproved) sources to be replaced on farmland. Further gains are supported by domestication activities, with the possible gains varying by domestication approach and intensity. The diagram illustrates that all productivity gains depend on having appropriate planting material delivery systems in place.

CoA 1.1 Safeguarding diversity

CoA 1.1 is concerned with safeguarding TGR vital for the sustainable future of humankind. The important roles of these TGR in supporting landscape resilience and productivity have been neglected, due in part to the often cryptic nature of variation (hidden to the naked eye), and inadequate valuation. In a reversal of the adage "can't see the forest for the trees", the focus of development has been at the landscape, forest or ecosystem level, often to the detriment of the trees themselves – "can't see the trees for the forest". In fact, TGR provide important environmental services to support production and enhance resilience, while they are an essential resource to support new domestications for tree products and services, as well as for enabling progress in ongoing domestications of important existing tree commodity crops such as cocoa, coffee, coconut, timber and other products. Furthermore, access to diverse, site-matched TGR is necessary to respond to important initiatives in landscape restoration, including the concept of a 'land degradation neutral world'.

At the same time as providing resources for domestication, however, the dynamics of tree domestication potentially support a trend either to landscape diversification (via successful integration) or to commodity crop monoculture (via displacement), and these different trajectories complicate safeguarding. Conventional methods that remain essential have been *in situ* conservation, needed because many tree species still exist

primarily in the wild, and *ex situ* seed/planted 'genebanks' for species that have been the subject of cultivation and some improvement. But, new and more holistic approaches that include on-farm *circa situ* methods are required, considering possible synergies and likely trade-offs with *in* and *ex situ* techniques, depending on species, production context and landscape.

The research of CoA 1.1 builds upon existing knowledge and current TGR safeguarding initiatives. It does so with innovative methods to develop and disseminate appropriate and efficient conservation and sustainable use approaches for TGR that benefit women, men, and their households, in different ecosystems, and in various national and regional settings. Research includes analyzing, spatially characterizing and mapping patterns of tree genetic diversity and threats that affect the well-being of rural people in forest and farm landscapes. Research seeks to resolve questions regarding mainstream theory on TGR conservation practice, such as the assumption that the cultivation of timber and tree commodities is sufficient to safeguard their genetic resources. Research determines the conditions when such wisdom holds, based on production systems, landscapes and tree biologies, and through synthesis integrates this information with the wider concerns of production system and landscape conservation. Economic analyses of the options provided by TGR are crucial to compare the value of land use for genetic safeguarding with alternatives, for example where wild relatives of tree crops are conserved compared to clearance and agricultural use.

Key research questions:

1. Indicators and methods: What are the most cost-effective indicators and methods to determine the extent, trends/threats and value (current and option, for productivity and resilience) of TGR in natural and restored forest, farm and other settings, to identify the location and intensity of threats to valuable TGR and support the development and implementation of appropriate safeguarding partnerships and activities?

2. Safeguarding combinations: What are the minimum requirements and optimal combinations of safeguarding approaches for TGR, considering synergies and trade-offs between them in specific contexts, including in particular geographic regions, production systems, landscapes, and policy environments, and considering different users' needs, to support sustainable resource management?

3. Stakeholder engagement: How can stakeholders be convinced and supported (e.g. through payments for ecosystem services) to develop, implement and monitor cost-effective conservation plans and strategies for safeguarding TGR in different contexts (forest, farm, etc.), taking into consideration conservation status, trends and threats for target species, and local knowledge and experience?

Deliverables

1. Effective and affordable methods and decision-support tools, including status and threat assessment maps and appropriate option value methods for the prioritization of safeguarding actions, which consider landscape, production systems, biodiversity (genetic diversity) hotspots, protected area or other assigned conservation status, TGR availability and value, and specific users' needs; 2. Nationally and regionally endorsed actions plans and networks for TGR safeguarding, with minimum requirements defined at the regional level; 3. User-friendly characterization methods and indicators with practical guidelines for their application in monitoring the status and trends of TGR and associated threats, with case study applications; 4. Case studies on the utility/limitations of ABS in supporting the characterization of TGR and for safeguarding; and 5. Policy briefs, reward systems, strategies and guidelines for appropriate safeguarding of TGR in various political, socioeconomic and environmental contexts, at different scales, and based on the biology of the species concerned.

CoA 1.2 Tree domestication to enhance products and services

CoA 1.2 focuses on the domestication of tree species identified as priorities by producers and consumers to enhance production, profitability and farm-level resilience. Large gene pools support the domestication of new tree species, of continued domestication of incipient domesticates, and of already domesticated tree

commodities, although the value of these gene pools has often been ignored in the past except for a few high value trees. The variation from within gene pools can be deployed 'as is' (for example, choosing the best existing provenances for restoration planting) for immediate impacts or can be incorporated into more formal breeding/improvement programs for longer-term gains in productivity and production stability. Greatly accelerated and better targeted genetic gains are achievable by combining traditional methods for selection such as multi-locational field trials with novel genomic, phenomic and modeling approaches that can now be applied to previously little-researched trees because of the lower costs of approaches, providing opportunities to revisit the use of these species in farming systems. Since wild trees tested in genomic studies evolved *in situ*, environmental datasets based on their sample locations are of particular value in genome-environment association studies to identify markers linked to adaptive traits.

Diversity breeding and decentralized participatory domestication approaches also support impact while maintaining resilience through the deployment of genetic diversity, with the participatory approach being gender-responsive. Research is concerned not only with traits directly connected to tree products, but with those that contribute to environmental service provision, and with the 'interaction traits' between components of production systems. Our research is concerned with two levels of activity in domestication. The first is to provide a limited number of worked examples of domestication ('spear' species that forcibly demonstrate the value of domestication, such as allanblackia; see legend to Figure 4C) as strategic models that can be adopted by others to domesticate further tree species. Work here focuses on currently underutilized species. The second level of activity is to provide a range of guidelines, training tools, online databases and maps, which through promotion networks for information exchange, spread best domestication practice globally.

Key research questions:

1. Domestication approaches: What are appropriate, cost-effective domestication approaches for priority trees, and how can impacts in providing products and services be effectively assessed among possible domestication options, to maximize efficiency in bridging production gaps and in enhancing profitability?

2. Trade-offs in domestication: How can domestication approaches be developed and implemented that fully consider the trade-offs involved across the intensification gradient (polycultures-monocultures), and support higher levels of species and genetic variation in production landscapes, to strengthen their resilience?

3. Smallholder involvement: What are appropriate measures to put in place (e.g. the protection of intellectual property) to support the wider participation of smallholders and local communities in developing new and unique 'cultivars' of a wide range of tree species, that supports impact by out-scaling?

Deliverables:

1. Dynamic (producer- and consumer-sensitive) lists of priority tree species for domestication, with key traits for production, including those that support positive agroecosystem interactions, identified; 2. Gender-responsive guidelines, and decision-support and practical tools, for tree domestication; 3. Public-private consortia engaged in tree domestication; 4. Improved 'varieties' of priority tree foods and for other tree products, with value visible for growers in comparative demonstration plots/trials; 5. Genetic resources mobilized through the genotyping of appropriately assembled germplasm collections, combined with public databases of genomic, phenotypic and environmental information; and 6. Appropriate ABS models for farmer-developed tree varieties.

CoA 1.3 Delivery systems for tree-planting material

CoA 1.3 focuses on research to support the development of trustworthy and efficient delivery systems for best quality tree planting material, for farmers and other growers including large restoration projects, addressing the consistent constraint of poor planting material availability that has been unaddressed in large part because of inadequate attention to appropriate institutional roles and stakeholder interactions. The research of CoA 1.3 bridges the knowledge to action gap on existing delivery systems, incorporating

development-based experience in working with tree nurseries, seed dealers and other input suppliers. Research is concerned with exploring the utility and implementation of appropriate systems and the constraints that must be addressed to reach impact. This includes adapting annual crop delivery approaches to trees, with adjustments based on tree uniqueness (time to maturity, fecundity, range of species, level of domestication, 'cryptic' gains, etc.). It also involves adapting the few successful existing delivery systems for tree commodities to a wider range of trees.

There are businesses opportunities for smallholders and other local entrepreneurs and SMEs, including women and youth, in the establishment and upgrading of tree nurseries, and in the provision of logistical services and agronomic advice, boosting rural economies where agroforestry initiatives are underway. Increasing commitments to restoration also provide new opportunities for planting material supplier businesses. Special effort to include women-preferred species enhances their participation. A range of innovative decision-support tools links planters with appropriate planting material, based on available sources, site and the purpose of planting.

Key research questions:

1. The baseline of delivery systems: what are the most effective ways to characterize, evaluate and monitor ultimate success of the current tree-planting-material delivery systems to smallholders and other growers, including of the sources, pathways, actors (collectors, producers, traders, other distributers, NGOs, government agencies, etc.) and policies involved, in order to provide a baseline from which to make improvements?

2. Appropriate delivery systems: what are the most cost-effective and equitable tree-planting-material multiplication and delivery systems for smallholders and other growers, to supply high-quality, site-appropriate material, taking into account: the required scale and reach; the appropriate division of costs and benefits among stakeholders; the need to provide complementary options to buffer production risks; and the existing policy environment?

3. Information and regulation: what decision-support tools, policy measures and regulatory frameworks are required to allow growers to match and anticipate production requirements and restoration objectives with suitable, available tree-planting material, taking into consideration changes in climate, markets, social diversity, quality of natural regeneration and other important trends?

Deliverables:

1. Delivery system models for tree-planting material that support and reinforce the needs and interests of different users, including for both women and men smallholders and (other) landscape restoration practitioners; 2. Community-based and entrepreneurial multiplication and delivery enterprises e.g. seed orchards and rural resources centers; 3. Appropriate quality standards (e.g. accreditation schemes) developed and promoted to actors in the germplasm production and delivery sector; 4. Measures to ensure these standards are mainstreamed by policy-makers, extension services and the private sector, including manuals, policy briefs, and other capacity and extension materials on delivery systems; 5. User-friendly decision-support tools to inform planting choices in conjunction with market information services and restoration requirements; and 6-8: Indicators to monitor the performance of delivery pathways with regard to models (6), to standards including the performance and viability of planting (7), and to evaluate quality and the needs for management (including enrichment) of natural regeneration (8).

Table 7. Hypotheses and assumptions behind the three CoA of Flagship 1's research

Cluster		Assumptions
CoA 1.1	Genetic diversity can be monitored by cost-effective development and application of adequate tools, with methods for safeguarding being adjustable in response to suitable indicators; an optimal combination of TGR safeguarding measures can be identified in specific ecological, geographical and societal contexts, considering the positive and negative interactions between the measures applied; regulatory frameworks and incentive schemes in favor of integrated TGR safeguarding can be designed	Demonstrating the value of TGR for improved livelihoods, restoration and domestication supports safeguarding activities in collaboration with farmers and other stakeholders; more efficient tools and approaches to support TGR safeguarding, including through the sustainable extraction of products, can be devised from an understanding and description of model species and the contexts of systems; policies and legal instruments implemented to provide for ABS can be compatible with the characterization of germplasm that supports TGR safeguarding priorities
CoA 1.2	It is possible to apply a range of context-specific domestication approaches and to determine their relative cost-effectiveness for different production systems and landscapes; appropriate domestication approaches are available to contribute effectively to farm- and landscape-level resilience through the adequate management and deployment of TGR, maintaining or enhancing diversity; the protection of small farmers' intellectual property enhances the local development of tree 'cultivars' of documented quality, and facilitates their diffusion through formal and informal channels (facilitated by CoA 1.3)	A key factor that supports the integration of new tree crops in agricultural production systems is an increase in productivity and/or product quality; sufficient genetic diversity is present within tree species to realize large genetic gains (and hence production gains, once material is delivered to growers through CoA 1.3); communities have already or can obtain land and tenure rights that allow them to reap the benefits from improving their production systems through better quality tree planting material inputs; policies and legal instruments implemented to provide for ABS do not need to prevent access to TGR to support genetic improvement activities
CoA 1.3	Context-specific characterization of planting material delivery systems can be undertaken for trees to allow for an adequate assessment of their efficiency; among the wealth of differently organized input supply systems that are currently applied it is possible to identify those that work best in a given context; it is possible to produce context- and tree biology-specific recommendations for tree planting material delivery systems, enabling high potential for increasing productivity and farm- and landscape-level resilience	Smallholders and other tree planters will demand higher-quality planting stock when its benefits have been demonstrated to them and/or when appropriate certification/traceability schemes are in place, increasing adoption and providing market opportunities for germplasm suppliers; better institutional organization of stakeholders involved in delivery can reduce transaction costs for farmers and other growers in obtaining suitable material; policies, legal instruments and certification schemes, implemented to provide for ABS, to protect breeders' and farmers' rights and to control planting material quality, provide a supportive environment for delivery and do not significantly increase transaction costs

2.1.1.7 Partnerships

Important partners include agricultural, forestry and horticultural research institutions of global and national excellence, as well as development agencies and practitioners, and private companies, as outlined below. To develop improved methods and action plans for TGR safeguarding in CoA 1.1, partnerships operate with conservation organizations and networks that work at regional and global levels, including APFORGEN, LAFORGEN, CacaoNet, COGENT, INGENIC and ICCO. To co-develop, inform and implement policy change in CoA 1.1, partnerships operate with government agencies including Treaty-competent authorities and inter-governmental actors, including FAO, CBD and the secretariats of the International Treaty on Plant Genetic Resources for Food and Agriculture and the Nagoya Protocol, along with their national focal point in target countries. To further integrate CoA 1.1's activities on TGR into a global context, Flagship 1 participates in the Global Tree Assessment led by Botanic Gardens Conservation International and the IUCN Global Tree Specialist Group. To set domestication priorities, access genomic and informatic resources, and help drive impact in new (and reinvigorated old) tree product markets in CoA 1.2, partnerships operate with the private sector at global and regional levels, including with Mars Inc., Nestle and Unilever and, to understand application at the local level, with SMEs and organized farmer groups, including women's self-help groups. To facilitate the development of tree domestication methodologies, partnerships operate with national and international forestry and horticultural research centers and foundations such as the World Vegetable Center and the International Tree Foundation (ITF), public and private breeders, and regional research hubs such as BECA. To develop domestication strategies and access newly developing methods including genomic approaches, CoA 1.2 partners with the advanced research organizations UC Davis (USA) and JHI (UK). To develop and understand the implementation of appropriate planting material delivery options in CoA 1.3, partnerships operate with a range of national tree seed centers, national and international development NGOs including CONCERN, VI and World Vision, government extension services and commerical companies such as Mars Inc.. Partnerships also operate directly with SMEs to understand and develop their role in delivery systems. To develop and implement policy changes supportive of tree planting material delivery, partnerships are in place with FAO and the OECD. To specifically support delivery options for restoration programs, partnerships operate with IUCN and WRI. To provide strategic research direction, facilitate negotiations with inter-governmental actors on policies and certification, and to develop key decision support tools for delivery systems, Flagship 1 includes scientists from the University of Copenhagen, the center of expertise globally on tree-planting material delivery approaches among international advanced research organizations.

With respect to the overall impact pathway (Figure 7), many partners, and many different interactions between them, are required to bring about change, and options are needed to minimize possible negative interactions between public (e.g. government agencies, research institutions, NGOs) and private sector actors (e.g. large companies, local entrepreneurs, community enterprises), and support the equitable distribution of benefits and costs in safeguarding, domestication and delivery activities between them. An important component of partnerships with different stakeholders, therefore, is the joint definition of problems for the co-development of appropriate solutions and roles in their implementation. Close and open collaboration with farmers is also required to understand the relevance of research and devised options, based on the different perceptions of women and men, and rich and poor, farmers of the appropriate role of TGR in supporting the availability of products and services, through direct and indirect provisioning.

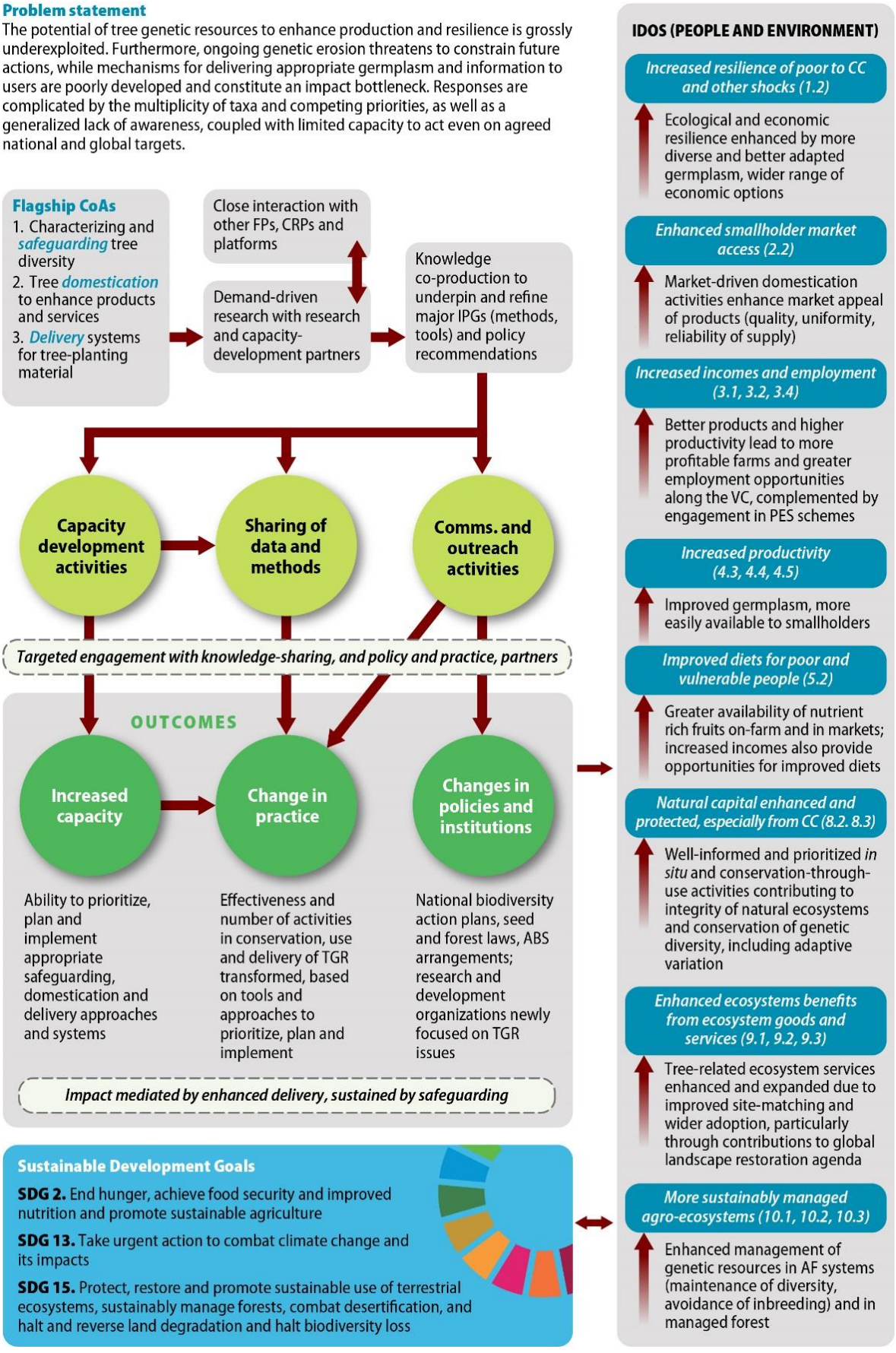


Figure 7. Schematic description of Flagship 1's pathways to impact

2.1.1.8 Climate change

Flagship 1 has an essential role in responding to anthropogenic climate change in both an adaptation and mitigation context. Predicting and mapping climate risks and safeguarding diverse TGR that have the potential to adapt to changing and possibly new climates provides the option value to respond to change, while diversity breeding and participatory domestication provide more resilient and adaptive tree planting material that is supplied through climate-responsive delivery systems for agroforestry practices. Research within Flagship 1 indicates how tree planting patterns will need to change, and the modifications that will be required to deliver planting material for climate-smart agricultural and restoration-based responses. CCAFS provides models to study plant species distributions that can be used to describe supportive tree planting material delivery systems to meet future location-specific climate-based adaptation and mitigation needs, while the development of new ensemble climate modeling approaches for determining probability-based delivery/suitability domains within Flagship 1 can provide reciprocal benefits to CCAFS (see also Table 5). This research indicates the level of interdependency of countries for appropriate tree planting material for restoration, reforestation and agroforestry under climate change, and for which clear procedures need to be put in place for germplasm exchange of tree species under the Plant Treaty and the Nagoya Protocol.

2.1.1.9 Gender

Operationalizing change through Flagship 1 provides particular opportunities for women. Access to productive TGR as an 'input' may not be as strongly controlled by men as other resources such as land and credit. Commitment to gender begins with a particular focus on recruiting, retaining and building the capacity of woman scientists in the Flagship 1 team through the African Women in Agricultural Research and Development (AWARD) post-doctoral fellowship program, among other initiatives. Flagship 1 is the only FTA Flagship to be led by a woman. Team members are trained in gender-responsive methods in research and practice that are required to achieve equitable and sustainable impacts. In CoA 1.1, the involvement of women (and young adults) in setting safeguarding priorities is based on their particular knowledge, uses and future needs.

Participatory demand-driven research is built on local skills and fosters the inter-generational transfer of knowledge on management practices, ecology and conservation actions, within which context women have an important role in communicating with the next generation. In CoA 1.2, full attention is given to the involvement of women (and youth and elders) in setting values, species priorities and traits for selection, particularly for tree foods that have a clear role in supporting family nutrition and women (and youth) incomes. Full engagement of women (and youth) in participatory domestication approaches and in business opportunities in value addition is supported through tested approaches that address the structural constraints that limit their participation. For CoA 1.3, the involvement of entrepreneurial women (and young entrepreneurs) in delivery systems will be enhanced, seeking specific comparative advantages through understanding their existing knowledge, skills and experiences. Research includes attention to appropriate financing instruments for enabling poorer women to participate individually or in collectives. Key research that cuts across CoA is the identification of gender-responsive arrangements that help women to enhance their roles in NRM decision-making and gain greater control over derived benefits.

2.1.1.10 Capacity development

Engagement with partners to develop research and innovative capacities is essential for Flagship 1, as is outreach to communicate the relevance of TGR and their exchange in supporting agroforestry and restoration programs, to support our theory of change. Through capacity development we seek to strengthen strategic partnerships to support and co-develop TGR conservation strategies, encourage the wide adoption of tree domestication approaches, and establish the infrastructure and approaches required for well-functioning delivery systems. To these ends, Flagship 1 will maintain its good record of capacity development from FTA Phase I, as revealed by relevant outputs (e.g. Figure 5). Building on existing

resources, plans for capacity development for CoA 1.1 include developing and delivering training materials for practitioners and university/research institution instructors (CapDev Element 2), and close collaboration with networks and institutions in Africa, Asia and Latin America (including SAFORGEN, APFORGEN and LAFORGEN, respectively) in how to develop plans and networks for safeguarding TGR. For CoA 1.2, specific plans include developing future research leaders by an innovative (post-degree) fellowship program for African breeders through the African Plant Breeding Academy[19] (CapDev Element 4) that supports the integration of new research approaches in breeding programs. Training of scientists and extension workers in organizational approaches and technical methods to support participatory domestication approaches (CapDev Element 2) that are then disseminated to local communities in order to support domestication impacts will also be undertaken. CoA 1.3 supports the development of capacity in national tree seed centers and farmers' networks, and among local entrepreneurs, in methods, processes and decision-support tools for developing appropriate delivery systems (CapDev Element 6). Partnership with AWARD enables the development of capacity on gender-responsiveness (CapDev Element 5). Youth will in particular be engaged through the development of innovative web-based learning tools, decision support platforms and information- and opportunity-sharing applications (CapDev Element 10).

2.1.1.11 Intellectual assets and open access management

The methods, strategies, data and decision support tools generated by Flagship 1, including maps, valuation methods, prioritization procedures, management guidelines, policy briefs, training materials and genomic/phenomic data sets will be made freely available and in a timely manner through open access online databases and portals, and in other formats suitable for different users, including on hand-held consumer devices such as smartphones. Due credit will be given to all the contributors involved in the development of these products. Improved 'varieties' of priority tree products, assemblies of tested germplasm and genetic material in multiplication stands are made available in the context of existing international, national and institutional ABS and IP arrangements such as the Nagoya Protocol and the International Undertaking on Plant Genetic Resources for Food and Agriculture, seeking as far as possible to maximize benefits to a wide range of users, with an emphasis on realizing benefits for local domesticators and smallholders. Working with PIM provides a framework for dealing with tenure, ownership and governance, while the Genebank platform Policy Module provides technical resources for dealing with ABS of domesticated tree resources, including for work undertaken in collaboration with the private sector. In addition, the tree commodity crops such as cacao and coconut that are part of the current safeguarding and delivery programs provide ABS models for newly domesticated trees and lesser-used species whose use is being intensified, indicating pitfalls and advantages of particular arrangements.

2.1.1.12 FP management

The lead CGIAR Centers for Flagship 1 are ICRAF and Bioversity International, but important collaborations within FTA Phase II are required with CIFOR, especially on safeguarding approaches. The main CGIAR partners remain the same compared to research on TGR in FTA Phase I, building on previous close collaborations. Since Flagship 1 is a new entity, however, it requires a new institutional arrangement for its management. Overall management is hosted by ICRAF, with CoA 1.1 led by Bioversity International, CoA 1.2 by ICRAF and CoA 1.3 by the University of Copenhagen, which is a longstanding partner of ICRAF and Bioversity International, with particular expertise in tree planting material delivery systems (see Table 8 and Annex 3.8 for management staff CVs). The arrangement of meetings of team members will take opportunistic advantage of the annual calendar events of individual institutions (e.g. annual Science Weeks) to invite staff from other lead institutions and other key partners to participate in scientific discussion, Flagship coordination and output finalization.

Table 8. Flagship 1 CoA leadership

Flagship Leader: Ramni Jamnadass (ICRAF)				
CoA	**Lead**	**Lead support**	**Primary CGIAR partner(s)**	**(Other) Primary non-CGIAR partner(s)**
1.1 (safeguarding)	Judy Loo, Bioversity International	Barbara Vinceti, Bioversity International	ICRAF, CIFOR	University of Copenhagen
1.2 (domestication)	Zac Tchoundjeu, ICRAF	_	Bioversity International	University of Copenhagen, UC Davis
1.3 (delivery)	Lars Graudal, University of Copenhagen	Roeland Kindt, ICRAF	ICRAF, Bioversity International	National Tree Seed Centers

2.1.2 Flagship Budget Narrative

2.1.2.1 General Information

CRP Name	Forest, trees and agroforestry Agri-food systems Program (FTA)
CRP Lead Center	CIFOR
Flagship Name	Tree Genetic Resources to bridge production gaps and promote resilience (“Tree Genetic Resources – TGR”)
Center location of Flagship Leader	ICRAF

2.1.2.2 Summary

Total Flagship budget summary by sources of funding (USD)

Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	9,824,435	10,208,195	10,619,336	11,060,048	11,532,710	12,039,911	65,284,637
Other Sources							0
	11,671,235	12,147,335	12,655,433	13,197,949	13,777,506	14,396,947	77,846,405

Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Assumed Secured)	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	7,835,435	5,000,000	2,500,000	2,000,000	2,000,000	0	19,335,435
Other Sources							0
	9,682,235	6,939,140	4,536,097	4,137,901	4,244,796	2,357,036	31,897,205

Funding Gap	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Required from SO)	0	0	0	0	0	0	0
W3 (Required from FC Members)	0	0	0	0	0	0	0
Bilateral (Fundraising)	-1,989,000	-5,208,195	-8,119,336	-9,060,048	-9,532,710	-12,039,911	-45,949,203
Other Sources (Fundraising)	0	0	0	0	0	0	0
	-1,989,000	-5,208,195	-8,119,337	-9,060,049	-9,532,711	-12,039,912	-45,949,203

Total Flagship budget by Natural Classifications (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
Personnel	4,080,000	4,284,000	4,498,200	4,723,110	4,959,265	5,207,228	27,751,804
Travel	422,500	422,500	422,500	422,500	422,500	422,500	2,535,000
Capital Equipment	450,000	450,000	450,000	450,000	450,000	450,000	2,700,000
Other Supplies and Services	3,771,400	3,838,900	3,909,775	3,984,193	4,062,333	4,144,380	23,710,982
CGIAR collaborations	510,000	561,000	617,100	678,810	746,691	821,360	3,934,961
Non CGIAR Collaborations	915,000	1,006,500	1,107,150	1,217,865	1,339,651	1,473,616	7,059,783
Indirect Cost	1,522,335	1,584,435	1,650,708	1,721,471	1,797,066	1,877,862	10,153,879
	11,671,235	12,147,335	12,655,433	13,197,949	13,777,506	14,396,946	77,846,404

Total Flagship budget by participating partners (signed PPAs) (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
ICRAF	6,872,687	7,195,837	7,540,895	7,909,530	8,303,555	8,724,934	46,547,439
Bioversity	3,336,437	3,489,387	3,652,428	3,826,310	4,011,843	4,209,904	22,526,310
CIFOR	1,462,110	1,462,110	1,462,110	1,462,110	1,462,110	1,462,110	8,772,660
	11,671,234	12,147,334	12,655,433	13,197,950	13,777,507	14,396,948	77,846,406

Explanations of these costs in relation to the planned 2022 outcomes:

For the explanation of these costs in relation to the planned 2020 outcomes, please refer to the FP narrative and more especially the PIM tables B and C

NOTE: Supporting Platform: Given the absence of a specific location to upload the costs/budgets of the various cross-cutting components (CCT) of the Supporting Platform (Gender, Youth, Capacity Devlopment, MELIA, Communication/Outreach, Site Integration, Partnerships, OA/OD) we have allocated these amounts across the 5 Flagships within the supply and services class (but they will be managed in practice by the relevant CCT component leads. The amounts added per FP for the SP (year 2017) are USD 1,271,000 of which USD 346,000 W1/W2

Use of W1/W2: W1/W2 are used strategically to leverage bilateral funding likely as basket funds, in such a way that different sources of bilateral contribute to the same major goals, this in order to build a program that is consistent and that can deliver its expected objectives across the different six countries in which we are planning to do our work. W1/W2 funds are also used for global comparative analyses on major issues, to strengthen science quality, implement open access and to foster the probability of outcomes thanks to targeted communication and outreach.

2.1.2.3 Additional explanations for certain accounting categories

Benefits: In general the following benefits are covered by the Centers: Pension, Health, AD&D Insurances and allowances for housing, education and transport. These have been rolled into the salary. It is difficult to standardize the benefits as they vary by Center (based on individual center polices), but alos vary by type of staff i.e. Internationally recruited and National Staff.

Other supplies and services:

2.1.2.4 Other Sources of Funding for this Project

About 80 % of bilateral funding for the initial period has been ascertained. In the following periods we consider that 60, 40, 35, 35, and 15 % of bilateral funding are secure at this stage. The gap is catered for by current applications submitted or in the pipeline. In the event that less funding is received, the geographical scope of the programme will be more restricted than programmed, and there is also some flexibility to reduce the scope of the individual clusters of activity, but still maintain the production of some IPGs (cf. PIM table D).

2.1.2.5 Budgeted Costs for certain Key Activities

	Estimate annual average cost (USD)	**Please describe main key activities for the applicable categories below, as described in the guidance for full proposal**
Gender	583,000	see FP and CRP narratives
Youth (only for those who have relevant set of activities in this area)	583,000	see FP and CRP narratives
Capacity development	1,166,000	see FP and CRP narratives
Impact assessment	0	Costs are indicated at the CRP level budget narrative as this is centralized within the Monitoring Evaluation Learning and Impact Assessment cross-cutting theme
Intellectual asset management	0	Costs are indicated at the CRP level budget narrative as they are mainly established at Center levels
Open access and data management	0	Costs are indicated at the CRP level budget narrative as they are mainly established at Center levels
Communication	1,150,000	see FP and CRP narratives

The above selected key activities are described in the proposal text and the PIM tables. They do not include the Support Platform (that is however included in the CRP budget narrative

2.1.2.6 Other

2.1.3 Flagship Uplift Budget

Outcome Description	**Amount Needed**	**W1 + W2 (%)**	**W3 (%)**	**Bilateral (%)**	**Other(%)**
Outcome 1U1. Global Information System on Tree Genetic Resources to describe, document and access information about TGR conservation and management	16,000,000	30	0	70	0
Outcome 1U2. Global network of multi-locational field trials combined with modeling to describe and inform delivery strategies under future climates	16,000,000	30	0	70	0

Note: The Flagship 2 section of this document was updated as of November 2017. All other sections remain as originally published in July 2016.

2.2. Flagship 2. Enhancing how trees and forests contribute to smallholder livelihoods

2.2.1 Flagship Project Narrative

2.2.1.1 Rationale, scope

There is a substantial body of evidence showing that the resilience, productivity and income of farming households are influenced by the extent and management of tree and forest cover on farms and in agricultural landscapes[1,2,3,4,5,6,7,8,9,10,11,12].

The objective of this flagship is to better understand the diversity of these relationships and to leverage them in order to reduce poverty, increase food and nutrition security and the income of smallholders of Africa, Asia and Latin America, while enhancing environmental integrity and the natural capital upon which farming is based, and increasing adaptability to climate change. By working in the field at strategically selected locations within an extrapolation framework (options-by-context) and with an array of partners, including development actors, we will at the same time generate and apply this better understanding, and will measure and assess resulting effects.

This involves testing a number of key hypotheses on the contributions of trees and forests to livelihoods of rural people (set out in Section 2.2.1.6) through integrated research on the ecological, economic and social interactions that determine how trees can improve agricultural productivity and who controls and is able to benefit from tree and forest resources. The flagship takes livelihoods as its starting point, rather than fields, farms or forests, because most farmers make decisions about how to manage farms, including trees and forest resources, in the context of all their livelihood constraints and opportunities, including those unrelated to trees (Figure 1).

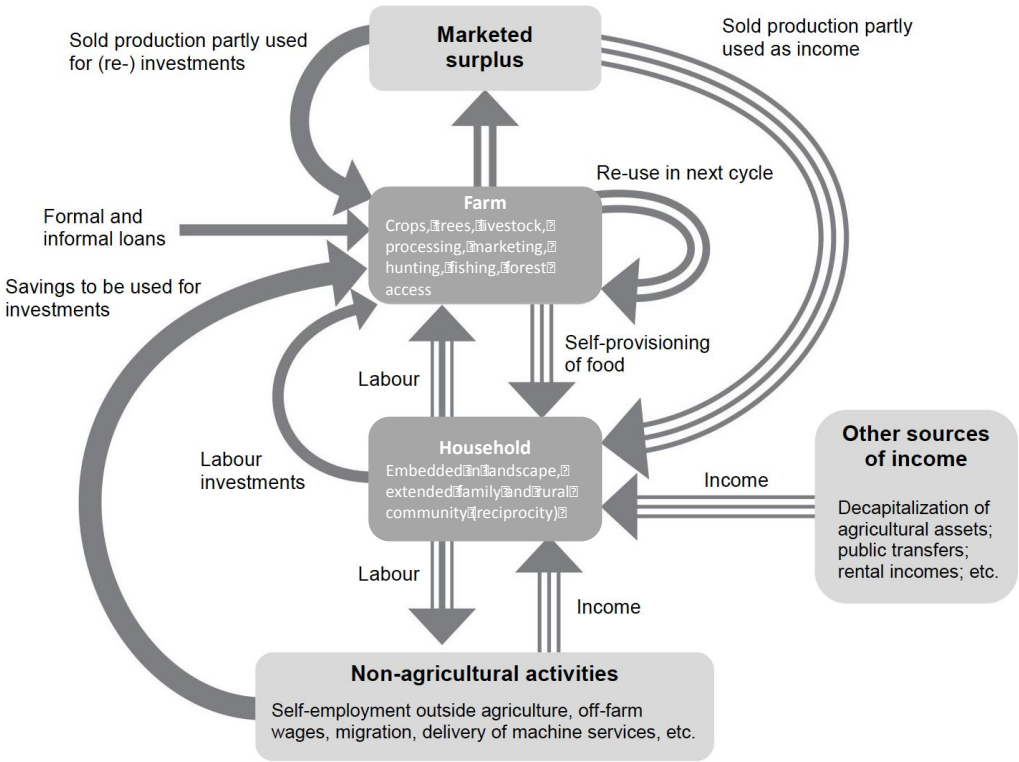


Figure 1 Generalised model of flows of income and sources of investments in an agricultural smallholding.

Source: adapted from High Level Panel of Experts on Food Security and Nutrition, 2013.[13]

Based on their components and prospects for significant improvement we have identified four major types of systems as the focus of our research:

- smallholder systems where production and marketing of food, fuel, timber and/or non-timber forest products (NTFP) from tree and forest resources are important livelihood components;
- major tree-crop commodity production systems (cocoa, coffee, oilpalm and rubber);
- trees on agricultural land supporting land restoration and sustainable intensification; and
- silvopastoral systems.

The extent, location and importance of these systems are set out in Section 2.2.1.6.

In addition to direct contributions to diet and income from timber, coffee, cocoa, rubber, oilpalm, fruits, nuts and other products, much of the contribution that trees make to agricultural production systems is through system intensification involving interactions with other livelihood components (Figure 2 and Table A). Farmers are concerned about the total factor productivity of their whole livelihood, not only the crop productivity part, and including how labor is used. This needs to be taken into consideration for agricultural innovations to be adopted and viable within the livelihood context that they are intended for[14,15]. For example, on-farm tree fodder production can increase livestock productivity whilst reducing labor required to collect fodder, freeing labor and time for other additional paths to intensification[16]. In some contexts, food security is constrained by lack or shortages of fuel to cook, or dung is used as fuel. On-farm firewood production alleviates the fuel constraint, allows dung to be used as fertilizer, increasing soil fertility and crop yield, and frees up labor[17]. Such knock-on effects of better tree management can often be as or more important than direct benefits from tree products. Trees can also play a key role in restoring and maintaining soil health because they are associated with higher abundance and activity of beneficial soil organisms, as well as contributing to soil fertility through tightening nutrient and water cycling, improving nutrient and water use efficiency and thereby closing yield gaps of staple food crops[12].

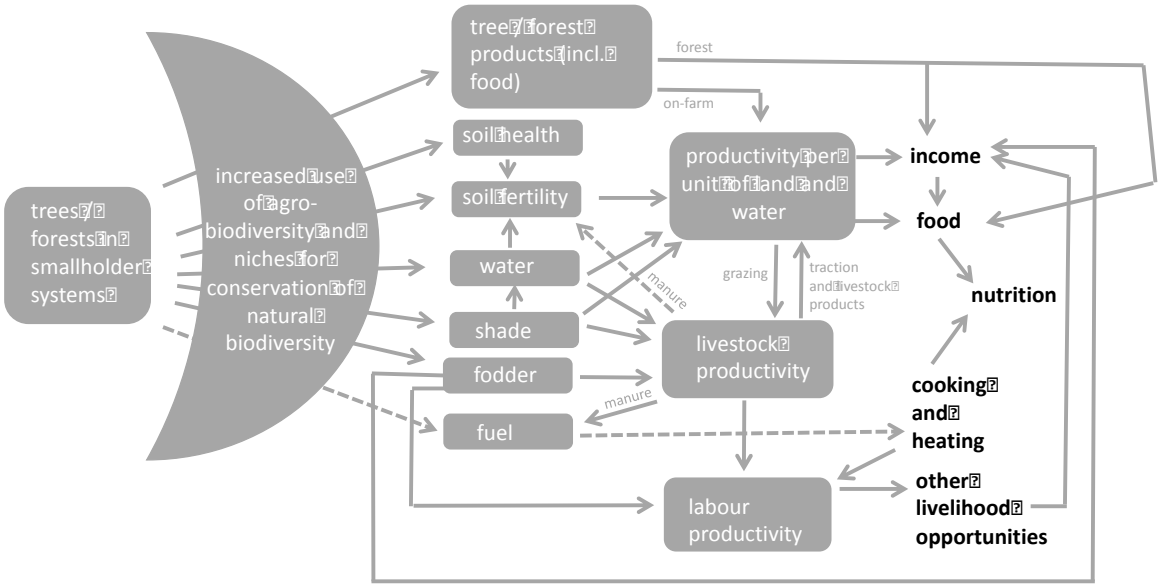


Figure 2. Major ways in which trees and forest resources impact smallholder livelihoods with quantification of effects and references set out in Table A.

Table A. Evidence of how trees and forests impact smallholder livelihoods depicted in Figure 2

	Impacted node from Figure 2	Nature and magnitude of effect	References
1	Soil fertility	It is well established that trees in crop fields can i) fix nitrogen (typically 50 to 320 kg ha^{-1} yr^{-1} but around 150 kg ha^{-1} yr^{-1} for the fertilizer tree systems widely adopted by smallholder farmers (see 8 below); ii) capture nutrients leached below the crop rooting zone and return them to surface soil via litter and root turnover (*e.g.* 42 kg N ha^{-1} recycled by deep rooting trees intercropped with fertilized maize and about half this for shallower rooting species such as *Gliricidia sepium*, favored by farmers because of their easy establishment, fast growth and nitrogen fixation), increasing nutrient use efficiency (*e.g.* N use efficiency of fertilizer tree systems with maize ranging from 49-59% compared to 10–22% for use of only inorganic fertilizer on maize monoculture); and iii) control soil erosion, especially using contour hedgerows on sloping land with high rainfall intensity (*e.g.* reducing soil loss by 80% on gradients of up to 25^{o} representing retention of between 1.8 to 12.7 t ha^{-1} of soil and the nutrients contained therein).	9,18,19,20,21
2	Soil health	Soil health refers to maintaining long term soil fertility indicated by soil organic carbon (SOC) and the ecosystem structure of soil biota. It has been established across a range of site conditions that beneficial soil organisms are (1.1-5.6 times) more abundant and generally more active in crop fields with trees than those without and closer to, rather than further away from, trees in crop fields). SOC varies across contexts but can be maintained at up to 300 Mg C ha^{-1} even in cultivated fields through agroforestry practices. Research now focuses on what tree species mixtures will deliver improvement and maintenance in soil health in different contexts.	12,22
3	Water	Trees impact water balances in several ways but the most important trade-off in agricultural terms is that of increased infiltration and lower bare soil evaporation versus the amount of water transpired by trees (that can be controlled by manipulating the amount and phenology of leaf area through tree species choice, spacing and pruning). This results in groundwater recharge in the seasonally dry tropics being maximized with an intermediate level of tree cover across agricultural landscapes. Evaporation is typically 30-60% of rainfall in semi-arid environments and trees in crop fields reduce it (*e.g.* by 35% when intercropped with food crops in Kenya (21% of rainfall) and by 41% with shade trees in coffee). Much higher infiltration (up to 60 times higher in intensively grazed silvopasture than pasture without trees) reduces flood risk as well as controlling erosion and contributing to groundwater recharge.	23,24,25
4	Shade	Shade in silvopastoral systems reduces heat stress in animals (particularly cattle) estimated to cost 1.2 billion USD yr^{-1} in lost production in the US dairy industry alone, to be higher in the tropics and likely to increase as a result of climate change. Shade is increasingly important as a means of ameliorating climate change effects in crops with tree shade buffering high temperatures to prolong grain filling in cereals and bean yield (and quality) in coffee. For example, wheat	26,27,28,29

	Impacted node from Figure 2	Nature and magnitude of effect	References
		yields in Ethiopia were 26% to 86% higher (0.5 to 0.7 t ha^{-1} yr^{-1}) under *Faidherbia albida* trees than in monoculture with proportionally larger effects in low yielding (drier) years. The area suitable for growing coffee globally is predicted to reduce by 19% overall with differential regional effects depending on altitude and latitude. Shade trees can reduce temperatures of coffee by up to 2°C, corresponding to the rise in mean global temperature expected by 2050, but require concomitant management to control competition.	
5	Fodder / Livestock productivity	The value of increased milk production through using tree fodder in Kenya was measured at between 62 and 122 USD per annum for a household with one cow, contributing from 17% to 33% of what is required for a household to exit poverty. This does not include benefits from firewood, soil fertility improvement, soil erosion control, fencing, stakes and sale of seedlings also derived from the same trees. More than 305,000 farmers have adopted fodder trees directly through the EADD (East African Dairy Development Project) in Kenya, Rwanda, Tanzania and Uganda, with a vibrant market for fodder tree seedlings emerging in Kenya, indicating considerable spontaneous (but as yet unquantified) diffusion beyond direct project beneficiaries. A further 30,000 farmers around Mt Elgon alone are targeted by a novel public-private partnership involving Vi-Agroforestry and Brookside Dairies brokered by the Livelihood Fund while the One Acre Fund, World Vision, Africa Harvest and many other development actors include promotion of fodder trees in their engagement with farmers in the region, reaching over 2 million people in East Africa alone with benefits from higher livestock production. New markets for green fodder are developing (*e.g.* in India demand exceeded supply by an estimated deficit of 696 M t yr^{-1} in 2015 creating opportunities that are particularly promising for women to exploit).	3,30,31
6	Fuel / Cooking / Heating	Woodfuel meets around a tenth of the world's energy demand, most significantly in Africa, where around 760 million people rely on firewood and charcoal as their primary source of energy for cooking. The annual value of local trade in charcoal in Africa is over 8 billion USD, employing 7 million people. A systems analysis of firewood and fodder usage in the highlands of Ethiopia revealed a mean household firewood deficit (of articulated demand over actual supply) of 5.95 t yr^{-1} and mean use of 3.2 t yr^{-1} with burning of 0.47 to 0.97 t dung hh^{-1} yr^{-1} depending on access to state forest resources. The nutrients in the burned dung represent potential cereal yield of 143 kg or 94% of per capita annual cereal demand (18% of mean aggregate household demand). National statistics indicate 34% of rural households taking more than one hour and 36% requiring >2 hours per day to collect firewood.	11,32,33
7	Income	Trees produce a number of globally and locally traded high value products important for smallholder income. Fodder and charcoal are covered already in rows 5 and 6 above. Many tree fruits are predominantly locally traded (*e.g.* 40 M t of mango are produced annually in over 90 countries (15 M t of this in India) but only 1.5 M t are internationally traded, including re-exporting, with a total import value of 1.9 billion USD). Fruit trees can produce high annual income per unit land for smallholders while providing other ecosystem services (*e.g.* the FTA AFLi project reported a mean of 2,240 USD	4,6,7,11

	Impacted node from Figure 2	Nature and magnitude of effect	References
		ha^{-1} yr^{-1} for son tra (*Docynia indica*) and 3,563 USD ha^{-1} yr^{-1} for longan (*Dimocarpus longan*) when intercropped with maize on sloping land in northern Vietnam). Additional value over a maize monoculture with a 15-year time frame and 10% discount rate was 8,250 to 14,530 with break even after 5 to 8 years. Planting fodder grasses to bridge the lag between investment and return was doubly effective providing immediate income and enabling stall feeding of animals reducing risk of livestock damage to establishing trees. While the NPV of additional value from silvicultural improvements for timber production alone from the FTA Kanoppi project in Indonesia were not attractive for farmers or investors at 1,241 USD ha^{-1} on a 20 year cycle and 8% discount rate, combining with NTFPs increased the NPV to 4,951 USD ha^{-1}, intercropping to 6,678 USD ha^{-1} and sustainable intensification with all three combined to 11,627 USD ha^{-1}. Much less intensive management required for farmer managed natural regeneration (FMNR) of trees in the Sahel (Mali, Burkina Faso, Niger and Senegal) resulted in extra income from tree products of 73-200 USD per household despite selling only 15-25% of harvested product. In contrast, coffee and cocoa are predominantly internationally traded (with an annual export value of 10 and 11 billion USD respectively), although mainly produced by smallholders (over 80% of production involving 15 and 6.5 million smallholders, respectively) with yields well below potential (550 kg ha^{-1} and 370 to 670 kg ha^{-1} respectively) and declining as plantations age, pests and diseases build up and soil fertility declines. Sustainable intensification through agroforestry tackles these multiple challenges, including a degree of climate change adaptation and livelihood diversification. For example, a Mars funded initiative increased average cocoa yields in Sulawesi from 0.5 to over 2 t ha^{-1} for 40,000 farm households and the current FTA Vision for Change program funded by Mars in Cote d'Ivoire, targets raising current yields of 0.2-0.5 t ha^{-1} to 1.5 t ha^{-1} for 150,000 farmers by 2020 with 17 cocoa development centers serving 17,000 farmers already established). FTA is leading the tree-crop value chain program for the African Development Bank's Transforming African Agriculture with Technology (TAAT) programme, that includes promoting FTA outputs to 500,000 cocoa farmers in Cote d'Ivoire, Ghana, Cameroon, Nigeria and Togo and 400,000 coffee farmers mainly in Rwanda, Uganda, Tanzania, Kenya and Ethiopia.	
8	Food (security) / land productivity	Meta-analysis across sub-Saharan Africa showed that fertilizer trees produced a mean maize yield increase of 1.3 and 1.6 t ha^{-1} for non-coppiced and coppiced fertilizer tree systems, respectively over unfertilized sole maize (farmer default practice). Over half a million farmers have adopted fertilizer trees systems in southern Africa (Zambia and Malawi), in the absence of supportive policy frameworks (on the contrary, incentives such as fertilizer subsidy, often favoring use of inorganic fertilizer), resulting in between 57 and 114 extra person days of maize consumption per household per year (affecting the food security of over 2.5 million people). Subsequent analysis of maize yield in four different agroforestry practices nationally across Malawi revealed large variation in performance amongst farms (5-8 fold with the top 20% of farmers achieving yield increases of over 2 t ha^{-1} yr^{-1}), indicating the scope for increasing both food yield and adoption	1,2,8,34,35,36,37

	Impacted node from Figure 2	Nature and magnitude of effect	References
		through better matching practices to context and developing a supportive enabling environment. Taking this approach in East Africa (Ethiopia, Rwanda and Uganda) the FTA Trees4FoodSecurity (T4FS) project engaged through partnerships with development actors, with over 30,000 farmers between 2013 and 2016 to develop options suited to context, leading to national policy reform in all three countries (see Table C) including the Ethiopian government adopting an entrepreneurial rural resource centre model developed and piloted by T4FS to produce quality germplasm and promote agroforestry in over 33,000 locations, which, if they operate on average at only 25% of the capacity of the pilots will reach 16.5 million farmers. Land degradation affects approximately 24% of the Earth's land area and impacts an estimated 1.5 billion people worldwide. A persistent decline in the capability of land to provide ecosystem services, land degradation poses a significant threat to rural livelihoods and local, regional and global food security. Despite global efforts to halt land degradation, the area of land affected continues to increase at an estimated rate of 5-10 M ha yr^{-1}. The flagship is already engaged with governments in Ethiopia, Uganda, Rwanda, Kenya, Mali, Niger, Peru and Brazil to help them meet commitments to restoration targets (see Table C).	
9	Nutrition	There is a significant positive relationship between indicators of dietary quality of children under 5 and landscape scale tree cover in Africa, associated with maximum fruit and vegetable consumption at an intermediate level of tree cover (45%) after which it declines. Wild fruits, fungi and vegetables from forest are a crucial source of micronutrients in many rural and smallholder communities, and often provide a major contribution to cash income at the household level. Bushmeat and fuelwood for subsistence and income generation contribute both directly and indirectly to food security and nutrition in sub-Saharan Africa, South-East Asia and Latin America. Recent research has shown that it is possible to exploit differences in phenology of fruit tree species to provide critical nutritional supplement (particularly of Vitamins A, C and B6) and maintain dietary diversity throughout the year, even in dry environments where extensive tree root systems and water storage in succulent roots allow trees to be productive at times in the year when herbaceous vegetation cannot supply this nutritional diversity without irrigation. In Machakos in Kenya an average household can achieve year round dietary diversity with 20 trees of 10 species either dispersed throughout their farm (on borders, around the home and in fields) or in a 8 m x 18 m (0.015 ha) fruit orchard.	11,38,39,40

A key feature of tree and forest resources is that they are often complementary to other livelihood components, such as: producing fodder and food at times when annual crops or grasses do not, diversifying diet through provision of key micronutrients and vitamins (notably A, C and B6) not provided sufficiently by crop staples and stabilizing income through product diversification, increasing the resilience of rural households, often with high potential to add value through local processing such as producing jam, juice or dry fruit products[38]. Where trees are combined with other crops it is possible, not only to significantly reduce yield gaps for annual crops, but to obtain higher overall production (land equivalent ratios >1), through the optimization of resources use (light, water and nutrients), at a site, through niche differentiation[41,42].

Trees on farms mitigate climate change through increasing carbon storage in biomass vegetation (estimated at 34.2 PgC in tree biomass on agricultural land globally[43]), in soils (estimated at up to 300 Mg C ha^{-1} for agroforestry with more research is required for specific C storage estimations for different systems and contexts[44]); and through the production of substitutes to high GHG intensive products (e.g. energy, construction materials) [45]. As climate change is increasing, the role of trees is increasingly important for the adaptation of agriculture, e.g. through buffering temperatures[46] and regulating water flow[23]. This includes reduction of high daytime temperatures prolonging grain or bean fill in cereals, coffee and other crops through to mediating water relations where more frequent and severe drought or flooding are forecast. Trees on farms and access to forest resources also diversify livelihood portfolios increasing the resilience of rural households to climate and other global change.

Smallholder livelihoods are characterized by what assets (natural, physical, financial, human and social) are available to be transformed into desirable outcomes (such as higher income, greater food security and less pollution), as mediated by social, institutional and organizational processes[47]. Livelihoods are sustainable where assets are maintained or increased but jeopardized where one or more, including the natural capital, are in decline[48]. Three key roles of trees: the productive role, the role as capital, and the ecosystem service role can lead to more sustainable farm livelihoods provided tree species are appropriately and genuinely integrated in agricultural production systems (Figure 2). However, constraints exist to many people benefiting from tree and forest resources, even on their own land: knowledge and agronomic constraints, investments constraints, lack of market access and of appropriate regulations for tree products, and forest legislation constraints that restricts what people can do with trees, with insecure land tenure or usufruct rights. This is why the flagship addresses the enabling environment (policies and markets) in tandem with technology development.

2.2.1.2 Objectives and targets

The anticipated breakdown of expenditure in relation to outcomes (Table 1) and Sub-IDOs (Table 2) reflects the priorities identified by this flagship to *reach* a large number of people with innovations that improve food security and income and restore productivity over a large area of land (Table B). These ambitious targets, commensurate with contributing to reaching SDGs 1, 2, 5, 7, 13 and 15, were arrived at based on the following rationale.

- Recent global assessments show 10% or more tree cover on over 43% of agricultural land (about 1 billion ha) that is home to 900 million people[1] and that 28% of household income is derived from forest resources by smallholders living at the forest margin[5]. The potential reach of agroforestry innovations is, therefore, very large.
- Research on agroforestry is relatively young as a discipline so that immediate gains are still possible from innovations involving use of improved germplasm and management, as well as expanding the use of tree resources on farms and in agricultural landscapes, in contrast to some

major annual crops, such as rice, that are approaching limits to areal expansion and levelling off of marginal returns to innovations targeting yield increase.

- Many agroforestry innovations have indirect positive effects in smallholder systems. Indeed, these innovations improve the efficiency of the system as a whole[49], so that the impact of an innovation goes beyond the direct benefit derived from tree and forest utilization and includes gains from increased crop and livestock production and opportunities to engage in other livelihood options that are enabled (Figure 2).
- Tree and forest resources are presently underutilized by smallholders in many places because of policy constraints related to (i) forest legislation[50] (farmers may not be legally able to, or may require permission to, utilize trees even on their own land, and their presence may affect whether land is designated as forest and thereby becomes restricted), (ii) land tenure[51] (where not secure, long term investment in trees may be risky) and (iii) markets (trade in many tree and forest products is regulated and for others, markets are underdeveloped[52]). This flagship is engaged in research to understand and alleviate these constraints at national and sub-national (state, provincial, district and local landscape) levels at which policy is implemented. Policy instruments often affect large numbers of people and areas of land, so that policy reform can unlock opportunities for many people, enabling large scale adoption of agroforestry innovations and investment in agroforestry development (Tables B and C).
- Smallholders are often constrained in their ability to establish high value tree crops or timber trees because there is a time-lag, of often several years, between the initial investment (which may be in extra labor and land costs as well as costs of seedlings and other inputs) and returns from use or sale of products. After these initial years following adoption, the value of the tree products and ecosystem services generated by the trees are greater than can be obtained from annual crops alone, so these innovations can transform livelihoods if the initial investment lag can be bridged[53]. This bridging can be done both technically (establishing trees in crop mixtures where the intercrops produce yields in the short term) and through financing solutions that provide resources up front for farmers to establish trees that are then paid back (with appropriate interest) when the trees yield products. This flagship is engaged in developing technical options that sequence yields, in linking policy development to the availability of appropriate subsidies, incentives and development bank (government) loans and novel private sector financing. These have potential to enable large numbers of smallholders to transform their livelihoods.
- This flagship invests about half of its resources in place-based research in which the research is embedded in the practice of development, enabling impact at scale). This involves a series of key co-located places where the flagship is engaged with development partners (as well as other flagships and CRPs). This leverages the research resources through connection to much larger expenditure on development, making it possible with recent developments in ICT to conduct research at a much larger scale than we have managed before (with tens of thousands of farmers) linked to development initiatives targeting millions of farmers and hectares (Table C). This more integrated work with development partners grounds the research in real-world constraints, ensures research outputs are relevant to next user needs, if necessary through revisiting our hypotheses, and provides demand driven research priorities for the more fundamental research within the flagship. It also allows integrated research on connecting innovation in technology (germplasm and management) with that on markets, extension provision and policy, generating integrated solutions across sectors that work at scale.

Targets are stated as indicators of the flagship's contribution to Sub-IDOs that can be annually tracked and reported (Table B). These are cumulative counts of people or ha potentially affected by relevant flagship innovations since the beginning of the program. This encompasses people within the reach of development partners using FTA innovations and those affected by policy change to

which FTA has contributed. The indicators, following the SRF, are not additive. We use theory of change (ToC)-based monitoring and outcome evaluation at project level to track progress at finer scale and learn from it, and strategic *ex post* impact assessment, funded from w1/w2 to verify the extent and levels of adoption and impact across projects. The use of systematic planned comparisons[54] within the place-based part of our research portfolio, generates rigorous data on the cost-effectiveness of alternative options and approaches required to inform investment decisions.

Use of w1/w2 funds (Tables 1 and 2) are targeted at deriving IPGs from analysis and synthesis across the entire project portfolio of the flagship (Figure 3). This results in a higher proportional investment of w1/w2 funds in Outcomes 1 and 5 (Table 1). In the case of Outcome 1 this is because of the resources required for assembly of the co-located project portfolio, development of new tools and methods across projects, synthesis across countries and strategic impact assessment. In the case of Outcome 2, focused on a new focal area for the flagship, w1/w2 resources are particularly required for scoping and synthesis across projects, countries and regions. The lower proportional investment of w1/w2 in Outcome 3 is because, already well-established connections to a vibrant private sector utilizing tree-crop commodities, has led to a robust bilateral investment. In terms of Sub-IDOs there is a higher proportion of w1/w2 funds targeted at increasing livelihood opportunities, developing a conducive policy environment and capacity development of partner research organizations (NARES) in line with our theory of change (see next section).

Table 1. Outcomes by windows of funding.

Outcomes	Amount needed (m. USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
1. Improved food security and livelihood opportunities for 20 million smallholder households (100 million people) and more productive and equitable management of natural resources over an area of at least 50 million ha. This outcome integrates some outputs from other research clusters through their scaling.	25	30	0	70
2. Improved livelihood opportunities involving timber, fruit and NTFPs contributing a 25% increase in income for over 5 million people and more equitable management of natural resources, including a 25% increase in women's participation in decisions involving tree and forest management and utilization and improvement in substantive representation of women in community forest management institutions	15	21	0	79
3. Diversified tree-crop production systems covering 5 million ha and improving diets and livelihood opportunities for 20 million people in smallholder producer households	20	16	0	84
4. Increased access to diverse, nutrient-rich food for 20 million people by closing yield gaps by trees in agricultural systems, improving and maintaining soil health, intensifying system interactions (fodder and fuelwood), directly contributing to production, reducing and reversing land degradation, and increasing the resilience of smallholder livelihoods	25	25	0	75
5. Reducing yield gaps through improved pasture management and animal husbandry on over 15 million ha and 1 million animals and contributing to reducing and reversing land degradation on over 5 million ha	15	28	0	72
Total	**100**	24	0	76

Table 2. Investments by sub-IDOs.

Sub-IDOs	Amount needed	W1/W2 (%)	W3 (%)	Bilateral (%)
3.2 Increased livelihood opportunities	15	28	0	72
3.3 Increased value capture by producers	7	20	0	80
5.2 Increased access to diverse, nutrient-rich food	10	25	0	75
8.1 Land degradation minimized and reversed	10	23	0	77
9.1 More productive and equitable management of natural resources	10	24	0	76
9.2 Agricultural systems intensified and diversified in ways that protect	12	24	0	76
10.1 Increased resilience of agroecosystems and communities	6	20	0	80
B.1 Gender-equitable control of productive assets and resources	10	20	0	80
C.3 Conducive agricultural policy environment	10	28	0	72
D.3 Increased capacity for innovation in partner research organizations	5	30	0	70
D.4 Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	5	18	0	82

Table B. Annually trackable indicators of contributions to Sub-IDOs and 2022 targets

Sub-IDO	Indicators (cumulative)	2022 Target
3.2 Increased livelihood opportunities	Cumulative number of people *reached* by development partners *using* FTA-related options or *affected by* government policy changes that enable adoption of FTA-related livelihood opportunities.	20 million households (roughly 100 million people)
3.3 Increased value capture by producers	Cumulative number of people with *access to* FTA-related technologies, market interventions and/or policy or institutional innovations that can demonstrably enable an income increase by at least 25%	1.2 million households (roughly 5 million people)
5.2 Increased access to diverse, nutrient-rich food	Cumulative number of people in smallholder households with *access to* FTA-related innovations that can demonstrably improve food production (quantity and availability seasonally) and dietary diversity (minimum dietary energy requirements and an adequate number of food groups).	350K households (roughly 1.75M people)
8.1 Land degradation minimized and reversed	Cumulative number of ha *reached by* FTA innovations that can demonstrably avoid degradation or restore productivity of degraded land.	22 M ha
9.1 More productive and equitable management of natural resources	Cumulative number of ha of land *reached by* FTA innovations in natural resource governance that can demonstrably improve productivity or equity.	1M ha
9.2 Agricultural systems intensified and diversified in ways that protect soils and water	Cumulative number of ha of land *reached by* FTA innovations involving improved tree cover management that can demonstrably protect soils and water.	8 M ha
10.1 Increased resilience of agroecosystems and communities	Cumulative number of people residing in communities reached by FTA innovations that demonstrably increase livelihood resilience	1 M people
	Cumulative number of ha of land *reached by* FTA innovations that demonstrably increase agroecosystem resilience.	12 M ha
B.1 Gender-equitable control of productive assets and resources	Cumulative number of women, and members of vulnerable groups, *affected by* decision making institutions governing the management of tree and forest resources, for which FTA innovations *are available* that can demonstrably increase numerical and substantive representation of these groups in decision making. This relates specifically to involvement in devolved governance of natural resources such as community forest associations, and does not include women who benefit from innovation in policy and practice more generally.	50K women
C.3 Conducive agricultural policy environment	Cumulative number of people *potentially affected by* policy changes with a demonstrable link to FTA innovation (evidenced by process tracing).	15M households (roughly 75M people)

Sub-IDO	Indicators (cumulative)	2022 Target
D.3 Increased capacity for innovation in partner research organizations	Cumulative number of people in partner research organisations *engaged in* co-learning communities of practice involving FTA innovations	1000
D.4 Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	Cumulative number of development partner staff *engaged in* co-learning communities of practice involving FTA innovations	3000

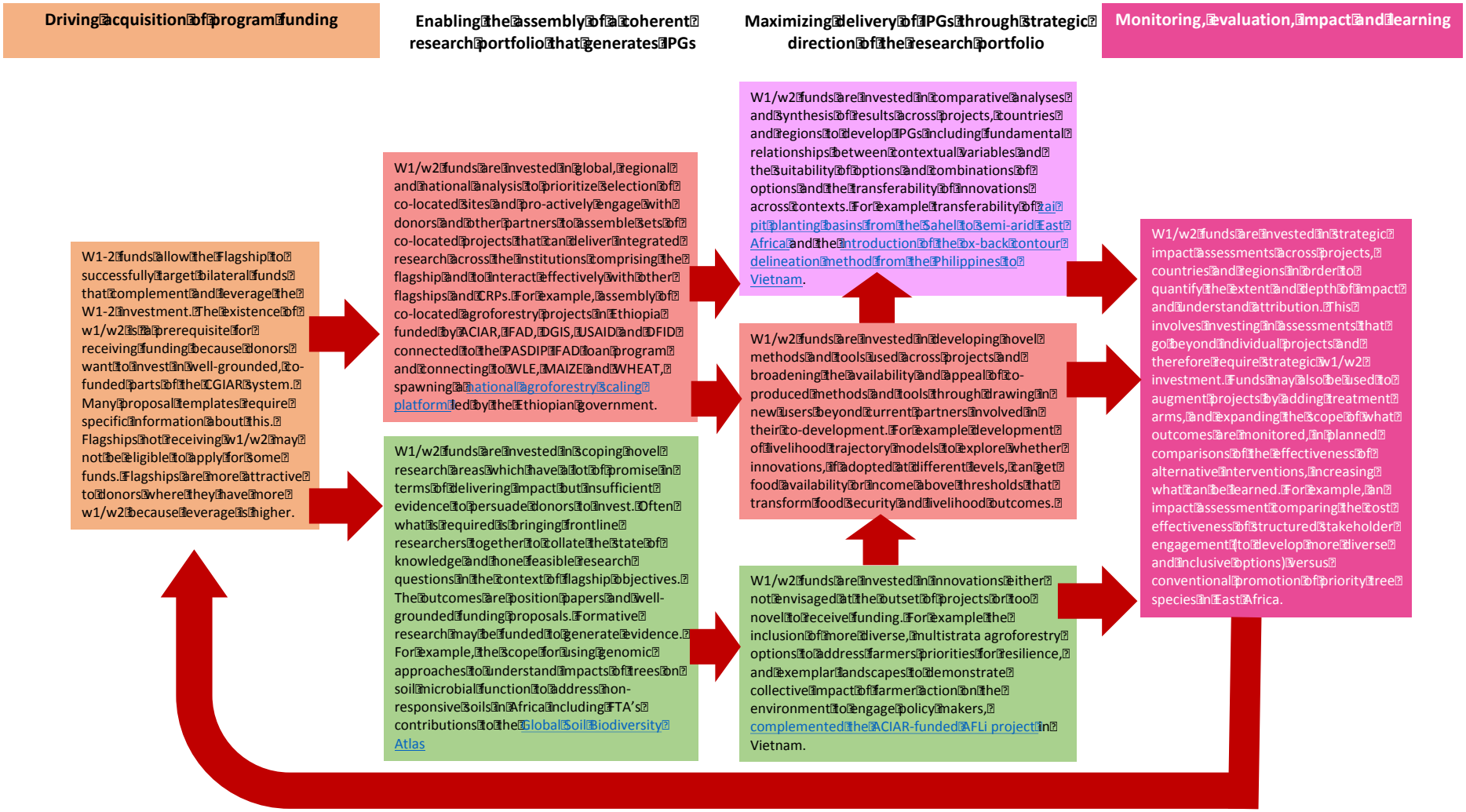


Figure 3. How strategic use of w1/w2 funds drives the flagship program structure and ensures delivery of IPGs and impact

2.2.1.3 Impact pathway and theory of change

The theory of change (ToC) for the flagship (Figure 5) rests on three interrelated assumptions evidenced in Tables A and C that: (i) current management of tree cover on farms, in pastures (including silvo-pastoral systems) and at forest margins can be improved contributing to sustainable intensification of livelihoods through higher total factor productivity[55], leading to higher food and nutrition security; (ii) smallholders and particularly women, can achieve higher returns from tree and forest products by better marketing and processing, thereby increasing their income; and (iii) people (especially women, young people and other marginalized groups) can participate more in, and benefit more from, using tree and forest resources, if policies, legislation and institutions affecting their use, are reformed to enable this, including financing investment to establish trees.

The flagship conducts basic research on priority topics that improves understanding of constraints to, and opportunities for, people to benefit from tree and forest resources, and our understanding of how trees can increase total factor productivity of livelihood systems, yielding IPGs in the process (Box 1, Figure 4). The improved understanding thus generated is then used within the flagship to develop methods, tools and policy interventions to operationalize this knowledge. This involves development of appropriate options for smallholders across large scaling up domains constituted by a portfolio of co-located project clusters, through partnerships with development actors (Boxes 2 and 4, Figure 4). The success of this approach rests on key assumptions about the willingness of development partners, and those who finance them, to engage with the place-based research through i) using evidence to decide upon the options they promote and ii) acknowledge where evidence is lacking and co-generate new knowledge about local adaptation of options and the contexts for which different options are suitable, through building planned comparisons into their promotion of options (Figure 5). The partnership strategy involved and how risks are managed is outlined in Section 2.2.1.7. The partners include national and local research providers, extension providers, the private sector (in terms of market actors) and policy makers, convened as nested scale innovation platforms at local, national and international levels.

These co-produced methods and tools are tested, improved and used in the place-based research through which they are generated, yielding new, generalizable knowledge (IPGs). Here, there is an important interaction with development partners and with development spending, that is several magnitudes larger than that for research. Through embedding research within the scaling up process, the flagship simultaneously accelerates impact for development partners and enables research to be conducted at the scale at which we aspire to make impact[56] (Boxes 2 and 4 in Figure 4 and Figure 5). Basic knowledge generated from the placed-based research about relationships between contextual factors and the suitability of different options and combinations of options (including interventions in the enabling environment), together with demand driven research priorities required to address bottlenecks to adoption, are fed back into the fundamental research effort (Box 1, Figure 4).

Transforming the co-produced knowledge, methods and tools (Box 2, Figure 4) into impact, requires change in knowledge, attitudes and skills and hence the behavior of NARES and NGOs who promote agricultural and forest innovations, policy makers and implementers who frame the enabling environment, private sector market actors, and public and private institutions that provide finance for sustainable development in ways outlined in Box 3, Figure 4. Within the co-located portfolio of place-based research (Table C) these changes are mediated and supported through development of nested scale (local, national, international) innovation platforms. The platforms directly involve the key actors mentioned above, and the successes and failures of the experience of convening them, together with results of systematic planned comparisons to compare the cost-effectiveness of different approaches to effecting change, generate important IPGs that are published and publicized. In this way the direct impact at the co-located sites is complemented by a second more

distributed pathway to impact where innovations, methods, tools and experience are adopted and used by a wider range of extension, policy and market actors beyond the co-located placed-based research sites. This wider uptake is fostered through capacity development and the targeted use of social media (Box 2, Figure 4).

Table B shows annually trackable indicators of reach; that is, for how many people and ha, FTA innovations are potentially available through development partners (e.g. farmers in Ethiopia within the catchment area of the government nurseries converted to entrepreneurial rural resource centers following the FTA model; farmers in Rwanda to which the One Acre Fund promotes trees using FTA options by context methods) and as a result of people falling within the jurisdiction of relevant policy change (e.g. farmers in Peru eligible for agroforestry restoration concessions that enable formalizing land title in Peru; farmers in Vietnam eligible for incentive payments to establish agroforestry on sloping land resulting from provincial policy change documented as being catalyzed by FTA research). We distinguish this 'reach' from the extent to which it is translated into adoption and impact that are the subject of specific studies to quantify these.

Progress along impact pathways is tracked at project level and used to inform project implementation and where necessary redesign.

The flagship has an integrated monitoring, evaluation, impact and learning (MEIL) strategy to track progress along impact pathways and the ultimate impact of the flagship. This includes the following key elements.

1. Tracking cumulative annual indicators at flagship level, of the reach of the flagship program (Table B), in terms of cumulative counts of people and ha for whom flagship innovations are available, through the promotion efforts of development partners, and the jurisdiction of policy reform.
2. Outcome evaluation at project level, to document and track changes in behavior of actors along specific impact pathways, using appropriate elements of outcome mapping, contribution analysis, realist evaluation and process tracing[57]. Reflection on this generates learning, that feeds back into modification of current project activity and design of new projects to maximize effectiveness.
3. Periodic strategic *ex post* impact assessment funded from w1/w2 to quantify the extent to which reach is translated into adoption and has an effect on poverty, food security and environmental integrity.
4. The use of planned comparisons in the place-based research portfolio to quantify the cost-effectiveness of alternative approaches and options[58].

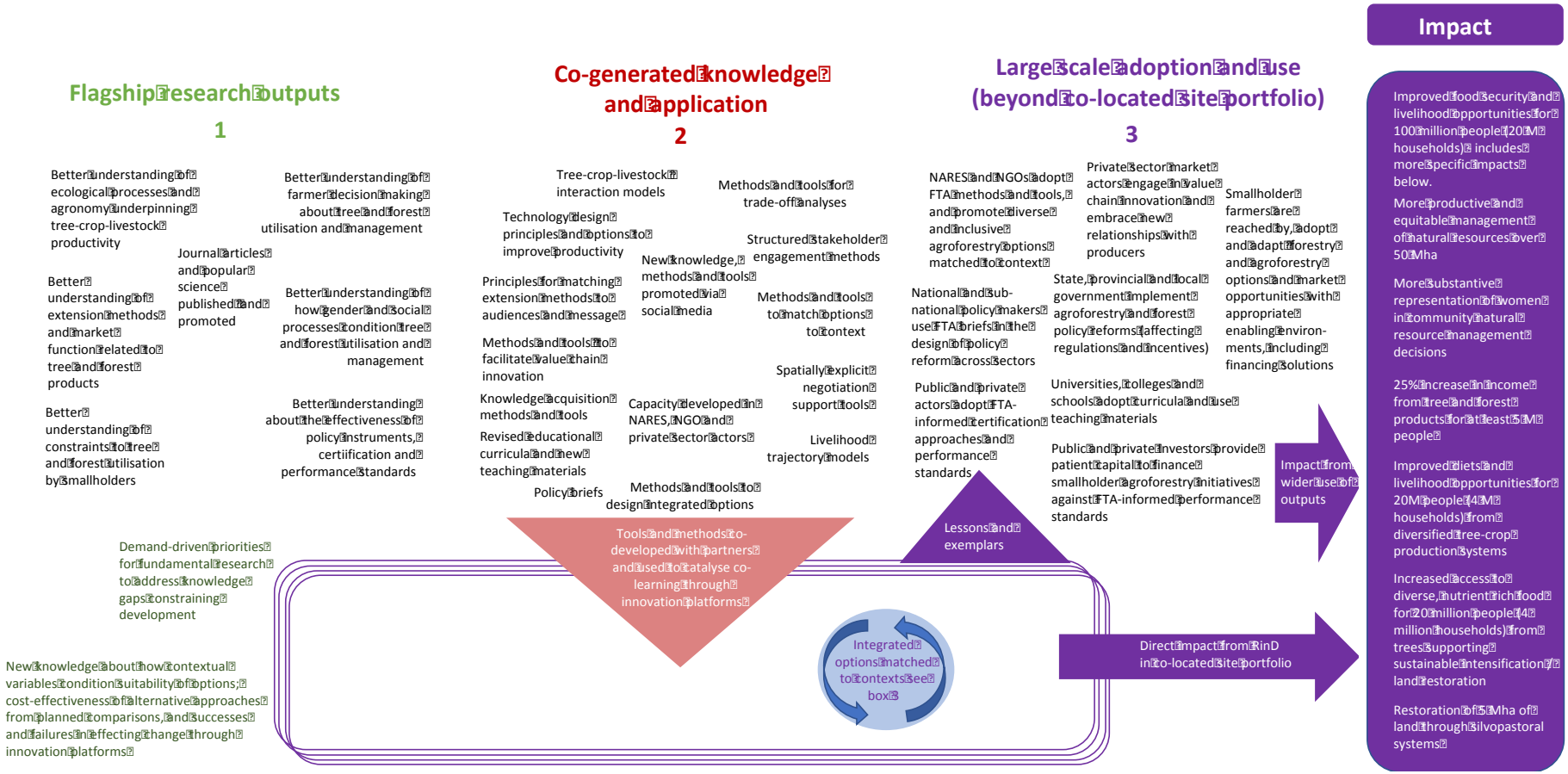


Figure 4 Key stages in the co-generation and use of research outputs to create impact

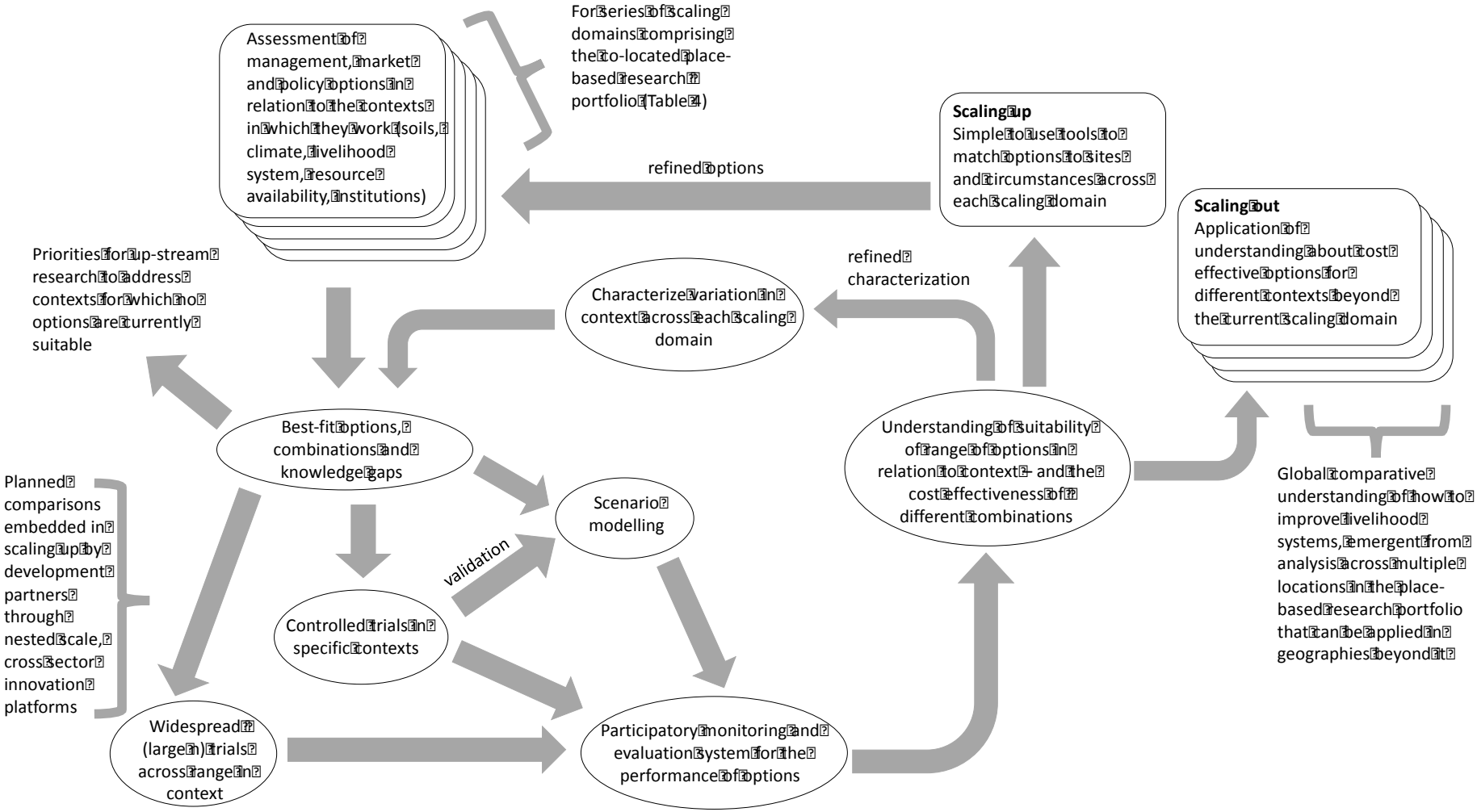


Figure 5. The research 'in' development (RinD) approach (adapted from Coe et al. 2014[59]) that embeds research within development practice by considering options in relation to context and systematically evaluating options across ranges in context[60] through coupling planned comparisons with innovations in data collection from extensive trials.

Table C. The co-located place-based, integrated research portfolio that links technological innovation at scale with national and sub-national policy and market intervention. Funding shown for associated development programs is indicative of uptake potential of FTA outputs but does not constitute funding for the underpinning research that requires w1/w2 resources without which the integrated portfolio cannot function.

Location	Co-located research projects and associated development initiatives	Examples of progress along impact pathway leading to impact at scale
Ethiopia	ACIAR – Trees4FoodSecurity, DFID – SAIRLA, IFAD – Dryland restoration, Irish Aid – Watershed Rehabilitation, DGIS - **Dry**lands**Dev**elopment program, USAID-Africa Rising associated with the PASDIP II IFAD loan program (144 M USD), and GEF UNDP – Integrated Landscape Management to Enhance Food Security and Resilience (10.2 M USD + 144 M co-financing) and connecting to CRPs on WLE, MAIZE, WHEAT and Livestock and FTA FPs 1 and 4.	In response to FTA co-located research results on performance of agroforestry options a cross-sector national agroforestry scaling platform in Ethiopia has been established with the Ministries of Agriculture, Forestry and Livestock that includes development of national policy, the establishment of a delivery unit in the Ministry of Agriculture scientifically supported by FTA and a commitment to hand over 33,000 government nurseries to entrepreneur youth and women's groups following the success of the FTA ACIAR-funded Trees for Food Security (T4FS) Rural Resource Centre (RRC) model for generating and promoting quality germplasm, farmer training and agroforestry knowledge. More than a thousand farmers are participating in FTA planned comparisons on tree establishment in collaboration with WorldVision.
Uganda	ACIAR – Trees4FoodSecurity; ACIAR – Value Chain Innovation Platforms4FoodSecurity; Heifer – EADD; the Nile-Congo Sentinel Landscape; IUCN - associated with the PRELNOR IFAD loan program (71 M USD) and GEF UNDP FAO – Fostering Sustainability and resilience in Karamoja (7.1 M USD with 51 M co-financing) and connecting to WLE, Livestock and FTA FPs 1 and 4.	Fifteen members of the Ugandan parliament including ten who sit on the Agriculture and Natural Resources committee and the Food Security Platform visited sites where FTA innovations were adopted in July 2017, established a cros-sector unit involving the Ministries of Agriculture and of Water and Environment to move forward a national agroforestry strategy currently in draft. A national task force co-ordinated by the Uganda Farmer's Federation (UNFEE) and involving an MP from the parliamentary Food Security Forum, a legal advisor and representatives from FTA (who through ICRAF together with Vi-Agroforestry are trialing agroforestry options with over 20,000 smallholder farmers in the country) has been constituted to advise on steering the strategy through parliamentary procedures.

Location	Co-located research projects and associated development initiatives	Examples of progress along impact pathway leading to impact at scale
Rwanda, Burundi and DRC	ACIAR – Trees4FoodSecurity, EU – Forests and Climate Change in the Congo (FFFC), EU - FORETS; the Nile-Congo Sentinel Landscape associated with GEF UNDP – Lake Tanganyika Catchment Management (13.5 M + 28.6 M co-financing), GEF FAO Support for Sustainable Food Production in Burundi (7.3 M USD + 45 M co-financing) and connecting to MAIZE and FTA FPs 1, 4 and 5.	Co-investment by the government of Rwanda with the FTA T4FS project will increase the number of pilot RRC's from two to nine, the One Acre Fund has engaged in an options by context analysis related to diversification of their tree promotion programme and FAO has contracted ICRAF to advise the Government on development of national agroforestry policy. Change in knowledge, attitudes and behavior of development partners to adopt more diverse and inclusive agroforestry options was documented in DRC and is now being taken forward by WWF across North Kivu using technical options and approaches developed by FTA. This builds on the success of FTA combining high end science (identification of erosion hotspots from satellite image analysis) with local knowledge to control sediment flow and enhance livelihoods in the Lake Tanganyika catchment where >2 million trees were locally raised and planted in 2012, including 16 native species not previously promoted in the region.
Kenya	IFAD – Dryland restoration, DGIS - **Dry**lands**Dev**elopment program associated with IFAD KCEP-CRAL loan program (116 M USD), GEF IFAD Upper Tana Nairobi Water Fund (7.2 M USD + 61 M co-financing) and in connection with WLE, Livestock and FTA FPs 1 and 4.	FTA research is embedded in the KCEP-CRAL loan program and the water fund through characterization of context, matching options to contexts and impact evaluation with >3000 farmers trying out and providing feedback on soil and water conservation, tree planting and post-harvest pest control innovations in systematic planned comparisons spanning three counties. Novel livelihood trajectory modelling using the Simile modelling environment is being used to identify levels of adoption of different interventions (and combinations) necessary for households to achieve food security and transition out of poverty.
Malawi / Zambia	ACIAR – Value Chain Innovation Platforms4FoodSecurity, DFID – SAIRLA, Irish Aid – Agroforesrtry for Food Security phases 1 and 2 associated with GEF IFAD – Enhancing the resilience of agro-ecological systems in Malawi (7.1 M USD + 87.3 M co-financing) and in connection with FTA FP1.	The use of fertilizer trees became well established in southern Africa following a critical meta -analysis that showed positive impacts on maize yields across the region, leading to support for scaling agroforestry to underpin food security by Irish Aid in Malawi and a farmer-led initiative to establish fertilizer trees in fields in Zambia. Assessments of the performance of agroforestry practices nationally in Malawi and impact assessment of AFSP have highlighted the variation in the performance of practices across contexts and the need for extension approaches that support farmers in establishing appropriate high quality trees. Novel modelling of tree-crop interactions that delivers accurate predictions of crop yield, incorporated in the APSIM framework, is being applied to help define niches for

Location	Co-located research projects and associated development initiatives	Examples of progress along impact pathway leading to impact at scale
		different practices.
Cote d'Ivoire / Ghana cocoa belt	Mars – vision for change, Danida – Climcocoa, Danida – VALOR associated with AfDB – CSSVD control, AfDB – TAAT tree-crop value chains.	FTA research showing that farmers wanted more trees and more tree diversity on their cocoa farms in Cote d'Ivoire associated with major public-private investment in rejuvenation strategies for cocoa through the Mars-funded V4C program and more recently in CSSVD control, has led to a national shift from an emphasis on full sun systems to a strategy embracing agroforestry to increase and sustain cocoa productivity coupled with new research on using agroforestry to mitigate effects of climate change on cocoa in Ghana. These now underpin an emerging AfDB investment to rejuvenate cocoa across West Africa as part of it's TAAT initiative.
Mali / Niger/ northern Ghana / Burkina Faso	IFAD – Dryland restoration, DGIS - **Dry**lands**Dev**elopment program, IFAD – WAFFI, USAID – scaling up climate smart agriculture, West Africa Sentinel Landscape associated with IFAD PASADEM (31.7 M USD), Rumanmu (25.7 M USD), (GEF UNDP – Family Farming Development Program in Niger (7.6 M USD + 60.3 M co-financing); IFAD PAPAM loan program in Mali (173 M USD), GEF IFAD – Participatory Natural Resource Management and Rural Development in BF (7.2 M USD + 35.9 M co-financing); GEF World Bank – Sustainable Land and Water Management in Ghana (12.8 M USD + 22 M co-financing);	The FTA impact study of farmer managed natural regeneration (FMNR) across five countries in the Sahel quantified for the first time the benefits that farmers were receiving from higher tree densities in their fields including 15-25% higher crop yield and higher livestock productivity in addition to 34-38% increase in value of tree products. Outcomes included a higher mean income of 72 USD per annum and increase in dietary diversity of 12-14% in households with over those without FMNR. There are over 5 million ha of FMNR in Niger alone and a lot of scope to further increase benefits to farmers through enrichment planting, tree and crop management innovations and improved marketing of tree products. In many parts of the region (e.g. Mali, Ghana and Burkina Faso) policy constraints to farmers benefiting fully from tree and forest resources remain and are being addressed through FTA participatory action research. There are >5000 farmers participating in systematic planned comparisons of FMNR enhancement options and providing feedback on their performance across Mali and Niger.
Vietnam	ACIAR – AFLi, FAO – national policy development; Mekong Sentinel Landscape, associated with provincial and national scaling.	The Ministry Nationally and Provincial Departments of Agriculture and Rural Development (DARD) in three provinces of northwest Vietnam have co-invested in the development of six exemplar agroforestry landscapes and the Yen Bai DARD has effected three specific policy changes to create incentives for farmers to adopt agroforestry options developed through the FTA ACIAR-funded AFLi project across the province.

Location	Co-located research projects and associated development initiatives	Examples of progress along impact pathway leading to impact at scale
Indonesia	ACIAR – Kanoppi, Canada – AGFOR embedded in national development	National agroforestry centre established, integrated cross-sector agricultural and forest policy approaches developed in three provinces and an integrated smallholder agroforestry project supported in Sulawesi.
India	Nationally embedded FTA program of research with ICAR; Western Ghats Sentinel Landscape; support for state level agroforestry research and development (e.g. Odisha)	National agroforestry policy inaugurated in 2013 now rolling out in state level implementation, together with availability of loans to smallholders to establish agroforestry through the National Bank for Agriculture and Rural Development (NABARD). Now exploring involvement in design of agroforestry options to enhance soil health associated with the role out of soil health cards nationally to farmers.
Peru	Range of projects on coffee, cocoa and timber in relation to national and regional restoration and forest policy, Western Amazon Sentinel Landscape.	Government has incorporated policy changes to enable implementation of an FTA options by context approach in an agroforestry concessions scheme to contribute to restoration in agricultural frontiers of the Amazon region as part of the county's 20 x 20 and Bonn Challenge commitment to restore 3.5 M ha by 2020. The legislation (passed in 2015) confers land rights to farmers provided that they establish sustainably managed agroforestry systems on >20% of the designated area. FTA is now working with the relevant Ministries on implementation guidelines. This builds on previous engagement in redefining agroforestry in forest legislation legalizing smallholder timber sales from sustainably managed fallows in the Amazon region.
Brazil	USAID (via Natura) – oil palm diversification; IUCN – land restoration through agroforestry; embedded in national development and policy processes	FTA restoration through agroforestry options and approaches have been adopted by the Brazilian forest service as well as a range of NGOs and state bodies working on restoration across the Cerrado and Caatinga biomes in Brazil contributing to the national target to restore 22 M ha of forest, cropland and pastures by 2030.
Central America	Series of silvopastoral system research projects at CATIE some collaborative with CIRAD, ICRAF and Bangor University; Nicaragua Sentinel Landscape	CATIE pioneered integrated co-located research at landscape scale through their MIP project making the Nicaragua-Honduras Sentinel landscape a hub for collaborative research across FTA. The key focus of this flagship is on development of silvopastoral systems and their impact on sustainable productivity and in association with FP5 reducing greenhouse gas emissions from livestock production systems and the development of sustainable coffee and cacao agroforestry systems in the face of climate change.

2.2.1.4 Science quality

The flagship produces the following three distinct types of international public goods (IPGs).

i) **Better understanding of fundamental processes** that are advances in the science underpinning the design of how trees and forest resources can best be established, managed and utilized in an agricultural context and that enable prediction of the likely impact of different alternatives. This includes making advances in ecological, social, economic and transdisciplinary sciences.

ii) **New methods and tools that can be applied across contexts** that result from our work with development partners including:

- tree-crop interaction and livelihood trajectory simulation models;
- structured stakeholder engagement methods to develop diverse and inclusive intervention options;
- farmer field scaling approaches that embed planned comparisons in development praxis;
- options by context analyses methods and tools, and
- spatially explicit negotiation support tools that bring evidence to bear on decisions in multi-stakeholder platforms.

iii) **Defining extrapolation domains: understanding of how contextual factors affect performance of options**, through:

- Comparative analysis across place-based research conducted over a range of contrasting locations (*e.g.* different fertilizer tree species and management options for different altitudes, annual rainfall, soil conditions and farm size to labor ratios across East and southern Africa; different enrichment planting options in terms of tree species and management to complement farmer managed natural regeneration across rainfall and demographic / infrastructure gradients across the Sahel; business model options for smallholder forest and agroforestry products in terms of product quality, collective marketing and contractual arrangements and pricing across the poorest provinces of Indonesia and Vietnam and then more broadly across SE Asia).
- A move on from increasingly intricate farmer typologies, to an approach where fundamental relationships between individual contextual factors (and combinations of them) and the performance of intervention options can be understood and used to drive customization of recommendations for farmers (*e.g.* developments in ICT make it possible to design simple applications (apps) that allow input of contextual information such as farmer objectives and labor availability (with mapped variables, like elevation, rainfall and an increasing number of soil variables automatically generated from the location of a smart phone) and used to screen options for local their local applicability).
- The identification of research needs with respect to contexts for which there are currently no appropriate options, focusing fundamental research on demand-led priorities (*e.g.* land restoration options that don't disadvantage the most vulnerable community members in the Ethiopian highlands, where exclosures result in reduced access to key resources for households with low ratios of land holding size to livestock; livelihood options for people with little or no land excluded from farm and forest land entering REDD+ schemes in Kenya, such as developing sustainable charcoal production models involving transfer of durable usufruct rights).

Producing this array of IPGs presents science quality challenges in terms of publishing transdisciplinary research, delineating effective research domains where multiple ecosystem services have different, only partially overlapping boundaries (e.g. watersheds and habitat networks) falling across administrative jurisdictions[61] and perceptions that research closer to the farmer is in some sense less scientific than research in more controlled conditions. We tackle these three interrelated challenges by collaborating with leading disciplinary scientists (see below), publishing interdisciplinary methods in respected journals creating a precedent for their wider use[62], innovating in the development of transboundary methods and tools[63] and

engaging in scientific debate on the importance and rigor of whole systems research, especially in the context of making development impact from research[64,65,66].

Specifically, in phase 2, together with universities in the UK (Prof. Davey Jones at Bangor) and the US (Prof. Diana Wall at Colorado State), we will apply the latest advances in genomics to better understand how trees improve soil health by enhancing the abundance and activity of soil organisms (CoA 2.4)[12]. We will do this by applying advances in DNA sequencing of soil microbial populations[67] to test hypotheses about non-responsiveness in soils and how trees affect soil health through fostering functionally balanced soil biota. We collaborate with CSIRO (Dr Neil Huth) and the Maize, Wheat and Rice CRPs in developing and extending the tree-crop interaction modelling capability in APSIM[68,69] and applying this with PIM to understanding impacts of agroforestry innovation on food security and global development impact. We collaborate in design of planned comparisons of alternative development options and impact evaluation with the University of Montana (Prof. Sarah Janzen), in livelihood trajectory modelling with the Simulistics group in Edinburgh (UK) and Prof. Annette Cowie on the GEF STAP (Scientific and Technical Advisory Panel) with respect to developing resilience indicators. We address a key implementation gap in relating land-use decisions at field and farm scale to impacts on ecosystem service provision at local landscape scales[70], by developing and applying spatially explicit negotiation support tools. Building on the Polyscape[71] approach developed in Phase 1, we couple this with sustainable agricultural intensification dashboards designed to be used to bring evidence to bear in multi-stakeholder platforms where policy decisions are made[72]. We continue to innovate in using systematic approaches for local knowledge acquisition, building on recent advances in statistical analysis of farmer rankings of tree attributes[73] to combine local and scientific knowledge in developing more diverse and inclusive agroforestry options[74]. We will continue to innovate in customizing and delivering context specific options through development of location-relevant guidelines[75], smartphone applications[76] and GIS tools (with the European Space Agency allowing access to high resolution satellite products). We will apply a new, unified theory of empowerment[77] together with advances in understanding vulnerability and equity[79] to address constraints in realizing effective and equitable governance of tree and forest resources.

2.2.1.5 Lessons learned and unintended consequences

In Phase 1, we pursued research along disciplinary lines (management options, markets, policy). We found that these interact strongly and need to be combined to achieve livelihood gains at scale. In Phase II, we need to reconcile place-based research with the production of generalizable IPGs, using a novel RinD paradigm (Figure 5).

We found in Phase 1 that conventional approaches to prioritizing tree species and management practices for scaling did not address the inclusive needs of socially differentiated actors or fine-scale variation in conditions and led to narrowing tree diversity at larger scales. In Phase II, we adopt an 'options-by-context' approach that recognizes variation among people and places, and develops context-specific and locally adaptable options that reach a broader range of people while conferring resilience at landscape and livelihood scales[74]. To do so, in Phase II, our systems characterization informs FP1 in defining field, farm and landscape niches for tree species and priorities for improvement. We jointly evaluate tree germplasm from FP1 across contexts (Figure 3) and embed innovations in tree seed and seedling delivery from FP1 within tools for promoting tree diversity that combine local knowledge with high-end science (including suitability mapping of tree species from FP1). We learn from large-scale, planned comparisons of tree promotion approaches to inform FP1.

In Phase 1, we identified a need for hard evidence on the cost-effectiveness of intervention options to inform investment decisions in scaling. We address this in Phase II through nested-scale planned comparisons.

In Phase 1, we established that trees on agricultural land are associated with a greater abundance and activity of beneficial soil organisms[12] we build on this in Phase II using genomic approaches to understand how different tree species, density and diversity affect the functional profiles of soil organisms and affect soil health.

In Phase 1, we analyzed how tree product markets, culture and policies have differential effects according to gender[80]; we will build on this in Phase II by pursuing gender-transformative research and greater engagement with the private sector in developing market access for smallholders.

In Phase 1, we identified a key implementation gap in linking farm-level decisions to impacts on ecosystem service provision at local landscape scales[70]; addressed in Phase II by developing novel GIS applications at 30 m resolutions fine enough to inform negotiation support.

In Phase II, we expand our research on silvopastoral systems in line with recommendations of the independent evaluation of FTA during Phase 1 and the huge land area over which these systems are relevant, together with the expanding demand for sustainable livestock products as set out in CoA5 (Section 2.2.1.6).

Intended and unintended consequences: Improving smallholder livelihoods involves dealing with complex systems behavior rather than linear, deterministic outcomes. While we have defined specific desirable outcomes that we aim to achieve in overall terms, this is done by guiding emergent practice through iterative cycles, within and beyond the research domain. During this process, we take steps to manage the risks inherent in the partnerships involved (see Section 2.2.1.7) and to monitor the winners and losers. A significant part of our research portfolio looks at who benefits from innovations in terms of policy and practice and what can be done to ensure that intended beneficiaries are reached. Examples from Phase 1 include understanding the impacts of forest policy on regenerating trees on farm and of partial devolution of forest authority on vulnerability[78] and empowerment[77] of smallholders. We have also explored issues of equity in distribution of benefits from carbon payment schemes and the requirements for social safeguards that will result in positive outcomes for smallholders[79]. We now direct the program at producing research outputs that can support negotiation of desirable outcomes by bringing new evidence to bear on them.

2.2.1.6 Clusters of activity (CoA)

The flagship comprises five research clusters. The first is an integrating cluster on livelihood systems analysis, synthesis and scaling that structures and integrates the research across the four other clusters (Figure 4). Within each cluster, specific geographic focii were selected (Table C) by applying the following criteria:

- demand from national and regional organizations evidenced by willingness to engage in policy reform and/or significant expenditure on development action (> USD 100 million over the phase 2 duration, earmarked nationally),
- potential for impact on SLOs and prospects for improved management of tree cover, resulting in a focus on forest margins where tree crops are expanding and agricultural land with >10% tree cover and locally high population density,
- prospects for site integration by co-locating research amongst partners within the flagship, with other flagships in the CRP (focusing on the FTA sentinel site network) and with other CRPs (collaborating on key crops: rice, maize, wheat, legumes, dryland cereals and tree crops).

CoA 2.1 Livelihood systems analysis, synthesis and scaling.

This cluster provides connections across all clusters, including comparative analysis and ongoing prioritization amongst and within the other clusters, facilitated by the design in this cluster of common approaches and methods which are used by all the other clusters in the flagship. The research in all four production system clusters involves a considerable diversity of tree species and encompasses fine scale variation in smallholder contexts (ecological, economic and social). The overarching hypothesis is that for research results to lead to actual impact on the ground, options for improvement (involving technology, market interventions and policy reform), need to be combined and matched to fine scale variation in context. This requires conducting research at scale (to encompass variation in context) and the development of novel methods, tools and appropriate capacity in boundary partners (NARES, NGOs and the private sector) that use them, that can be most effectively realized through embedding a proportion of the research in development programs. Through the use of multiple, contrasting sites for place based research, generalizable results and international public goods are derived across the research portfolio.

Research questions: What are the key tipping points in the adoption of forest and agroforestry innovations (and combinations of them) leading to transformation of livelihoods in different contexts and how can these be determined for food security and poverty reduction outcomes? What tools and methods will most efficiently, effectively and equitably support i) generation and selection of diverse and inclusive options that improve the use of trees and forests by smallholders, for different scaling up domains and ii) co-development of principles for matching options to the fine-scale variation in the context of smallholder livelihood systems within scaling up domains? How do contextual factors (biophysical and socio-economic) affect the suitability of different types of innovations? How can new scientific evidence be most effectively curated to support i) policy development and ii) negotiation among stakeholders, bridging farm to local landscape scales (<1000 km^2), to manage the impacts of land-use change on ecosystem service provision? How does variation in asset endowments and dynamics within households according to gender and age affect how more intensive use of tree and forest resources can help to build critical livelihood assets (*i.e.* human, social, natural, physical and financial capital)? How can access to and control over these assets by women and young people be improved?

This cluster develops and applies approaches, methods and tools aimed at identifying opportunities for change, trade-offs and negotiation among them (e.g. Polyscape[71], SHARED[81]). This includes specific attention to social inclusion with a focus on gender and young people and includes network analysis to understand potential for and track actual spread of innovations. We focus on household livelihood systems and how they interact with one another at local landscape scales, while recognizing that expanding livelihood options often requires action at larger scales encompassing markets and policies. We consider issues of local knowledge, labor availability, migration and rights as key factors, and provide a framework for modeling interactions in and among livelihood systems with a focus on what levels of adoption of innovations (or combinations of them) are required to deliver transformative outcomes[82]. We use anthropological techniques and sociological and economic survey approaches to analyze key issues such as land tenure, power relations in market access, the role of government in responding to and supporting smallholders and communities, collective action, community organization and governance. We partner with development organizations to enable systematic research on options across variations in context within large-scaling up domains (Figures 4 and 5 and Table C) together with state of the art satellite products in collaboration with the European Space Agency (ESA) to characterize context and track resilience indicators being developed and tested in conjunction with the GEF STAP (Section 2.2.1.4). Planned comparisons, involving trials with large sample sizes and crowdsourcing of data, using recent advances in information and communication technology, such as open data kit mobile apps, are combined with controlled trials and modeling to measure the performance of innovations across contexts and deliver results as usable tools co-developed with users (Section 2.2.1.4). This will contribute to smallholders getting increased access to diverse, nutrient-rich foods and livelihood opportunities, as well as to more productive and equitable management of natural resources (Sub-IDOs 5.2, 3.2 and 9.1).

CoA 2.2 Smallholder timber, food and fuel production and marketing

We hypothesize that smallholder income can be increased and made more equitable by better connecting smallholders to markets and facilitating the development of markets for key tree and forest products. Future timber supplies will increasingly come from farm-grown sources and farmers can benefit from this by improved management practices, silviculture, harvesting and marketing. Demand for charcoal from growing urban populations will increase and developing sustainable production is more viable than imposing controls that are rarely effective and if so, tend to displace the problem. Markets can be developed for a range of non-timber tree and forest products, including fruit that women can particularly benefit from.

Research questions: How can barriers be removed to smallholders accessing markets for tree and forest products, allowing them to capture more of their value, especially for people who are socially or economically marginalized (including women and young people)? What types of products and markets are most suitable and what interventions are most cost effective to realize these outcomes? How can smallholders profitably produce and market quality timber on a small scale? How do different approaches to forest management impact smallholder livelihoods at the forest margin?

Timber, fruit and other NTFPs grown on farms or cultivated in, or gathered from, forests by smallholders often have potential for value to be added locally (e.g. furniture making, drying fruit, or making jam and juice) and contribute substantially to many smallholders' incomes and food security. In this cluster, we focus on enhancing smallholder livelihoods by better production and marketing of these products on farms and investigate the impacts of different forms of forest management on livelihood outcomes[78]. We collaborate across FPs to deliver on integrated timber production (combined analysis of farm and forest supply) and design of community forestry interventions that combine livelihood and forest management outcomes. Often, land and tree tenure create barriers to people (often women) obtaining benefits from trees and associated products[83] and forest legislation often mitigates against farmers exploiting timber in managed fallows at forest margins or regenerating trees on farms, so we focus on policy analysis and engagement to remove these constraints. We are researching how smallholders can get improved access to lucrative and legal timber[84] and fruit markets through expanding sustainable harvest of a diversity of NTFPs, as well as ways to increase income from trees by incorporating quality germplasm (in collaboration with FP1) and appropriate tree management in farming and smallholder forest systems[85]. A major thrust of research surrounds the social aggregation of smallholders in various institutions and the associated private-sector engagement that can improve market opportunities by smallholders accessing financing and inputs to intensify their livelihoods, and through more lucrative arrangements for selling products. We experiment with alternative ways of catalyzing value-chain innovation platforms that can achieve these outcomes. This research contributes to increasing livelihood opportunities and more productive and equitable management of natural resources (Sub-IDOs 3.2 and 9.1).

CoA 2.3 Developing and sustaining smallholder tree-crop commodity production

The overarching hypotheses are (i) that appropriate incorporation and management of companion trees in cocoa and coffee production systems, alongside appropriate fertilizer and pest control, can increase and sustain productivity of existing stands and buffer against climate change; (ii) that rubber and oil palm production systems can be made more sustainable through intercropping; and (iii) that smallholders can derive higher income from product sales through improved certification schemes and by exploiting specialist market niches.

Research questions: How can smallholder tree-crop commodity production systems be sustainably managed in the face of climate change, price volatility, declining yield and soil fertility following forest conversion, coupled with constraints on opening new forest areas, and those imposed by the dynamics of migration? What is required in terms of an enabling environment to switch from unsustainable monocultures to more diverse and resilient production practices?

Tree crops produce important globally traded commodities including cocoa, coffee, rubber and oil palm and smallholders are involved in the production of these commodities. Cocoa and coffee alone are the mainstay of over 20 million smallholder households globally. There is a hotly contested debate around the need to intensify production and how to do this without aggravating environmental and social costs, around which a plethora of certification schemes have emerged. In Phase 1, we established the importance of trees in sustaining soil fertility and yield in cocoa as well as in providing diversification options and contributing to the food security of smallholder farmers[86]. Pests and diseases affect yield and are influenced by climate and tree shade – with important opportunities for trees to buffer climate change and contribute to the control of pest and disease spread[87]. Yield gaps for coffee vary at the fine scale in relation to soil conditions and farmer practices, with trees having the potential to buffer anticipated climate change effects[88]. The farming of cocoa and oil palm are competing land uses at forest frontiers, making diversified production systems attractive to policy-makers reconciling production and environmental goals. We have major engagements to develop national schemes for diversified cocoa in Peru and oil palm in Brazil to address these needs. There is a huge area of recently planted rubber, particularly in China. We are looking at developing 'green rubber' production practices that are environmentally benign and sustainable. This research contributes to increasing livelihood opportunities through diversification of monocultures and closure of yield gaps by sustainable intensification focused on agronomic management, including planting materials, pruning and fertilization (Sub-IDOs 3.2 and 9.2).

CoA 2.4 Trees supporting sustainable agroecological intensification

The overarching hypothesis is that the establishment and better management of tree cover in crop fields and farmsteads can increase and sustain soil health and crop yields while contributing to system intensification through provision of fodder and fuelwood on farms.

Research questions: What are the optimum levels of tree density and diversity in different contexts required to increase total productivity of smallholder livelihood systems while conferring resilience at farm and landscape scales? We also need to understand how to effectively promote the desired density and diversity, given a widespread history of removing trees from agricultural land, conflicts between grazing animals and tree regeneration and promoting of a few, largely exotic tree species on farms and in woodlots, rather than more diverse options. What is the relationship between tree cover (density and diversity) and soil health and where are there trade-offs and synergies between production goals and the provision of other ecosystem services?

Trees are an important cornerstone of system intensification in many contexts; they improve and sustain soil fertility by tightening nutrient and water cycling[23], fix nitrogen, control erosion and sustain soil biota[12]. By providing fuelwood and fodder on farms, they free up labor for other tasks and may substitute for other resources, such as fuelwood instead of dung being burnt, which can then be returned to the soil. In Phase 1, we established that farmers typically retain a range of trees on their farmland for different purposes with characteristic profiles of tree use and management, and that farmers have detailed knowledge about tree attributes for a diversity of species that determine their utility for intensification[89],[90]. We also established fine-scale variation in the performance of fertilizer trees in relation to landscape position, species, altitude, soil properties, rainfall and agronomic practice[34]. Advances in genomics[67] are allowing us, for the first time, to connect functional profiles of the living soil to different tree species, densities and management. We are now combining high-end science with local knowledge to develop and test species-diverse tree management options to intensify livelihood systems and increase their resilience. We are researching governance options to address tree ownership and control the free grazing of cattle, which often prevents farmers from managing naturally regenerating trees on their land. This research contributes to smallholders getting increased access to diverse, nutrient-rich food, closing yield gaps as trees improve and maintain soil health, and directly contributing to production, reducing and reversing land degradation, and increasing the resilience of smallholder livelihoods (Sub-IDOs 5.2, 8.1 and 3.1).

CoA 2.5 Sustaining silvopastoral systems for production, animal welfare and the environment

The overarching hypothesis is that establishment and better management of tree cover on pastures can contribute simultaneously to higher livestock productivity, animal welfare and biodiversity conservation as well as restoring degraded rangelands and avoiding future degradation.

Research questions: What is the relationship between tree cover (density and diversity) and pasture and animal productivity and welfare in silvo-pastoral systems? Where are there trade-offs and synergies between production goals and the provision of other ecosystem services?

FAO[91] estimates that grasslands are by far the largest agricultural use of land (26% of all land globally and >70% of agricultural land) and contribute to the livelihoods of 800 million people. Trees in pastures are ubiquitous in the Sahel and much of Latin America and provide fodder and shade for animals as well as sustaining soil fertility and contributing to biodiversity conservation. It is increasingly realized that while retaining trees on pastures can halt and reverse degradation following deforestation, appropriate species and densities are required to do this profitably and productively. In Phase 1, we established not only the importance of tree cover on pastures for production and biodiversity conservation, but also the sustainability problems that can arise for tree regeneration unless measures are taken to retain sufficient refuges at landscape scales for farm-level regeneration to be possible[92]. As climate change advances, deepening and lengthening dry spells in the seasonally dry tropics, trees and shrubs are increasingly seen as a supplementary fodder source[93]. Loss of production due to heat stress in farm animals has been estimated at over USD 40 billion per year from extrapolation of estimates from the US diary industry[28] and presents a

major animal welfare challenge. We are researching how best to develop multi-strata silvopastoral systems, live fences, windbreaks and fodder banks as key development options to sustain smallholder livelihoods based on pasture use. This research decreases yield gaps through improved pasture management and animal husbandry, and contributes to reducing and reversing land degradation (Sub-IDO 8.1).

2.2.1.7 Partnerships

Partnership strategy: the flagship has three main types of partnership those with donors, those with upstream research providers and those with the users of our research outputs (the organizations that implement development, including national systems and nongovernmental organizations). Partnerships with the private sector cut across these types as they may involve funding, collaboration in cutting-edge science and the use of research outputs. By engaging with development partners, the private sector and policy-makers from the outset of our research we ensure that our outputs address important issues in a form already suitable for uptake and thereby maximize the likelihood of generating outcomes and impact. The RinD strategy relies upon effective partner engagement and we manage risks associated with this through six mitigation measures (Table D).

Table D. Partnership risks in the context of research in development (RinD) and their mitigation.

Risk	Mitigation measures
Sub-optimal functioning of innovation platforms	Ongoing communication with and monitoring of, innovation platforms to identify potential problems before they emerge and to avoid them developing in the future
Key partnerships fail	Operating with a diversity of partners and partnership models (thereby "avoiding having all our eggs in one basket") and creating space for learning which forms of partnership work best
	Focusing on the quality of partnerships that we establish in terms of their reciprocity, efficiency and effectiveness
Perceptions of benefit derived from partnership not mutually appreciated	Selecting some quick-win routes to impact at the outset, so that early successes, as achieved in Phase 1 piloting, will sustain the partnerships that are established
Expectations amongst partners differing creating implementation challenges	Persisting and continuing to innovate where challenges in establishing and sustaining partnerships arise, learning from experience and trying new approaches where necessary, linking innovation in partnerships with development organizations and the private sector, to policy processes and publicity, creating incentives around success

Upstream partners deliver understanding and expertise that underpin the development of new options. These include: Simulistics[94] (a software development SME) co-developing a proprietary modeling environment comprising a series of plug and play sub-models of key livelihood components and their interactions, that can adapted and parameterized for specific contexts; CSIRO collaborating to incorporate trees within their APSIM suite of globally calibrated crop models; Bangor University of Wales, UK researching genomics to understand the functional profiles of soil biota; local knowledge and participatory GIS; and a range of other advanced research institutes (SLU, Sweden; Cornell, Columbia, Colarado and Montana in the USA; and, University of Adelaide, Australia). We have ongoing collaboration with African universities including JKUAT in Kenya (joint long-term research site with many registered postgraduate students), Makerere University in Uganda and the universities of Mekele and Hawassa and Wondo Genet College of Forestry in Ethiopia. We engage with the private sector at a large scale (Mars Inc. on cocoa in Côte d'Ivoire; Natura on oil palm diversification in Brazil) and with national SMEs that co-develop novel products such as nonperishable forms of *Docynia indica* in Vietnam[95]. IFAD, WWF, WorldVision, Vi-Agroforestry, One Acre Fund, CARE and SahelEco are examples of partners for delivery at scale. The Ministries of Environment and

of Agriculture in Peru and EMBRAPA in Brazil are engaged with us in developing option-by-context matrices for cocoa and oil palm, respectively. We have high level policy platforms for national agroforestry policy with the governments of Ethiopia, Uganda and Rwanda (Table D). Local governments of three provinces in northwest Vietnam are co-investing in scaling-up the effectiveness of introducing trees on sloping land and we are engaged with three county governments in Kenya (Machakos, Makueni and Kitui) in developing innovation platforms around sustainable intensification.

Comparative advantage. Institutions tend to separate agriculture and forestry, so that new approaches are necessary to address the farm–forest interface. CGIAR is in a unique position to broker this engagement, both because it brings about novel methods, tools and approaches, and because it demands profound change in the way that national and regional bodies do business. FTA can influence these issues because it has garnered a unique combination of partners, from upstream research to development practitioners, covering a broad range of disciplines. They work together across a carefully selected geographical range, that typifies the challenges that are faced globally. Furthermore, this flagship collaborates with a number of CRPs that bring an additional specialist dimension, such as CCAFS and RTB on developing tree-crop commodity production systems (CoA3), with maize, rice, wheat, and WLE in addressing sustainable intensification (CoA 4) and with Livestock in silvopastoral systems (CoA 5).

2.2.1.8 Climate change

Enhancing smallholder livelihoods requires explicit consideration of global change, with climate change as one of several key drivers that affect longer-term productivity and resilience. Climate change is more important for some of the production systems we are working on than for others. For example, some tree-crop commodities such as coffee are particularly sensitive to climate change and we work collaboratively with CCAFS on integrating climate change predictions about areas likely to be suitable for growing coffee in the future, into our intervention options, as well as the potential for using shade trees to buffer these effects. Similarly, climate change is likely to have larger implications for smallholder forestry and agroforestry in some geographies more than in others, with some of the most severe issues relating to combined rainfall and temperature effects in already dry and highly variable climate zones within which population is increasing at an alarming rate (e.g. some parts of the Sahel). Since trees are generally long-lived, we factor climate change into the development of options more generally, collaborating with FP1 on appropriate germplasm for climate proofing in different contexts and with FP5 on mitigation and adaptation options. From a livelihoods perspective, while mitigation initiatives present opportunities to enhance income, they often have differential effects across social groups. Thus, we focus on developing carbon finance initiatives that are positive rather than negative in terms of equity, vulnerability and empowerment of marginalized groups such as women and ethnic groups that are constrained in their access to land.

2.2.1.9 Gender

Gender-focused research comprises over 20% of our research portfolio. This is driven both from the need to achieve greater gender equity as a goal in its own right and from the hypothesis that natural resource management (NRM) that is more inclusive of women will be more effective. We do a gender audit across each research cluster, each year and interact with gender specialists to explore the extent to which we are asking relevant and sufficient gender research questions and are using appropriate and comparative methods and tools. The emphasis of our gender research is shifting from understanding gender differences to exploring the means of achieving more equitable NRM and reduced labor requirements for women (gender-transformative outcomes). In Phase 1, we found that a numerical representation of women in NRM institutions did not necessarily confer better NRM outcomes for issues important to women who were shaping the decisions[96]. In Phase II, we will address substantive representation in institutions and broader research on gender to encompass the changes in the enabling environment required to achieve gender equity.

2.2.1.10 Capacity development

The co-learning paradigm (Figure 5) embedded within our ToC (Figure 4) and key impact pathways (Figure 4) places capacity development center stage, requiring a profound shift in the way research, development and private-sector organizations operate. Specifically, we recognize the transaction cost involved in getting a critical mass of people within partner organizations to a level of awareness, understanding and with an appropriate skill set for 'research in development' to become self-sustaining. We are confident that this is possible because of early successes in Phase 1, through which initial engagements were sustained because of positive feedback resulting from adopting new approaches[97]. In Phase II, we will ramp up this co-learning by careful assessment of capacity needs followed by addressing the capacity development needs that are identified (CapDev Element 1). This will result in improving the innovation capacity of research (D.1.3) and development (D.1.4) organizations/or partners, and the private sector. The adopted co-learning paradigm moves away from a top-down approach to knowledge transfer in favor of co-production – and hence ownership – of new knowledge and experience. We explicitly deliver learning materials and delivery approaches (Element 2) and by strengthening communities of practice (that include innovation platforms), we contribute to Element 10. We partner with a number of universities and have built in PhD and MSc studentships as a key element of the FP (Element 4).

2.2.1.11 Intellectual asset and open access management

Intellectual assets (IA) produced under FTA are in compliance with the CGIAR principles on the management of intellectual assets (CGIAR IA principles) and CIFOR IA management policy for effective dissemination of research outputs and maximizing global impact. The following CGIAR IA principles shall be adopted as guidance on IA management of FTA:

- FTA research results and development activities are regarded as international public goods for the maximum possible access.
- Partnerships are critical to ensuring access to the best knowledge and innovation to achieve maximum impact.
- There will be sound management of intellectual assets (IA) and intellectual property rights (IPR) with integrity, fairness, equity, responsibility and accountability.
- All IAs produced under FTA are managed in ways that maximize global accessibility.

In line with the CGIAR open access and data management policy and CIFOR OA policy, FTA outputs will be made available under the least restrictive licensing to describe the legal rights to information products and encourage their use and adaptation. It will be published in a format that can be downloaded, indexed and searched by commonly used web applications. The outputs will be disseminated through open access repositories to ensure it is archived and shared systematically with other Centers and made accessible as IPG.

A specific narrative on FTA IA management and open access implementation is available in Section 1.0.12 and 1.0.13 of the Full FTA Proposal, including a detailed strategy for IA management in Annex 3.10 and OA/OD implementation in Annex 3.9.

2.2.1.12 FP management

The FP involves scientists from multiple disciplines and institutions. Social scientists (macro and micro economists, market specialists, rural advisory service specialists, anthropologists, impact evaluation and policy and institutional researchers) constitute roughly a third of staff effort in the flagship (Table E), about a third are interdisciplinary systems or agroforestry scientists, and the remaining third are primarily biophysical, agronomic or ecological scientists.

The FP is led by Fergus Sinclair, Leader of Systems Science at ICRAF who has held the flagship leader position through the first phase. He will head up a management team comprising the cluster leaders and representatives of key partners INBAR, Tropenbos and FAO, liaising electronically (also using a Yammer group and via quarterly virtual meetings.

Cluster leaders have been nominated from across the partners within FTA and will be financially supported to organize research within their cluster across partners within FTA as well as, where appropriate, with other CRPs.

Patricia Masikati, a very practical, outcome-orientated system modeler at ICRAF will coordinate upstream inputs from CSIRO at field and from Simulistics at farm and livelihood scales in CoA1 and will work with Tim Pagella on leading evaluation of ecosystem service trade-offs and synergies at local landscape scales. She will also interact with ICRAF's modeling team in Bogor, Indonesia (Betha Lusiana and Adrian Dwiputra) to develop in-house capacity to adapt and develop APSIM sub-models.

The FP leadership is organized as follows:

1. Systems analysis, synthesis and scaling. Tim Pagella (specialist in stakeholder engagement and ecosystems services), Bangor University.
2. Timber, food and fuel production and marketing. Peter Cronkleton (anthropologist), CIFOR
3. Tree-crop commodities. Philippe Vaast (coffee and cocoa agronomist), CIRAD
4. Sustainable intensification. Catherine Muthuri, (ecophysiologist), ICRAF
5. Silvopastoral systems. Francisco Alpizar (economist), CATIE.
6. FAO representative. Edmundo Barrios (soil scientist), FAO
7. INBAR representative. Jayaraman Durai (Manager, South-South Bamboo and Livelihoods Development Project)
8. Tropenbos representative. Rene Boot (Director of Tropenbos)

Table E. Key scientists, involvement in CoAs and primary expertise

Scientist, Centre	CoA 2.1	CoA 2.2	CoA 2.3	CoA 2.4	CoA 2.5	Primary Expertise
Fergus Sinclair, ICRAF	x	x	x	x	x	Systems science
Tim Pagella, Bangor	x					Ecosystem services
Peter Cronkleton, CIFOR	x	x	x			Anthropology
Philippe Vaast, CIRAD			x			Tree-crop systems
Catherine Muthuri, ICRAF				x		Tree-crop interactions
Francisco Alpizar, CATIE						Economist
Edmundo Barrios, FAO	x			x		Soil ecology
Patricia Masikati, ICRAF	x			x	x	Simulation modelling
Leigh Winowieki, ICRAF					x	Soil scientist
Anne Larson, CIFOR	x	x				Policy and institutions
Karl Hughes, ICRAF	x			x		Impact evaluation
Ric Coe, ICRAF	x					Statistics / Research Methods
Ingrid Oborn, ICRAF / SLU	x					Crop science
Jason Donovan, ICRAF		x				Economist (markets)
Ann Terheggen, ICRAF	x	x				Economist (macro)
Steve Franzel, ICRAF					x	Economist, Rural Advisory Services
Rhett Harrison, ICRAF				x		Forest ecologist
Habtemariam Kassa, CIFOR		x				Rural Development
Aulia Perdana, ICRAF		x				Economist (Markets)
La Nguyen, ICRAF	x	x		x		Soil scientist / Agroforestry systems
Sarah-Lan Mathez, ICRAF						Ethnology
Olivier Deheuvels, CIRAD			x			Cocoa agronomy
Jean-Michel Harmand , CIRAD				x	x	Ecophysiology
Sonia Ospina, CATIE					x	Silvopastoral systems
Antoine Kalinganire, ICRAF					x	Tree scientist
Christophe Kouame			x			Cooca specialist
Jeremias Mowo, ICRAF				x	x	Agroforestry
Javed Rizvi, ICRAF		x		x		Agricultural scientist
Jim Roshetko , ICRAF			x	x		Smallholder agroforestry
Tor Vagen, ICRAF	x			x	x	GIS
Jules Bayala, ICRAF				x	x	Ecophysiology
Lucien Diby, ICRAF			x			Soil science
Ann Degrande, ICRAF			x			Economics
Anthony Kimaro, ICRAF				x		Agroforestry
Evelyne Kiptot, ICRAF	x	x				Adoption (Rural Advisory Services)
Madelon Lohbeck, ICRAF	x			x	x	Functional traits
Augustin Mercado, ICRAF				x		Agroforestry
Peter Mortimer, ICRAF				x		Agroecology
Judith Odoul, ICRAF		x				Markets
Clement Okia, ICRAF				x		Agroforestry
Valentina Robiglio, ICRAF	x		x			Forest policy
Patrice Savadogo, ICRAF				x	x	Agroforestry
Emily Smith, ICRAF	x		x	x		Agroforestry
Ana-Maria Paez-Valencia,	x	x	x	x	x	Gender Specialist

2.2.2 Flagship Budget Narrative

2.2.2.1 General information

CRP name	Forest, Trees and Agroforestry agri-food systems Program (FTA)
CRP Lead Center	CIFOR
Flagship name	Livelihood Systems Flagship
Center location of Flagship leader	ICRAF

2.2.2.2 Summary

Total Flagship budget summary by sources of funding (USD)

Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	14,852,075	15,537,152	15,884,811	16,336,512	16,484,382	17,115,953	96,210,887
Other Sources							0
	16,698,875	17,476,292	17,920,908	18,474,413	18,729,178	19,472,989	108,772,655

Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Assumed Secured)	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	11,393,000	5,727,631	439,783				17,560,414
Other Sources							0
	13,239,800	7,666,771	2,475,880	2,137,901	2,244,796	2,357,036	30,122,184

Funding Gap	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Required from SO)	0	0	0	0	0	0	0
W3 (Required from FC Members)	0	0	0	0	0	0	0
Bilateral (Fundraising)	-3,459,076	-9,809,522	-15,445,028	-16,336,512	-16,484,383	-17,115,953	-78,650,473
Other Sources (Fundraising)	0	0	0	0	0	0	0
	-3,459,076	-9,809,522	-15,445,028	-16,336,512	-16,484,383	-17,115,953	-78,650,473

Total Flagship budget by Natural Classifications (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
Personnel	6,948,471	7,237,095	7,598,950	7,978,897	8,223,931	8,635,127	46,622,474
Travel	720,865	645,000	645,000	645,000	637,500	637,500	3,930,865
Capital Equipment	17,737	100,000	0	100,000	0	100,000	317,737
Other Supplies and Services	6,239,759	6,528,640	6,653,408	6,654,770	6,914,811	7,050,407	40,041,797
CGIAR collaborations	0	0	0	0	0	0	0
Non CGIAR Collaborations	593,928	686,040	686,040	686,040	510,000	510,000	3,672,048
Indirect Cost	2,178,114	2,279,516	2,337,509	2,409,706	2,442,936	2,539,955	14,187,738
	16,698,874	17,476,291	17,920,907	18,474,413	18,729,178	19,472,989	108,772,652

Total Flagship budget by participating partners (signed PPAs) (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
CIFOR	5,009,388	5,090,808	5,176,299	5,266,065	5,360,319	5,459,285	31,362,166
ICRAF	9,734,161	10,235,777	10,683,694	11,229,564	11,723,804	12,318,161	65,925,162
INBAR	320,999	183,655	192,838	202,480	212,605	223,234	1,335,814
CIRAD	553,342	541,842	692,885	572,784	589,425	606,898	3,557,177
CATIE	779,984	1,007,914	749,060	767,064	785,968	805,817	4,895,809
TROPENBOS	301,000	416,294	426,129	436,454	57,058	59,592	1,696,529
	16,698,874	17,476,290	17,920,905	18,474,411	18,729,178	19,472,987	108,772,645

[Note: For an explanation of these costs in relation to the planned 2020 outcomes, please refer to the FP narrative, especially PIM tables B and C.]

NOTE: Support Platform: Given the absence of a specific location to upload the costs/budgets of the various cross-cutting components (CCT) of the supporting platform (gender, youth, capacity development, MELIA, communication/outreach, site integration, partnerships, OA/OD) we have allocated these amounts across the five Flagships within the supply and services class (but they will be managed in practice by the relevant CCT component leads). The amounts added per FP for the SP (2017) are USD 1,271,000, of which USD 346,000 is for W1/W2.

Use of W1/W2: W1/W2 are used strategically to leverage bilateral funding likely as basket funds, in such a way that different sources of bilateral contribute to the same major goals, this in order to build a program that is consistent and that can deliver its expected objectives across the different six countries in which we are planning to do our work. W1/W2 funds are also used for global comparative analyses on major issues, to strengthen science quality, implement open access and to foster the probability of outcomes thanks to targeted communication and outreach.

2.2.2.3 Additional explanations for certain accounting categories

Benefits: In general, the following benefits are covered by the Centers: pension, health, AD&D insurance and allowances for housing, education and transport and they have all been rolled into the salary. It is difficult to standardize the benefits as they vary by Center and by type of staff i.e. internationally recruited versus national staff.

2.2.2.4 Other sources of funding for this project

We are confident of the bilateral estimates as these are conservative and follow consolidated trends in support for the areas of research proposed through long-term partnerships with key donors and the private

sector. The W1/W2 funding is important for managing the portfolio of bilaterally funded projects across Centers and other partners, pioneering novel approaches and synthesizing key outputs across projects and Centers. Our main risk mitigation strategy is by seeking plurality of funding sources for the main aspects of the work. We prioritize research amongst research clusters and within each research cluster, and specifically the use of W1/W2 funds to leverage and support bilaterally funded activity, so that there are clear courses of action in the event that funding falls below expectations.

2.2.2.5 Budgeted costs for certain key activities

	Estimate annual average cost (USD)	**Please describe main key activities for the applicable categories below, as described in the guidance for full proposal**
Gender	3,300,000	see FP and CRP narratives
Youth (only for those who have relevant set of activities in this area)	1,500,000	see FP and CRP narratives
Capacity development	1,600,000	see FP and CRP narratives
Impact assessment	0	Costs are indicated at the CRP level budget narrative as this is centralized within the Monitoring Evaluation Learning and Impact Assessment cross-cutting theme
Intellectual asset management	0	Costs are indicated at the CRP level budget narrative as these are costs managed at Centers' level
Open access and data management	0	Costs are indicated at the CRP level budget narrative as these are costs managed at Centers' level
Communication	1,600,000	see FP and CRP narratives

The above selected key activities are described in the proposal text and the PIM tables. They do not include the Support Platform (that is included in the CRP budget narrative)

A significant part of our research portfolio explicitly addresses gender – approximately 20% overall related to gender and 10% specifically targeting gender transformative outcomes leading to more equitable control of and benefits from natural resource management. We have a growing portfolio that focuses on young people, most notably novel research on value chain innovation platforms that constitutes approximately 6% of the total budget in 2017 and we anticipate this rising to 12% by 2022. As outlined in the proposal, the RinD approach that we adopt for a significant part of our portfolio involves key capacity development with partners and is specifically catered for in bilateral project funding at approximately 5% of total cost. Intellectual asset management together with open access and data management are important in this Flagship both because of discovery at one end of the spectrum (related to using genomics to elucidate soil function and modeling tree-crop interactions) and managing large, open access data sets, including spatial mapping of parameters and local knowledge bases (operated under principles of free prior and informed consent) – overall this amounts to approximately 9% of the total budget and is an integral part of the research conducted. The Flagship builds communication into bilaterally funded projects as well as communicating collectively on Flagship outputs, outcomes and impact accounting for 5% of the total budget.

2.2.2.6 Other

The livelihood systems research in this Flagship requires multi-disciplinary teams of researchers conducting trans-disciplinary research, involving scientists from multiple Centers operating over large scaling domains in concert with development partners, upstream partners and the private sector. We have well-developed connections to ensure cross-linkages with the other FPs in FTA, as well as both other Agrifood System CRPs with which trees interact (i.e. maize, rice, wheat, DCL, livestock) and global integrating CRPs (CCAFS and WLE).

2.2.3 Flagship Uplift Budget

Outcome description	Amount needed (USD)	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other (%)
Outcome 2U1. Increase in water use efficiency of agroecosystems over 5 million ha of Africa through establishment of intermediate tree cover in fields, farms and agricultural landscapes	15,000,000	30	0	70	0
Outcome 2U2. Increase in women's participation (numerically and substantively) in decision-making bodies for forest and agroforestry management in seven countries	9,000,000	30	0	70	0
Outcome 2U3. One million young people benefiting from income gained through the development of novel forest and agroforestry product value chains	9,000,000	30	0	70	0
Outcome 2U4. Twenty five million ha of avoided degradation in pastures with attendant livestock productivity increases, animal welfare gains and biodiversity conservation benefits	12,000,000	30	0	70	0

2.3. Flagship 3. Sustainable global value chains and investments for supporting forest conservation and equitable development

2.3.1 Flagship Project Narrative

2.3.1.1 Rationale and scope

The vision. Flagship project 3 (FP3) facilitates innovations in public policy, business models and private investments and finance to stimulate the sustainable supply of timber from natural and planted forests, enhance the sustainable production of high-value tree crops (oil palm, rubber, cocoa, coffee and coconut) and reduce the impacts of agricultural expansion (soybean and beef) in forests. It does this by supporting the uptake of more intensive and integrated agricultural production and forest management systems that comply with higher social and environmental standards, thus supporting forest conservation and improving the integration of smallholder and small and medium enterprises (SMEs).

The challenges. FP3 addresses key global challenges associated with the need to reduce deforestation, forest degradation and conversion of species-rich agricultural and forest landscapes while meeting a growing global demand for food, feed and fiber. This entails improved public and private arrangements to enhance the governance of global value chains to adhere to sustainability standards in order to reduce negative environmental impacts; it involves supporting more intensive and integrated management and production systems with a greater participation of smallholders and SMEs in the value chains, while also emphasizing women, youth and other marginalized groups.

Background. Commercial agriculture is driving significant deforestation, mainly associated with the expansion of oil palm[1], soybean and beef supply[2] for national and international markets[3]. Unsustainable logging in natural forest contributes to forest degradation[4] and often logged-over forest is replaced with agricultural cash crops or tree plantations. The latter often expand through monocropping systems, which lead to biodiversity loss and increased greenhouse gas (GHG) emissions[5]. Commercial pressures on land have accelerated due to a growing demand from emerging economies (e.g. China and India)[6]. In recent years, several public and private policy responses have emerged. Commodity-specific voluntary standard systems (VSS) were developed to promote more sustainable production[7]. Major corporate groups are also adopting commitments to 'zero deforestation'[8]. Some governments in consumer countries, notably the EU and United States, have introduced regulations to limit imports of timber and biofuels that do not comply with legal and sustainability standards[9]. A major development is the integration of environmental, social and governance (ESG) criteria by financial service providers (FSPs) into their financial products and services design[10]. The latter is, however, limited to international FSPs and has yet to fully permeate the financial sector in producer countries[11].

Problem statement. Public policy often has contradictory impacts in either reducing or fostering deforestation and degradation of forests and of species-rich landscapes[12]. VSS and self-regulatory commitments are gaining increasing traction among consumer goods companies, traders, industry and financial institutions, but their adoption rates are still low, their long-term effects are uncertain[13] and emerging economies still offer unrestricted market access. Some of the voluntary standards also threaten to weaken the position of smallholders and SMEs since they lack the capacity and resources to comply with more stringent sustainability requirements[14,15]. Moreover, voluntary standards typically lack gender sensitivity and inadequately address issues related to women workers[16,17]. Approaches linking VSS to regulatory frameworks and business models integrating smallholders and SMEs in fair partnerships could help to overcome these barriers. Yet the latter are often perceived as economically unviable and are associated with greater financing and investment risks[18]. In addition to the possible crowding out of smallholders and SMEs from value chains with more rigid standards, the zero deforestation initiatives aimed at protecting high-carbon stock lands are likely to increase pressures on what are considered degraded lands that are often controlled by smallholders[19].

Scientific rationale. Enhancing the sustainability and inclusiveness of global timber, tree-crop and agriculture value chains increasingly requires more complex governance arrangements involving governments, civil society and the private sector across both consumer and producer countries. An improved evidence base is needed on the complementarities between regulatory frameworks, system standards and corporate sector self-regulatory commitments that can reverse the conditions shaping inefficient, unsustainable and inequitable land use. In addition, better knowledge is needed on how to build business options and fair partnerships that create opportunities for these local actors increasingly involved in global value chains and promoting investments that safeguard the rights of marginalized groups such as women and indigenous people. Finally, better understanding is required on the potential of financial institutions and innovative financing mechanisms to support the adoption of sustainability practices while addressing the needs of investors and smallholders and SMEs.

Scope. FP3 assumes that complementary public and private institutional arrangements aligned with finance may trigger widespread adoption of sustainable practices and greater integration of smallholders and SMEs in the global value chains. FP3 will focus on three areas of work:

- public and private institutional arrangements that create an enabling environment for enhancing the sustainability of commodity supply
- business models that integrate smallholders to deliver positive impacts across social, economic and environmental dimensions
- responsible finance initiatives to bring appropriate business models to scale up and encourage corporate and smallholder uptake of improved sustainability practices.

2.3.1.2 Objectives and targets

Objectives. FP3 contributes to the co-development of knowledge on policies, governance arrangements, business models and finance options and innovations to enhance the sustainability and inclusiveness of timber, tree crops, agricultural production and value chains. FP3 will identify knowledge gaps, distill best practices, produce methods and tools, convene stakeholder meetings, engage in business and multi-stakeholder platforms and co-generate options of policies and practices to:

- improve the sustainability of production by identifying complementarities between public regulations, private commitments and VSS
- inform businesses and service providers about business models that are more inclusive, gender-responsive, economically viable and environmentally sustainable
- support ESG integration in FSP products and services to increase the flows of investments in forest and tree-crop sectors, including contributions to the development of alternative finance mechanisms, i.e. The Landscape Fund (TLF)[20] to support smallholders and SMEs.

Outcomes. By 2022, FP3 will achieve three main outcomes:

- Public and private actors will adopt more effective institutional arrangements and mechanisms for ensuring sustainable and inclusive supply of timber and select tree and agricultural crop commodities.
- Private-sector platforms, individual companies and corporate groups, smallholders' organizations and business and service providers will develop and implement business models that are more inclusive, gender-responsive, economically viable and environmentally sustainable.
- FSPs will integrate ESG criteria into their products and services design, which will contribute to expanding their lending to more sustainable land uses and the integration of smallholders and SMEs in the timber and tree-crop sectors with the support of TLF.

We will work with eight commodities in nine Tier 1 countries (in bold) and nine Tier 2 countries in Southeast Asia (**Indonesia,** Malaysia), Mekong (Cambodia, Laos and Vietnam), South America (Bolivia, **Brazil,** Colombia and **Peru**), Mesoamerica (**Guatemala,** Honduras and **Nicaragua**), Central Africa (**Cameroon** and **Democratic**

Republic of the Congo) and Eastern and Southern Africa (Kenya, **Mozambique**, **Tanzania** and Uganda). Seven of these countries overlap with the countries prioritized by the CGIAR for site integration. A subset of commodities will be selected in each region (Figure 1).

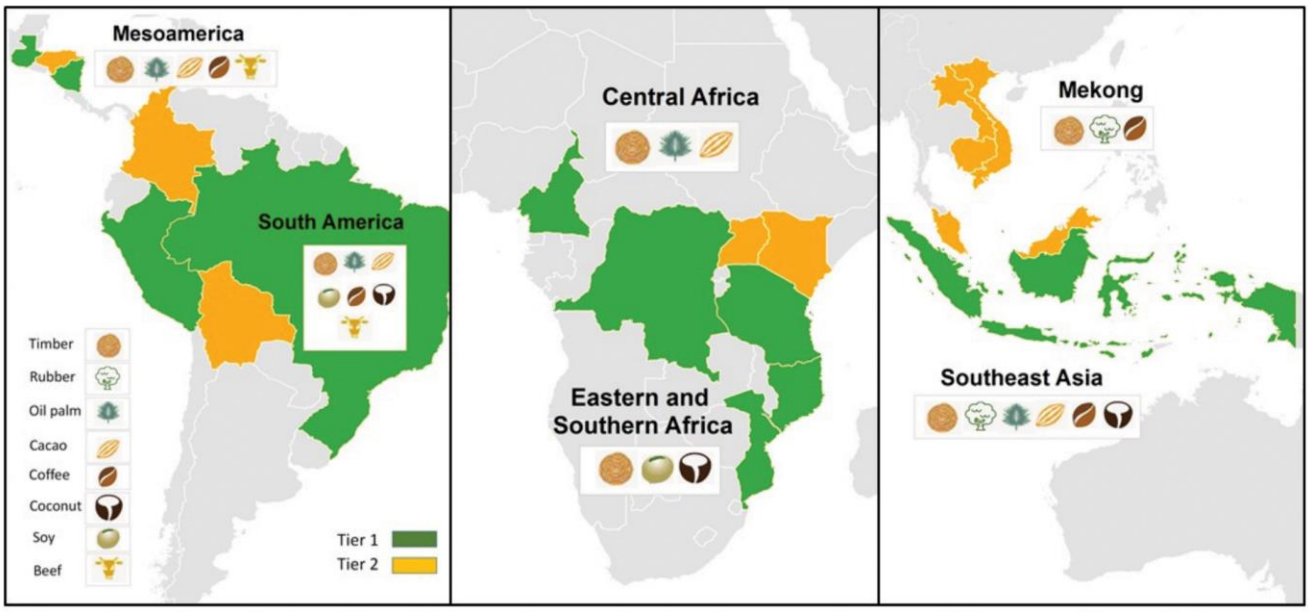


Figure 1. Selected countries and commodities by region.

Targets. By 2022, FP3 will have contributed to an additional 25 million ha of forests becoming subject to sustainable forest management practices, avoiding the deforestation of 2 million ha. In addition, FP3 will support adoption of improved management practices by 5 million smallholders, out of which 3 million will be assisted to exit poverty. This will be achieved by:

- promoting the development of integrated public-private arrangements in at least three major producer countries that directly increase the uptake of sustainability standards
- ensuring that at least 50% of tropical timber and tree crops is produced under internationally recognized sustainability standards or commitments in Tier 1 countries
- engaging with five business platforms and 20 businesses and service providers in five select global commodity value chains that leads to active promotion of inclusive business models
- creating an enabling environment so that at least 30% of the FSPs lending to timber, tree and select agricultural crops adopt ESG criteria and increase by 25% of associated lending to smallholders and SMEs in Tier 1 countries, drawing on lessons from TLF in three countries.

Strategic relevance. FP3 contributes to four sustainable development goals (SDGs): decent work and economic growth (SDG 8), reduced inequalities (SDG 10), responsible consumption and production (SDG 12) and life on land (SDG 15) and two CGIAR system level outcomes (SLOs): (i) reduced poverty and (ii) improved natural resource systems and ecosystem services. It contributes to five IDOs (bold) and seven sub-IDOs (italics):

- **Enhanced smallholder market access** (IDO 2) via *improved access to financial and other services* (sub-IDO 2.1) by supporting financial schemes adapted to the needs of smallholders and SMEs, including women and youth. In addition, *reduced market barriers* (sub-IDO 2.2.) by devising interventions that create market opportunities while complying with environmental standards.

- **Increased incomes and employment** (IDO 3) via *diversified enterprise opportunities* (sub-IDO 3.1) through developing inclusive business models and *increased value capture by producers* (sub-IDO 3.3) by creating shared value through corporate-smallholder partnerships. More efficient technical, business and financial services will be co-generated with public and private actors.
- **Natural capital enhanced and protected, especially from climate change** (IDO 8) via *land, water and forest degradation (including deforestation) minimized or reversed* (sub-IDO 8.1) by linking public regulations and voluntary standards systems that create conditions for improving natural forest management and avoiding deforestation, and upgrading smallholder production systems.
- **Equity and inclusion achieved** (IDO B, cross-cutting) via *gender-equitable control of productive assets and resources* (sub-IDO B.1) through addressing barriers to participation in and benefits from value chains for women and youth, improving gender-responsiveness of business models and promoting policies for increasing equitable access to and control over productive resources.
- **National partners and beneficiaries enabled** (IDO D, cross-cutting) via *increased capacity for innovation in partner development organizations and in poor and vulnerable communities* (sub-IDO D.4) through capacity development actions linked to the above sub-IDOs.

Tables 1 and 2 show the anticipated allocations of funds to the outcomes and to the CGIAR sub-IDOs.

Table 1. Outcomes by windows of funding.

Outcomes	Amount needed (in million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
3.1. Public and private actors adopt effective governance arrangements, mechanisms and tools for ensuring sustainable, inclusive, equitable commodity supply in at least three countries	30	25	0	75
3.2. Five business platforms and 20 businesses and service providers develop and implement business models that are more inclusive, gender-responsive, economically viable and environmentally sustainable	24	25	0	75
3.3. At least 30% of financial service providers lending to timber, tree and agricultural crops adopt ESG criteria and increase by 25% in the lending to models that integrate smallholders and SMEs	21	25	0	75
Total	75	25%	0%	75%

Table 2. Investments by sub-IDOs.

Sub-IDOs	Amount needed (in million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
2.1 Improved access to financial and other services	14	25	0	75
2.2 Reduced market barriers	8	25	0	75
3.1 Diversified enterprise opportunities	9	25	0	75
3.3 Increased value capture by producers	12	25	0	75
8.1 Land, water and forest degradation (including deforestation) minimized or reversed	18	25	0	75
B.1 Gender-equitable control of productive assets and resource	4	25	0	75
D.4 Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	9	25	0	75

2.3.1.3 Impact pathway and theory of change

FP3 embraces ambitious targets based on the assumption that much of the desired change needed to achieve our expected targets will be driven by new knowledge, as well as improved alignment between public and private actors' views and interests. We, however, do not ignore the existence of strong, entrenched interests and incentives supporting non-inclusive and unsustainable business practices in the commodity chains that have to be reversed. FP3 builds on processes and initiatives that the research team is already involved in in order to capitalize on existing social capital and leverage. Moreover, by specifically targeting influential stakeholders within our network that are strategically placed to champion our research, we aim to maximize multiplier effects across diverse political and economic systems and regulatory scales. We expect to achieve these outcomes through three mutually reinforcing pathways involving the joint generation of knowledge products and through targeted engagement and capacity development actions with key select actors (Figure 2).

Pathway 1: Informing political decision-makers and policy dialogues on improved policy options. We will engage governments and intergovernmental platforms to enable more informed policy decision-making processes. At the **subnational level**, we will keep supporting debates on ways to improve sustainable timber, palm oil and soybean/beef production based on territorial approaches that exploit complementarities with supply chain interventions. At the **national level**, we will support decision-making processes building on well-established relationships with **key government actors**, including the Ministries of Forestry, Environment, Agriculture and Commerce and key State agencies in Tier 1 countries (e.g. Indonesia, Brazil, Peru, Cameroon, Democratic Republic of the Congo and Tanzania) and promoting private actors and smallholders' organizations to have a voice in the debates. At the **global level**, we will engage and inform **intergovernmental commodity-specific platforms**, prioritizing those with whom the research team has an established rapport such as the Alliance of Cocoa Producing Countries (COPAL), the Council of Palm Oil Producing Countries (CPOPC) and the International Coconut Genetic Resources Network (COGENT). We will recommend approaches and policy instruments to be included in strategic government planning linked with civil society and smallholders' organizations. Based on our acquired knowledge, we will disseminate policy recommendations targeted at influential stakeholders through participation in international events (e.g.

Global Landscapes Forum) and targeted communication. We will make sure that our recommendations align with those generated by FTA FP2 and FP4.

Pathway 2: Engaging multi-stakeholder processes to improve implementation of standards. FP3 has a strong track record of effective participation in global and national multi-stakeholder processes, where our scientists are seen as credible sources of information. We have actively contributed to improving timber **certification standards** with the Forest Stewardship Council (FSC). FP3 will continue to actively participate in **commodity-specific round tables**, such as the Roundtable of Sustainable Palm Oil (RSPO), the Global Roundtable for Sustainable Beef (GRSB), the association of sustainability standards (ISEAL Alliance), the Sustainable Agriculture Network (SAN) and other less formalized platforms (e.g. The Forests Dialogue). At the national level, we will continue our engagement with **multi-stakeholder initiatives**, such as the Indonesian Sustainable Palm Oil System (ISPO), the Sustainable Cocoa Production Program in Indonesia (SCPP) and the Brazilian Roundtable on Sustainable Livestock (GTPS). Our analysis on the governance approaches and instruments for enhancing sustainability will inform the actions of **international NGOs** that we have existing collaborative agreements with, such as The Nature Conservancy (TNC), World Wide Fund for Nature (WWF-International), The Rainforest Alliance and Oxfam, as well as **national civil society organizations** and key producer and smallholders' associations, including women's organizations. In addition, we will collaborate with the Netherlands Development Organisation (SNV) to disseminate and apply innovative new approaches to sustainable commodity supply, inclusive value chain development and equitable partnerships.

Pathway 3: Supporting private sector initiatives and commitments to sustainability to improve practices. FP3 scientists collaborate closely with **private sector sustainability initiatives**, such as the World Cocoa Foundation, the Indonesian Business Council for Sustainable Development (IBCSD), the Brazilian Beef Exporters Association (ABIEC) and timber producers and trader's organizations in the Congo Basin and South America. FP3 will contribute to private actors' efforts to sustainability by monitoring and evaluating the progress and by informing on practices that enable these actors to deliver on their commitments. This will include drawing on research conducted under FTA FP1 and FP2 in order to ensure private sector uptake of more sustainable production practices, which includes higher quality planting materials and more efficient production systems. Recommendations on scaling options will be shared with **business sustainability platforms**, particularly through the Tropical Forest Alliance (TFA2020). In addition, we will monitor progress and disseminate innovations through the Global Landscapes Forum: The Investment Case, an annual forum organized by CIFOR with key partners in the finance sector. Practical lessons learned through the s' initiative will also be harnessed and shared across other sustainable landscape funds (e.g. Eco-business, Althelia Ecosphere). **Large financial institutions** with active lending and investment portfolios in agriculture and forestry will be targeted through existing knowledge-sharing partners such as the UNEP Finance Initiative (UNEP-FI) and Profundo, as well as key **financial platforms** such as Finance Alliance for Sustainable Trade (FAST) and the Global Alliance for Climate-Smart Agriculture (GACSA).

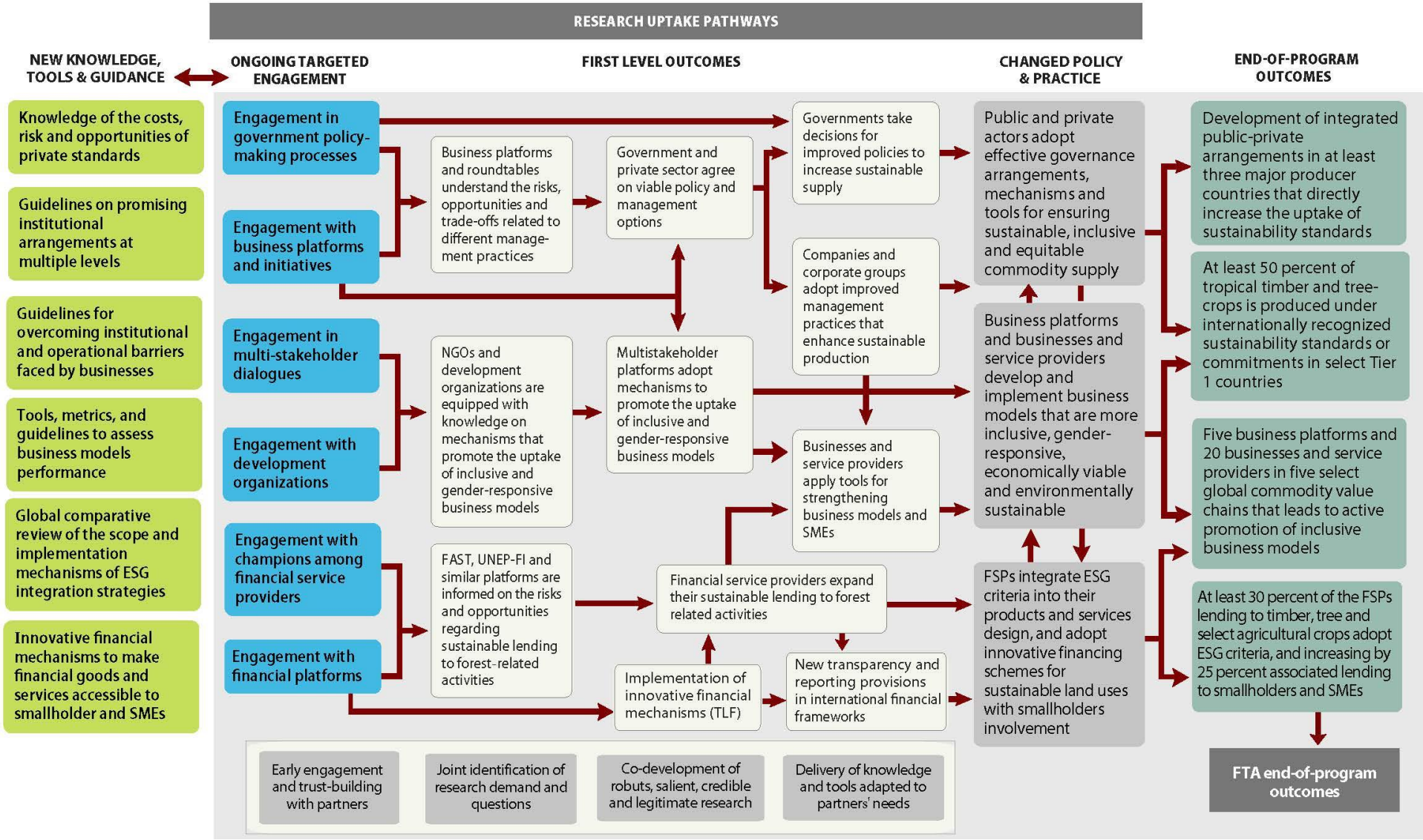


Figure 2. FP3 theory of change and impact pathways.

2.3.1.4 Science quality

State of evidence. Significant knowledge exists on the limited effectiveness of public policy to address environmental impacts from land-based investments that tend to be linked to incentive misalignments, implementation failures and weak enforcement[21]. Similarly, the influence of social, political and economic factors on agent behavior, institutional systems and governance arrangements has been aptly explored[22]. Research has also shown that VSS are increasingly filling the public policy gap[23] and has highlighted how VSS can incentivize behavioral change[24]. Major knowledge gaps still exist on the direct and indirect social and environmental impacts of different types of governance arrangements and the potential synergies within and between different types of VSS and public regulations at various scales[25]. These impacts are greater in the forest and mosaic landscapes.

A body of literature has emerged that examines the welfare impacts and participation determinants of business models that integrate smallholders in value chains for high-value agricultural products, especially contract farming and cooperative schemes[26]. Building viable business models that include women and men, a diversity of smallholder and family farmers and rural SMEs requires strong coordination across a range of stakeholders, learning and adaptation over time and innovative interventions across scales[27,28]. However, critical questions remain unanswered about the challenges and risks associated with enhancing the participation of resource-poor smallholders in value chains linked to high potential markets and their differentiated impacts across gender[29,30]. Similarly, research is needed on the scalability options of different types of inclusive development interventions.

FSPs have, in recent decades, increasingly been implicated in providing products and services to unsustainable forestry and land uses. While some international FSPs have begun to integrate ESG criteria into their financing decisions, there is a lack of knowledge on how best ESG integration can translate into the adoption of sustainability practices[31]. Important questions remain about how to scale FSP adherence to ESG principles and how to enable FSPs to more effectively leverage their capacity to influence corporate policy and practice. ESG integration implications for smallholders and SMEs and the impacts from emerging innovative financing mechanisms[32] need to be explored.

Novelty of science and methods. FP3 proposes the use of novel, multi-disciplinary approaches to analyze the drivers and adoption determinants of sustainability standards that link policy and social network analysis, political economy approaches, producer and consumer behavioral studies, and global value chain analysis. Some of these approaches have already been used in our previous research[33,34]. We will assess the implications of governance arrangements and adoption of production and management practices and business models through surveys with value chain stakeholders. We will link political economy analysis on the interactions between public and private policies and sustainability initiatives in specific subnational jurisdictions with more macro-oriented and spatially explicit modeling exercises at national and regional levels (e.g. GLOBIOM)[35], to understand the (potential) impacts of VSS in their interaction with regulations on land-use change, yields gaps and socioeconomic impacts. To inform these modeling exercises, we will make use of global production to consumption systems (PCS) analysis tools that have already been developed by our partners to better understand the leverage points for public and private policy intervention[36].

The work on business models will involve a systematic analysis of the social, economic and environmental performance of different models across diverse geographic, economic and institutional contexts. We will use a range of complementary methods that include (intra-) household surveys, participatory action research, economic valuations, remote sensing analysis and farm-level field assessments, relying, where possible, on primary longitudinal data. We will use this data to develop different types of statistical and (participatory) scenario models to identify the magnitude and nature of social, economic and environmental outcomes and critical success factors. This knowledge will be complemented by political economy and gender analyses, assessments of the effectiveness of relevant past interventions and social and policy network analysis to more effectively translate the findings into actionable policies and targeted interventions that produce greater impacts at scale.

In addition, FP3 will identify mechanisms that encourage or impede more meaningful integration of ESG into FSP product and service design and how they promote the adoption of more inclusive business models and practices. This will be linked to TLF action research. We will also conduct analysis of viable mechanisms through which FSPs can most effectively exert influence over corporate policy and practice, as well as innovative financial schemes that can reach smallholders and SMEs. Both analyses will use comprehensive metrics systems that will be developed in conjunction with FSPs and other relevant private and public actors. Specialized financial data portals developed by Bloomberg and Thomson will also be used to test empirically how the financial structures and financing sources of different types of corporate actors have changed over time in response to emerging differentiation within the financial sector around ESG integration. We will also conduct analysis of the performance of new finance instruments (e.g. impact investing, fossil fuel divestitures, green bonds) to complement the work on ESG integration and the opportunities arising from investments in support of smallholder sustainable land use through TLF and other schemes.

Research team niche and qualifications. The main knowledge gaps that FP3 aims to fill in order to advance theories and build new ideas and analytical approaches are summarized in Table 3.

Table 3. Topics where knowledge gaps exist that constitute FP3 main research niche

Knowledge gaps	Using current approaches	New ideas, extending theory
. Direct and indirect social and environmental impacts associated with different policy interventions for enhancing the sustainability of commodity supply	. Sustainable livelihood approaches (SLA) . Sustainable production to consumption systems (PCS)	. Spatial and temporal interactions among direct and indirect impacts from disparate public and private policy interventions across multiple scales
. Complementarities and conflicts within and between different types of voluntary standard systems (VSS) and public regulations across scales	. Governance of Global Value Chains (GVCs) . Multi-level and polycentric governance frameworks	. Effective public-private 'hybrid' governance approaches for sustainable supply at multiple levels adopting value chains and territorial perspectives
. Challenges and risks, benefits and costs associated with smallholders' integration into value chains with greater adoption of social and environmental standards	. Inclusive green growth (IGG) frameworks . Upgrading in global value chains (GVCs) . New institution economics (NIE)	. Explaining how different types of business models, contractual, institutional and production arrangements shape outcomes and potential for replication
. Effectiveness of financial services providers (FSPs) to influence corporate policy and practice with positive impacts for smallholders and the natural resources base	. Financial risk modeling . Capital structure analysis . Precedent transaction analysis	. Understanding the role of finance innovations in shaping finance actors' and smallholders' behaviors with regard to natural resources use and management

FP3's core team comprises an interdisciplinary group of scientists with ample expertise to address knowledge gaps and build on new ideas (Table 4). FP3 team comprises social scientists, ecologists, foresters, agricultural economists and geographers. Some members have prior expertise in assessing policies and governance arrangements[37,38,39], and direct and indirect social and environmental impacts of investments[40,41,42]. Collaboration with FP4 scientists will help in identifying how such arrangements could be more effectively embedded in landscape governance systems. This expertise will be complemented by external expertise on economic and land-use modeling (International Institute for Applied Systems Analysis,

IIASA) and analysis of PCS (Stockholm Environment Institute, SEI) (see Section 2.3.1.7). Some members of the team possess in-depth knowledge of value chain development and business models[43,44], making them well placed to identify options to generate greater shared value and enable more effective smallholder upgrading within diverse agricultural and forestry sectors[45,46]. Other team members contribute with biophysical expertise to enable more effective assessment of the environmental sustainability of diverse agricultural, tree crop and extractive production systems[47], work that benefits from interactions with scientists related to FP2 (see Section 2.3.1.6). Our work on finance will builds on work conducted by Tropenbos in the forestry sector[48,49] and will be complemented by specialized research partners working in this field, such as Profundo and UNEP-FI. This area of research will be strengthened through hiring of two finance experts. In order to enhance team flexibility and promote creative thinking, our team combines both junior and senior scholars, as well as scientists who actively link research, policy engagement and capacity development.

Table 4. Key scientists involved (CVs in Annex 3.8).

Name, institution	Original discipline	H	Total no of citations	Rank in CGIAR	FP3 role/liaison	FTE
Pablo Pacheco, CIFOR*	Economist, Geographer	31	3038	74	FP3 leader CCAFS liaison	1.00
Marie-Gabrielle Piketty, CIRAD*	Economist	14	850	227***	FP3.1 leader	0.50
George Schoneveld, CIFOR*	Business economist, Geographer	16	723	249	FP3.2 leader	1.00
Herman Savenije, Tropenbos*	Finance, forester	7	100	541***	FP3.3 leader	0.30
Manuel Guariguata, CIFOR*	Ecologist	37	5986	35	FP3.1 scientist	0.50
Bryan Finegan, CATIE**	Forest ecologist	32	4987	55***	FP3.1 scientist	0.21
Plinio Sist, CIRAD*	Forester	25	2327	102***	FP3.1 scientist	0.25
Alain Rival, IRAD	Agronomist	21	1546	142***	FP3.1 scientist	0.17
David Gaveau, CIFOR	Landscape ecologist	21	1786	129	FP3.1 scientist	0.50
Patrice Levang, IRD-CIFOR*	Agronomist	20	1922	121	FP3.2 scientist	0.25
Laura Snook, Bioversity**	Forest ecologist	19	1241	164	FP3.1 scientist	0.20
Paolo Cerutti, CIFOR*	Forester	17	838	230	FP3.1 scientist	0.83
Guillaume Lescuyer, CIRAD	Forest economist	16	897	211	FP3.2 scientist	1.00
Pierre-Marie Bosc, CIRAD	Agroeconomist	15	575	281***	FP3.2 scientist	0.25
Dietmar Stoian, Bioversity*	Forest economist	14	856	225	FP3.1 focal FP3.2 scientist	0.25
Jason Donovan, ICRAF*	Economist	13	1013	190	FP3.2 focal PIM liaison	0.50
Herry Purnomo, CIFOR	Modeling	12	640	265	FP3.2 scientist	1.00
Andrew Wardell, CIFOR	Social scientist	11	780	238	FP3.3 scientist	0.50
Emilie Coudel, CIRAD	Social scientist	10	397	339***	FP3.2 scientist	0.17
Marcel Djama, CIRAD	Economist	9	247	419***	FP3.1 scientist	0.17
Emmanuelle Cheyns, CIRAD	Social scientist	8	267	402***	FP3.1 scientist	0.30
Jean-Marc Roda, CIRAD	Economist	7	226	433***	FP3.3 scientist	0.25
Anne Terheggen, ICRAF	Economist	6	140	498	FP3.1 scientist	0.50

Notes: *CV included in Annex 3.8 under FP3 team, **CV included in Annex 3.8 under FP4 team, ***Scientist not ascribed to the CGIAR, thus the rank corresponds to their position in relation to the CGIAR ranking.

2.3.1.5 Lessons learned and unintended consequences

FP3 builds on work conducted under FTA Phase I, viz. FP2: "Management and Conservation of Forest and Tree Resources" and FP5: "Global Governance, Trade and Investment." FP2 focuses on analyzing sustainable production potential and access by different stakeholders to timber and non-timber resources. FP5 focuses on assessing the influence of emerging economies, notably China, in driving investments in sub-Saharan Africa; the impacts for people's livelihoods and forests of the expansion of large-scale investments in select commodities (e.g. oil palm, soybean, beef, cacao) across regions; and the influence of timber certification (FSC) and import policies in consumer countries (EU timber regulation and EU-RED) on domestic market dynamics and formalization of smallholder and chainsaw milling operations. In addition, FP5 has undertaken analysis of the implications from the adoption of voluntary standards in the dynamics of production and rural livelihoods in the cacao sector.

Some key lessons from this research are:

- Large-scale plantation agriculture and wood production, driven by international and national financiers, investors and producers, shapes agrarian and land-use transformations, often with significant trade-offs between food supply and socioeconomic (including gendered) and environmental impacts[50,51].
- Public policy, due to perverse incentives and implementation failures, often is ineffective in dealing with negative environmental impacts. Sustainability standards and associated certification schemes have made contributions to ameliorating some of these impacts, but these schemes show mixed results with regard to environmental performance and the promotion of better inclusion of smallholders and rural communities in global value chains[52,53].
- Where local communities and SMEs have greater capacity and control in global value chains, it is possible to overcome the failure of public regulations through the adoption of VSS, yet this may also have negative undesired effects if it is not accompanied by access to market rewards[54,55].
- In the coffee and cacao sector, Fairtrade certification has considerable potential to support increased benefits for smallholders but Fairtrade needs to take a more active role in working with local SMEs in order to advance context-relevant strategies and help promote more impactful development interventions with State agencies, NGOs and downstream buyers[56].
- The social risks of large-scale investments are relatively high, yet can partly be ameliorated when investors are encouraged to adopt business models that more productively integrate smallholders into the corporate supply chains. Those business models often improve the welfare of participants, but also change local land-use dynamics by incentivizing land commodification, increasing *per capita* farm sizes and promoting in-migration, while often excluding resource-poor smallholders[57].
- Targeted interventions are required to better manage the social and environmental trade-offs that arise from the adoption of alternative business models. More effective interventions are those combining actions at the company level with others to build social business capabilities[58].

The lessons above suggest that while the adoption of improved governance and business models is necessary to tackle negative environmental impacts, it may have contradictory social and economic effects, with winners and losers. One of the key factors that may trigger significant change at scale in the adoption of sustainability practices and business models is the availability of and access to finance that is contingent upon the adoption of good practices. However, the latter tends to work only in contexts where more integrated value chains prevail and may not have positive effects on smallholders, especially of those who are resource poor. In addition, a wider development of VSS may tend to disempower rural farmers in the long term, especially marginalized social groups.

2.3.1.6 Clusters of activity (CoA)

Clusters of activity. FP3 comprises three CoAs with interconnected goals and approaches (Figure 3). The first cluster (**CoA 3.1**) examines the policy and institutional environment shaping the structure and dynamics of timber and agricultural commodity value chains (oil palm, rubber, soybean and beef) that are articulated to global markets and contribute significantly to deforestation and forest degradation. The second (**CoA 3.2**) focuses on business models in timber and tree-crop value chains (e.g. palm oil, cacao, coffee and coconut) that link corporations with smallholder farmers and SMEs. The third cluster (**CoA 3.3**) assesses how the financial sector influences the social and environmental performance of value chains and businesses, and links to CIFOR's action research planned under the TLF.

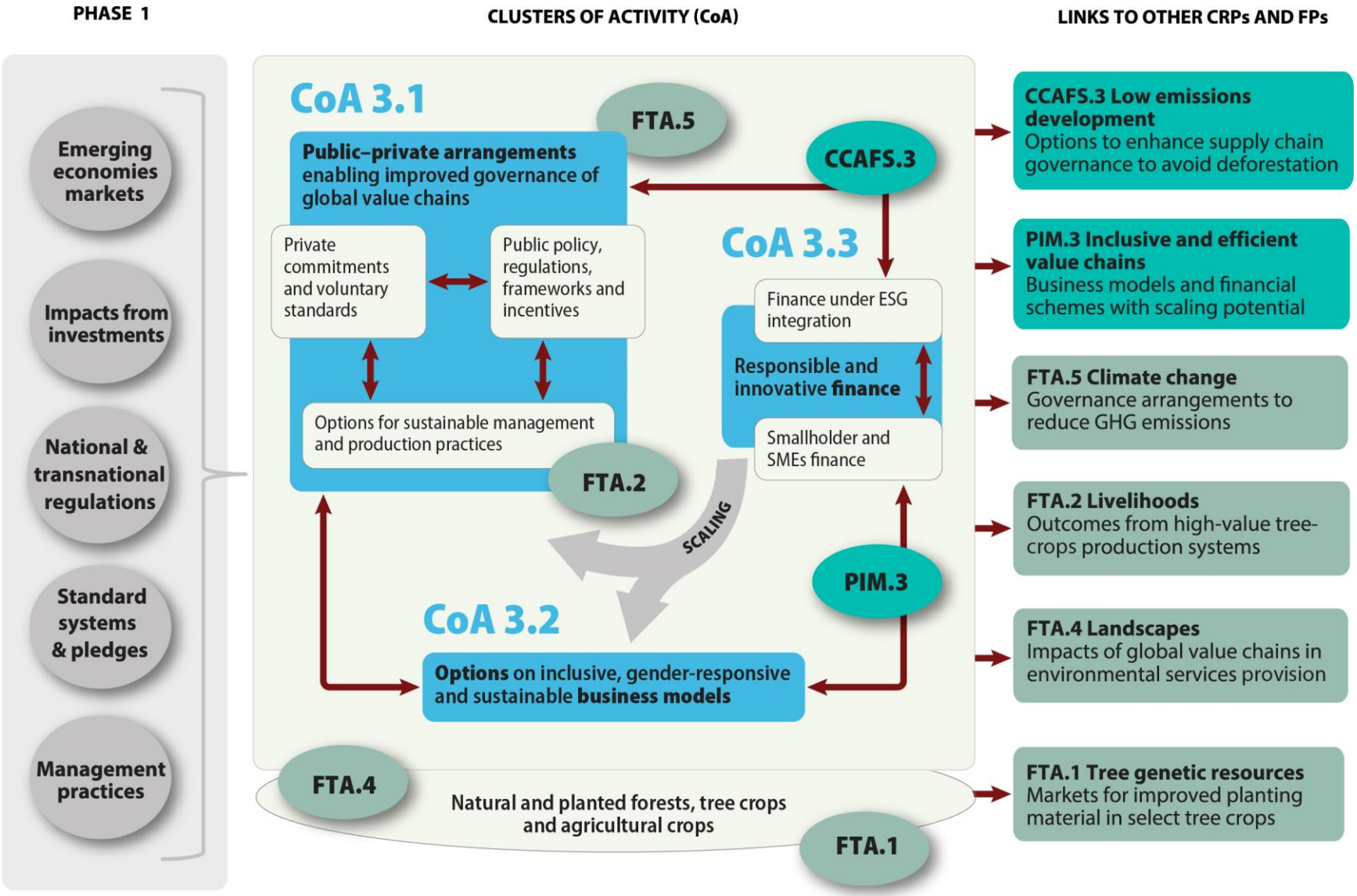


Figure 3. FP3 clusters of activity and links to other FPs in FTA, PIM and CCAFS.

FP3 CoA 3.1 Enabling sustainable commodity supply chains

Problem statement and rationale. There is an increasing need to address the adverse social and environmental impacts of unsustainable timber extraction and the expansion of agricultural commodities (e.g. oil palm, rubber, soybean and beef) with a large forest footprint. Governments tend to promote these commodities due to their significant contribution to fiscal revenues and economic benefits, but they struggle to ameliorate their associated negative social and environmental impacts. Emerging voluntary sustainability standards (e.g. certification and commodity round tables) as well as private self-regulatory commitments (e.g. zero deforestation) aimed at enhancing the social and environmental performance of commodity production suffers from a number of limitations. These initiatives differ in their approaches, scope and targets, conflicting in some cases and complementing government-backed efforts in others, with smallholders and SMEs often being excluded as they lack the capacity to comply. This calls for exploring antagonisms and complementarities between different types of regulatory instruments and private initiatives, as well as for identifying mechanisms to address uptake barriers. Research will examine the goals and scope of these disparate initiatives, implementation challenges, adoption barriers and their outcomes, not only with respect to supporting the adoption of improved landscape management and more intensive agricultural production practices, but also with respect to their potential to reduce yields gaps and generate positive social and environmental outcomes. Research will also assess what is required in supply chain management and business operation development in the value chain to support sustainable supply chains. Finally, we will assess the costs, benefits, risks and opportunities, and the trade-offs of different management options linked to diverse value chain configurations and institutional contexts.

Hypothesis. Private sector sustainability standards, in conjunction with supportive public policy, will foster improved management and business practices with enhanced socio-environmental performance.

Key research questions. The main questions related to enabling sustainable supply chains are listed below.

- What political, institutional and social factors contribute to shape the adoption and implementation of public policies and private sustainability standards and commitments?
- How do private standards and commitments, in their interaction with public policy at different scales, influence the effectiveness and adoption rates of sustainable practices in value chains?
- What are the public, private or hybrid arrangements that have the most potential for enhancing the adoption of sustainability practices and social inclusivity in the value chain?
- What production and management practices are needed to simultaneously increase sustainable supply and social inclusion and equity (gender, intergenerational)?

Key outputs. The main deliverables to support sustainable value chain development are:

- a global comparative analysis, bases on a systematic comparison across case studies, identifying the political, economic and social factors (including gender) enabling or preventing the adoption and implementation of private sustainability initiatives in their interaction with public policies
- a comparative assessment of the challenges and opportunities and effectiveness for improving sustainability across disparate voluntary standards (e.g. certification, zero deforestation)
- guidelines on innovative solutions for addressing implementation gaps to improving sustainability and social outcomes through changes in incentive structures, supply chain management and business processes and operations across diverse value chain configurations
- guidelines and tools on the most promising public–private institutional arrangements at different levels for achieving sustainability that combine State and privately-driven interventions, and opportunities for developing ‘hybrid’ public-private approaches
- a decision-support tool based on a global comparative analysis of costs, benefits and trade-offs of improved natural forest management practices with regard to planted forests and tree crops and strengthened capacities for co-developing the most appropriate practices and models.

FP3 CoA 3.2 Business models in timber and tree-crop value chains

Problem statement and rationale. There is a growing consensus that the transformative potential of markets needs to be better leveraged to achieve development goals. The assumption is that business models that productively integrate smallholders and SMEs offer win–win opportunities by increasing buyer access to raw materials while improving smallholder and SME access to profitable (global) markets and services that facilitate the uptake of more intensive and environmentally sustainable production practices. However, understanding is lacking on the conditions under which such business models can effectively overcome existing bottlenecks and deliver positive, long-term impacts at scale. On the one hand, smallholders and SMEs may struggle to meet the quality and sustainability standards adopted by large buyers and processors. On the other hand, downstream buyers and processors may lack the necessary knowledge, resources and capacity to develop business models that include smallholders and SMEs and may be reluctant to invest in such models due to their perceived risks. Innovation in business models thus requires new insights into the constraints faced by smallholders and SMEs, and the potential trade-offs between social, environmental and economic objectives. This work will provide improved knowledge on opportunities to overcome such bottlenecks by enabling value chain support organizations (e.g. government agencies, financial institutions, civil society organizations, development agencies, multi-stakeholder initiatives) to improve and better link their service delivery in support of more inclusive, gender-responsive, equitable and sustainable business models.

Hypothesis. Downstream value chain actors adopting business models that integrate smallholders and SMEs will contribute to achieving inclusive development and sustainability objectives.

Key research questions. The main questions related to this cluster are:

- What types of business models involving smallholders and SMEs can be identified and how economically viable, socially inclusive and environmentally sustainable are they?
- What barriers to participation do women, youth and other marginalized groups face in different business models and value chains across different institutional and economic contexts?
- What are the factors that explain the distribution of benefits across different types of business models and how can benefits be distributed more equitably among different stakeholders?
- How can value chain service providers contribute to the development of more impactful and adaptive business models in different value chain configurations?
- What governance and institutional arrangements could facilitate scaling of business models that better manage social, environment and economic objectives?

Key outputs. The main deliverables related to the work on business models are:

- guidelines for overcoming institutional and operational barriers and obstacles faced by businesses in integrating smallholders into their operations and respective value chains
- a typology of business models for timber and tree-crop commodities, based on their economic, environmental, social performance and related trade-offs, with emphasis on women and youth
- best practice guidelines, tools and metrics for the design, implementation and assessment of business models that are more socially inclusive, economically viable, environmentally sustainable and can potentially produce greater impact at scale
- guidelines for organizations providing technical, business and financial services to value chains for strengthening the capacity of smallholders and SMEs to engage with businesses on an equal footing.

FP3 CoA 3.3 Scaling through responsible finance and investments

Problem statement and rationale. FSPs, such as private banks, development finance institutions and institutional investors could potentially play an important role in augmenting corporate social and environmental performance in forest and tree-crop value chains through the adoption of ESG criteria.

Instead of leading to improved corporate social and environmental performance ESG integration may also stimulate a bifurcation of the financial sector as businesses that already exhibit good social and environmental performance can secure ESG-conditional financing, while others become more dependent on FSPs that do not demand compliance with ESG. In addition, the existence of more responsible FPSs does not necessarily lead to increased finance for smallholders. One challenge is to identify mechanisms that both promote more widespread adoption of ESG among a greater number of FSPs and increase their capacity to effectively leverage their potential influence over corporate strategy and practice. Another challenge is to find more effective ways to link progress in responsible finance by FSPs with improvements in smallholder and SME access to finance. With the latter, innovative financial architectures and alternative lending schemes are emerging, which could contribute to further mainstreaming responsible finance norms. CIFOR's TLF initiative is one of a dozen such funds that aim to finance sustainable land-use investments by improving smallholder and SME access to affordable credit. This work will examine ways to address the two challenges.

Hypothesis. Linking ESG integration into FSP operations while improving access to smallholder and SME finance may trigger wider uptake of sustainable supply and inclusive business models.

Key research questions. The main questions related to responsible finance and investment are listed below.

- What are the incentives and constraints that shape the implementation of responsible investment and financing practices by FSPs under different institutional and economic conditions?
- How do different types of FSPs integrate ESG into the design of their products and services (e.g. project finance, asset management, debt and equity capital markets) to attend different financial operations along value chains and what factors shape their ESG integration strategies?
- What mechanisms could promote more widespread adoption of ESG criteria among different types of FSPs and improve the influence thereof on corporate social and environmental performance as well as including more supportive criteria to include smallholders?
- What factors restrict the access of smallholders, including women and youth, and SMEs to financial products and services, and under what conditions could access and availability to these goods and services be enhanced to support inclusive and sustainable development objectives?
- What institutional architecture(s) are needed to improve smallholder and SME access to affordable credit and what other complementary technical and market conditions have to be in place?

Key outputs. The main deliverables to be produced under this cluster are:

- three regional comparative reviews of the scope and implementation mechanisms of ESG integration strategies for different types of FSPs products and services
- analysis of the conditions and mechanisms that incentivize FSPs to more explicitly integrate ESG or similar criteria into their products in different institutional and economic contexts
- analysis of the impacts of ESG-conditional finance on the social and environmental performance of different types of corporate value chain actors across disparate socio-ecological contexts
- metrics and tools that enable FSPs to better screen prospective corporate clients and evaluate the social and environmental performance of their financial portfolios
- analysis of innovative financial mechanisms implemented by FSPs to make financial goods and services more accessible to smallholder and SMEs in timber and tree-crop value chains.

Links among the three clusters of activity

The three clusters of activities are strongly interconnected. The work under **CoA 3.1** focuses on an enabling environment for advancing sustainable commodity supply in ways that satisfy a variety of stakeholders and the environment. This analysis also addresses the risk of exclusion and disempowerment of smallholders in value chains, as well as policy, institutional and market options to mitigate them. The identification of the most appropriate regulations, incentives and private sector standards and commitments for advancing sustainability in commodity chains informs **CoA 3.2** which looks at business models upstream in the value

chain and opportunities and mechanisms that are more socially inclusive, economically viable and environmentally sustainable. This includes arrangements and mechanisms in support of smallholders, particularly women, youth and other marginalized groups, to ensure a more equitable distribution of risks and rewards along the value chain. **CoA 3.3**, in turn, will shed light on opportunities for scaling business models that effectively integrate ESG or similar criteria through the development of innovative financing architectures of responsible finance that advance the adoption of sustainability standards and practices in forest and tree product value chains.

CoA 3.1 will link with **CCAFS FP3** (low-emission development), specifically CoA 3.3 for conducting research on options to enhance supply chain governance to avoid deforestation, with emphasis on beef production in the Amazon and palm oil in Indonesia. **CoA 3.2** and **CoA 3.3** will link with **PIM FP3** (inclusive value chains), specifically CoA 3.3, with a primary focus on assessing business models for participation of smallholders in forest and tree-crop products, and financial schemes with potential for scaling. FP3 also links with other **FTA** FPs, specifically with: (1) **FP1** (tree genetic resources) by exploring opportunities from improved tree-planting material in some value chains; (2) **FP2** (livelihood systems), through assessing the performance of smallholder production systems that embrace high-value trees (e.g. cocoa, coconut, coffee, oil palm) under different business models; (3) **FP4** by exploring the impacts of global value chains in environmental services at the landscape level and initiatives to deal with them, such as certification and; (4) **FP5** by providing analysis of the effectiveness of governance arrangements in supporting the transition to more sustainable supply chains and thus reducing GHG emissions.

2.3.1.7 Partnerships

The FP3 implementation partners are **CIFOR**, **CIRAD**, **ICRAF**, **Bioversity International, CATIE** and **Tropenbos**. FP3 will engage a select number of research partners for co-production of knowledge. Development or knowledge-sharing partners with complementary capacities will be engaged to undertake work on research, field implementation, outreach engagement and capacity building.

Table 5. Selected partners in FP3 and their roles.

Type of partnership	Type of center/ organization	Center/ organizations	Key role	Stage of involvement in research to impact
Managing partners	CGIAR	CIFOR	Focus on CoA 3.1, CoA 3.2 and CoA 3.3, emphasis in timber, oil palm, soybean, beef	Research (discovery, proof of concept), policy engagement, capacity development, fundraising
		ICRAF	Focus on CoA 3.1 and CoA 3.2, emphasis in cocoa, coffee, oil palm, rubber	
		Bioversity	Focus on CoA 3.1 and CoA 3.2, emphasis in timber, cocoa, coffee and coconut	
	Non-CGIAR	CIRAD	Focus on CoA 3.1 and CoA 3.2, emphasis in timber, oil palm, soybean and beef	
		CATIE	Focus on CoA 3.1 and CoA 3.2, emphasis in timber, cocoa and coffee	
		Tropenbos International	Focus on CoA 3.2 and CoA 3.3, linking with civil society organizations	
Contributing research partners	Advanced research centers for supporting	SEI	Research under CoA 3.1; inform global platforms on production and trade	Engagement in research, exploring new ideas, proof of concept and
		IIASA	Modeling under CoA 3.1 on implications of governance arrangements	

Type of partnership	Type of center/ organization	Center/ organizations	Key role	Stage of involvement in research to impact
	research	Copernicus Institute	Research under COA 3.1; engagement with European debates and platforms	fundraising
		RFF	Research under CoA 3.1, on the effectiveness of policy instruments	
		ISL	Research under CoA 3.3, engagement with responsible finance platforms	
		Profundo	Research under CoA 3.3; engagement with responsible finance initiatives	
	Developing country research partners	Universities and institutes (e.g. USP, IPB)	Research under CoA 3.1, CoA 3.2 and CoA 3.3, engagement in national policy dialogues and capacity development	Local research, capacity building and scaling and multiplication
		NGOs (e.g. Centro Terra Viva, SPDA)	Research under CoA 3.1, CoA 3.2 and CoA 3.3, identification of country-specific research priorities and policy engagement	
Knowledge-sharing partners	Development organizations	SNV	Piloting CoA 3.2 and 3.3 innovations for smallholder capacity development	Identification of research gaps, co-development of options, proof of concept
	Multilateral organizations	UNDP, UNEP-FI, WB	Co-development and dissemination of new approaches and tools for supporting innovations based on lessons learned from previous experiences and available evidence	
	Business networks	FAST		
	Certification initiatives	Certification systems (SAN, FSC, RSPO)	Platforms for identification of research gaps, relevant questions and co-development of options, with emphasis on CoA 3.1	
Policy and out-scaling partners	Regulators	Ministries and State agencies	Engagement in co-hosting of policy debates and link with ongoing policy dialogues and policy-making processes	Identification of research gaps, scaling
	Environmental organizations	TNC, WWF	Piloting CoA 3.2 and 3.3 innovations for sustainable commodity supply and land use with multi-stakeholder approaches	Scaling, feedbacks from implementation actions
	Business platforms and networks	TFA 2020	Platforms for co-development of approaches with potential for uptake and critical assessment of implementation progress	
		ISEAL		

Research partners include: **SEI**, **IIASA**, the **Copernicus Institute** for Sustainable Development at Utrecht University and the **Institute for Sustainability Leadership** at the University of Cambridge. **SEI** will contribute to identifying global supply–demand flows and the role of different types of value chain actors in our prioritized commodities and **Resources for the Future** on assessing the effectiveness of specific policy instruments. **IIASA** will contribute by examining the effect of public regulations and private commitments in commodity supply (e.g. certification, zero deforestation) and their impacts on production, trade and GHG emissions as a result of land-use change and agriculture. The **Copernicus Institute** will help to assess the

direct and indirect environmental impacts from investment decisions and alternative governance scenarios. The **Institute for Sustainability Leadership** will support research on finance and link with the Banking-Environment initiative. **Profundo** will contribute specialist approaches in the finance corporate sector. We also have established research partnerships in selected countries. For example, we will work with the **Museum Emilio Goeldi** (MPEG), **EMBRAPA Eastern Amazon** and the **University of Sao Paolo** in Brazil, as well as **FORDA** and **Bogor Agricultural University** (IPB) in Indonesia. We also have long-term partnerships with NGOs, such as **Centro Terra Viva** in Mozambique and **Peruvian Society of Environmental Law** (SPDA) in Peru.

Knowledge-sharing partners include: **SNV**, an international development organization that provides direct technical support to smallholders, SMEs, government and businesses to develop inclusive agricultural value chains; **Fairtrade International**, a multi-stakeholder association that develops and facilitates adherence to fair trade standards; United Nations Development Programme (**UNDP**), a UN agency supporting countries to develop policies, institutional capabilities and build resilience in order to sustain development results; **FAST**, an alliance of FSPs focused specifically on the financial needs of smallholders and SMEs operating with environmental and social responsibility; **UNEP-FI**, a platform of public and private financial institutions working with UNEP on ESG standards and finance; and the **GACSA** Investment Action Group. The partnerships with **SNV** and **Fairtrade International** will provide opportunities for testing innovative business models and approaches. **UNDP**, particularly in Indonesia, will provide links with several ministries, mainly linked to the **InPOP** platform. **FAST** is a key link to FSPs interested in working with smallholders and SMEs. **UNEP-FI,** an existing partner of CIFOR on developing innovative financial schemes, will serve as a knowledge broker with UNEP-FI members.

Policy and outscaling partners. FP3 will work closely with international organizations such as: the Food and Agriculture Organization of the United Nations (**FAO**), **WWF International**, **TNC**, **IFC**; and multi-stakeholder and business platforms such as: **FSC**, **RSPO**, **SAI**, Tropical Forest Alliance (**TFA 2020**), **GRSB** and **IPOP**. The latter partners involve both international- and national-level actors. FP3 will also link with issue-based platforms supporting sustainable, small-scale agriculture such as **BCtA**, Inclusive Market Development (**IMD**) and the Global Development Alliance (**GDA**); financial institutions associated with CIFOR's **The Landscape Fund** including the Netherlands Development Finance (**FMO**), **Innpact,** Banking Environment Initiative (**BEI**), **EIB**, Norwegian Investment Fund (**NorFund**); and the **Fair Climate Fund** and similar initiatives supporting businesses in adopting socially and environmentally sound practices.

2.3.1.8 Climate change

FP3 will directly address critically important climate change issues, because sustainable global commodity value chains will contribute to the reduction of GHG emissions, both from deforestation and forest degradation, from agricultural production practices and Emissions Embodied in Trade (EET). Tropical deforestation currently contributes 10–11% to global GHG emissions[59]. Over the last two decades, export-driven commodity agriculture linked to oil palm, soybean and beef production has constituted the main driver of deforestation in the tropics[60], which has been accompanied by increases in EETs[61]. The production of agricultural commodities for national and international markets is a significant source of GHG emissions from agriculture, forestry and other land uses[62]. Likewise, oil palm is expanding onto peat swamp soils producing emissions from the decomposition of peat over many decades following the cutting down of forest[63]. Natural forests have usually been logged using destructive conventional techniques and remnant forests are likely to be further degraded due to fire, as well as edge and isolation effects[64]. Increasing demand for timber may continue to stimulate additional destructive logging and increase vulnerability to forest conversion, stimulated by a perceived lack of value of the degraded ecosystem[65]. All of these degradation processes produce GHG emissions beyond those caused by deforestation. FP3-generated knowledge and tools will contribute to climate change mitigation in three ways: (i) by supporting effective implementation of private commitments to increase sustainability in the agricultural commodity sector and therefore reducing GHG emissions; (ii) by facilitating innovation in the climate-smart production of timber

from natural forests and through 'tailored' tree-crop products to meet an increasing national and international trade and (iii) by reducing EET of agricultural commodities.

2.3.1.9 Gender

Gender research in FP3 will continue to build on past FTA gender work on timber, palm oil and cacao value chains. Emerging strands of strategic gender research include the gendered implications of cash-crop expansion, product certification schemes, business models and financial services. Furthermore, the collection and analysis of socioeconomic (gender, age, class, ethnicity, etc.) disaggregated data is of crucial importance for both identifying synergies and managing potential trade-offs between social, economic and environmental outcomes of value chains and business models. In addition to conducting research in a gender-sensitive manner, gender-specific research questions in each of the CoAs are identified. The purpose is to provide policy-makers, companies, producer organizations and service providers with gender-responsive policy options and business models for actively promoting gender equity. Our approach to equity includes both gender and intergenerational equity by emphasizing opportunities for women and youth. In addition to data collection and analysis, FP3 work on gender will also include target and priority setting, dissemination of knowledge products and monitoring and evaluation. The integration of gender into FP3 will be monitored by the gender equality in research scale (GEIRS), developed by the FTA gender integration team and rolled out in 2015. By adopting a dual approach to gender, i.e. conducting gender-specific research and integrating gender throughout the FP3 research portfolio, FP3 is expected to contribute to a specific sub-IDO on improving gender-equitable control of productive assets and resources (see Section 2.3.1.2). Youth issues, as well as other issues stemming from socioeconomic differentiation will be considered in our research. There will be a particular focus on business models and the potential business opportunities for the youth.

2.3.1.10 Capacity development

FP3 capacity development will be guided by the Capacity Development Framework developed under CGIAR. FP3 will address gaps in linking research and development by working with partners in a number of ways through a continuous horizontal learning process. First, we will develop future research leaders by integrating MSc and PhD students from partner universities into our research projects (CapDev element 4). Second, we will develop and disseminate guidelines and learning tools (CapDev element 2) to multi-stakeholder processes (e.g. FSC, RSPO), business platforms (e.g. ISPO, GTPS, TFA 2020) and key selected State agencies. For example, guidelines and tools will be produced for monitoring the effectiveness of selected VSS, the implementation of zero deforestation commitments and alternative options to support inclusive business models linked to palm oil, cacao, coffee, coconut and timber. Third, we will conduct gender-specific analysis and develop methods (CapDev element 5) related to the different areas of work mentioned above, aiming to integrate gender-explicit criteria into sustainability standards (e.g. RSPO) and criteria for assessing private commitments. Fourth, we will contribute to strengthening multi-stakeholder and innovation platforms by providing knowledge on complementary public and private institutional arrangements (CapDev element 10) to tackle specific governance challenges; for example, oil palm governance linked to smallholder integration and production intensification in Indonesia and SMEs development in the cacao sector in Peru. Fifth, we will work through FSP research and boundary partners engaged in CIFOR's action research on TLF. Finally, we will work with the CGIAR community of practice on capacity building and other co-learning communities of practice on the ground. In addition, we will inform with our work some PIM-supported value chain hubs involving researchers and practitioners engaged in joint learning on value chain interventions and will be able to share our approaches and research findings.

2.3.1.11 Intellectual asset and open access management

Intellectual assets produced under FP3 are in compliance with the CGIAR principles on the management of intellectual assets (CGIAR IA principles) and CIFOR IA management policy for effective dissemination of its

research outputs and maximize global impact. The following CGIAR IA principles shall be adopted as guidance for IA management of FTA: (i) research results and development activities are regarded as international public goods for the maximum possible access; (ii) partnerships are critical to ensuring access to the best knowledge and innovation to achieve maximum impact; (iii) sound management of IA and intellectual property rights (IPR) with integrity, fairness, equity, responsibility and accountability; and (iv) all IAs produced under FP3 are managed in ways that maximize global accessibility.

In line with the CGIAR open access and data management policy and CIFOR OA policy, FP3 outputs will be made available under the least restrictive licensing to describe the legal rights to information products and encourage their use and adaptation. The different outputs will be published in a format that can be downloaded, indexed and searched by commonly used web applications. The outputs will be disseminated through open access repositories to ensure they is archived and shared systematically with other Centers and made accessible as international public goods. For more details, see Section 1.0.12 on FTA IA Management and Section 1.0.13 Open Access Implementation in the CRP narrative.

2.3.1.12 Flagship management

FP3 will provide a platform for conducting collaborative research for scientists from the different partner organizations (CIFOR, CIRAD, ICRAF, Bioversity International, CATIE and Tropenbos). It will promote the integration of research across regions, commodities and themes (following the main thematic priorities defined in the three CoAs). FP3 will be coordinated by Pablo Pacheco, a Principal Scientist at CIFOR and each CoA will be coordinated by a designated scientist: CoA 3.1 by Marie-Gabrielle Piketty, CIRAD; CoA 3.2 by George Schoneveld, CIFOR; and CoA 3.3 by Herman Savenije, Tropenbos.

Table 6. Expertise of FP3 coordinator and CoA leaders (see also CVs in Annex 3.8).

Scientist	Role	Expertise
Pablo Pacheco, PhD (CIFOR)	FP3 leader	He is a Principal Scientist at CIFOR based in Bogor, Indonesia. He is the Team Leader of "Value Chains, Finance and Investments" at CIFOR and coordinates Flagship 5 on "Global Governance, Trade and Investment" under the CGIAR Program on Forests, Trees and Agroforestry (FTA). He holds a PhD in geography from the Graduate School of Geography at Clark University, an MSc in agricultural economics and a BA in sociology. His work focuses on the implications of globalized trade and investment on forests, people's livelihoods and economic development with a focus on timber, soybean, beef and oil palm in South America and Southeast Asia and the associated State and non-State responses to manage their social, economic and environmental impacts and trade-offs. He has about 200 publications including journal articles, books, book chapters, working papers and policy briefs. He is actively engaging policy debates with public and private actors in these topics.
Marie-Gabrielle Piketty, PhD (CIRAD)	FP3.1 leader	She is Economist and Senior Scientist at CIRAD-GREEN research unit (PhD from Paris-I/Sorbonne University). She has been working on the limits of FSC certification in Brazil and, more broadly, on the difficulties of environmental certification and value chains private commitments to reconcile economic effectiveness, social equity and environmental sustainability without stronger synergies with public policies. She has expertise in evaluating public policies and value chains private commitments governing land-use change in agricultural frontiers, with emphasis in agricultural commodities in Brazil and Indonesia. She has coordinated the work of CIRAD scientists with expertise on value chains, corporate strategies and international standards in FTA FP5.1.
George Schoneveld, PhD (CIFOR)	FP3.2 leader	He is a Senior Scientist at CIFOR, based in Nairobi, Kenya. He holds a PhD in geography from Utrecht University through the Dutch Ministry of Foreign Affairs IS Academy on Land Governance, an MSc in international development studies and an MSc in international business economics. He has led numerous research

Scientist	Role	Expertise
		activities and projects on the drivers, global governance, business models and social, economic, and environmental impacts of private investments in the agriculture, bioenergy and forestry sectors in Eastern, Southern and West Africa, Southeast and South Asia and South America. His experience with a wide range of qualitative and quantitative methods and disciplines, which include value chains, finance, business strategy, political economy and livelihood studies, has enabled him to undertake highly integrative and multi-disciplinary research.
Herman Savenije, MSc, (Tropenbos International)	FP3.3 leader	He is a Program Coordinator at Tropenbos International, based in Wageningen, The Netherlands. He holds an MSc in tropical forestry and has focused his work on assessing the role of forest finance and investment, including finance for supporting ecosystem services provision, in the context of broader approaches for enhancing forest governance and sustainable timber chains, including the effectiveness of forest certification. He has been lead writer in several publications on the topic and played an important role in leading a community of practice on forest governance, finance and investment among other leadership roles in the sector. He has been involved in the publication of several volumes of *The European Tropical Forest Research Network News* (ETFRN) on forest governance, illegal timber trade and farm and forest organizations.

The FP3 coordinator will be in charge of the overall coordination of program development conducting tasks such as planning, budgeting and reporting, as well as securing bilateral resources by supporting proposal development efforts and ensuring coordination with other FTA FPs and CRPs. CoA coordinators will contribute to the process of planning, budgeting and reporting for their respective CoAs and will help to co-develop the research portfolio under each of the CoAs, including support for fundraising, in consultation with the FP3 coordinator. This will ensure that there is programmatic consistency across FP3 CoAs and across the six regions where FP3 will be focusing its work. FP3 and CoAs coordinators will ensure thematic and regional balance in each of the CoAs team based on the end-users' priorities and availability of financial resources. In order to ensure coordination in developing and implementing FP3, quarterly virtual meetings and one in-person annual retreat will be held at either one of CIFOR, ICRAF and/or CIRAD's annual meetings. These meetings will integrate knowledge-sharing partners and as much as possible, policy and out-scaling partners. CoA leaders will be supported by focal points from CGIAR partner Centers and will be assisted by an advisory team involving the main non-CGIAR partner organizations involved in FP3 (Table 7).

Table 7. FP3 CoA leaders, focal points and advisors.

Cluster of Activity	Leader / coordinating	Managing partners focal points	Non-CGIAR advisory team
CoA 3.1	CIRAD: Marie-Gabrielle Piketty	CIFOR: Paolo Cerutti CATIE: Bryan Finegan CIRAD: Plinio Sist	SEI: Toby Gardner SAN: Andre de Freitas (TBC)
CoA 3.2	CIFOR: George Schoneveld	ICRAF: Jason Donovan Bioversity: Dietmar Stoian CIRAD: Pierre-Marie Bosc	SNV: Hans Smit Others TBD
CoA 3.3	Tropenbos International: Herman Savenije	CIFOR: Andrew Wardell	Profundo: Jan Willem van Gelder FAST: Noemi Perez (TBC)

2.3.2 Flagship Budget Narrative

2.3.2.1 General information

CRP Name	Forest, trees and agroforestry Agri-food systems Program (FTA)
CRP Lead Center	CIFOR
Flagship Name	Sustainable global value chains, finance and investments
Center location of Flagship Leader	CIFOR

2.3.2.2 Summary

Total Flagship budget summary by sources of funding (USD)

Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	10,528,290	10,981,599	11,457,574	11,957,347	12,482,109	12,985,471	70,392,394
Other Sources							0
	12,375,090	12,920,739	13,493,671	14,095,248	14,726,905	15,342,507	82,954,160

Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Assumed Secured)	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	6,924,731						6,924,731
Other Sources							0
	8,771,531	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	19,486,501

Funding Gap	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Required from SO)	0	0	0	0	0	0	0
W3 (Required from FC Members)	0	0	0	0	0	0	0
Bilateral (Fundraising)	-3,603,560	-10,981,600	-11,457,574	-11,957,348	-12,482,110	-12,985,472	-63,467,663
Other Sources (Fundraising)	0	0	0	0	0	0	0
	-3,603,560	-10,981,600	-11,457,574	-11,957,348	-12,482,110	-12,985,472	-63,467,663

Total Flagship budget by Natural Classifications (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
Personnel	3,755,273	3,943,036	4,140,188	4,347,197	4,564,557	4,792,785	25,543,039
Travel	605,000	635,250	667,012	700,363	735,381	772,150	4,115,157
Capital Equipment	108,940	114,387	120,106	126,111	132,417	139,038	741,000
Other Supplies and Services	4,572,400	4,737,450	4,910,752	5,092,720	5,283,786	5,484,405	30,081,514
CGIAR collaborations	0	0	0	0	0	0	0
Non CGIAR Collaborations	1,709,108	1,794,563	1,884,291	1,978,506	2,077,431	2,140,036	11,583,937
Indirect Cost	1,624,369	1,696,052	1,771,320	1,850,350	1,933,332	2,014,092	10,889,518
	12,375,090	12,920,738	13,493,669	14,095,247	14,726,904	15,342,506	82,954,154

Total Flagship budget by participating partners (signed PPAs) (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
CIFOR	9,289,235	9,680,591	10,091,515	10,522,986	10,976,030	11,451,725	62,012,084
Bioversity	370,369	388,888	408,332	428,749	450,187	469,187	2,515,713
ICRAF	184,704	193,939	203,636	213,817	224,509	235,032	1,255,638
CIRAD	1,193,343	1,253,010	1,315,661	1,381,444	1,450,517	1,519,815	8,113,792
CATIE	133,973	140,672	147,706	155,091	162,846	170,988	911,278
TROPENBOS	1,203,464	1,263,637	1,326,819	1,393,160	1,462,818	1,495,758	8,145,658
	12,375,088	12,920,737	13,493,669	14,095,247	14,726,903	15,342,505	82,954,149

For the explanation of these costs in relation to the planned 2020 outcomes, please refer to the FP narrative and especially PIM tables B and C.

NOTE: Supporting platform: Given the absence of a specific location to upload the costs/budgets of the various cross-cutting components (CCT) of the Support Platform (Gender, Youth, Capacity Development, MELIA, Communication/Outreach, Site Integration, Partnerships, OA/OD) we have allocated these amounts across the five Flagships within the supply and services class (but they will be managed in practice by the relevant CCT component leads). The amounts added per FP for the SP (2017) are USD 1,271,000 of which USD 346,000 is W1/W2

Use of W1–2: W1–2 are used strategically to leverage bilateral funding as basket funds, in such a way that different sources of bilateral contribute to the same major goals; this will build a program that is consistent and that can deliver its expected objectives across the different six countries in which we are planning to do our work. W1–2 funds are also used for global comparative analyses on major issues (e.g. REDD+, bioenergy), to strengthen science quality, implement open access and to foster the probability of outcomes as a result of targeted communication and outreach.

2.3.2.3 Additional explanations for certain accounting categories

Benefits: In general, the following benefits are covered by the Centers: pension, health insurance, AD&D insurance and allowances for housing, education and transport. These have all been rolled into the salary. It is difficult to standardize the benefits as they vary by Center (based on individual Center polices), and by type of staff i.e. internationally recruited and national staff.

Other supplies and services: Under Supplies and Services, we include costs related to consultants, research support, communications (publications and multimedia knowledge-sharing) and outreach (bilateral meetings, workshops and events). This budget line is important for FP3 to get short-term support on specific topics (consultants) and to get our knowledge out there in the policy debates.

2.3.2.4 Other sources of funding for this project

Efforts to raise bilateral funding will continue throughout the implementation period. The three research areas this Flagship (focused on sustainable supply chains, business models and responsible finance and investments) are gaining interest in the donor community, so opportunities for securing additional bilateral funding are there. W1/W2 will be used strategically to leverage bilateral funding that can be used as basket funds, in a way that different sources of bilateral contribute to the same major project goals, in order to build a program that is consistent and that can deliver its expected objectives across the different six regions in which we are planning to do our work, with the main focus on Tier 1 countries.

2.3.2.5 Budgeted costs for certain key activities

	Estimate annual average cost (USD)	Please describe main key activities for the applicable categories below, as described in the guidance for full proposal
Gender	707,000	see FP and CRP narratives
Youth (only for those who have relevant set of activities in this area)	0	Youth as a new topic for this FP will be initiated via the youth cross-cutting theme of the supporting platform
Capacity development	2,800,000	see FP and CRP narratives
Impact assessment	0	Costs are indicated at the CRP level budget narrative as this is centralized within the monitoring evaluation learning and impact assessment cross-cutting theme
Intellectual asset management	0	Costs are indicated at the CRP level budget narrative as this is mainly something managed at Centers' levels
Open access and data management	0	Costs are indicated at the CRP level budget narrative as this is mainly something managed at Centers' levels
Communication	1,200,000	see FP and CRP narratives

The above selected key activities are described in the proposal text and the PIM tables. They do not include the Support Platform (that is included in the CRP budget narrative)

2.3.2.6 Other

2.3.3 Flagship Uplift Budget

Outcome Description	Amount Needed (USD)	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other (%)
Outcome 3U1. Governance arrangements adopt explicit jurisdictional approaches under produce and protect perspectives linking private sector interventions in the supply chain with government interventions at the territorial level in at least three countries	7,800,000	17	0	83	0

Outcome Description	Amount Needed (USD)	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other (%)
Outcome 3U2. Apply lessons on business models that are more inclusive, economically viable and environmentally sustainable to three selected, globally traded, non-timber forest products (e.g. shea butter, Brazil nuts, acai) in at least five countries	8,200,000	25	0	75	0
Outcome 3U3. Expand the pilot cases of TLF to three more countries, with possibility to increase in an additional 10% the lending to models that integrate smallholders and SMEs to support more integrated and sustainable land uses	8,800,000	35	0	65	0

2.4. Flagship 4. Landscape dynamics, productivity and resilience

2.4.1 Flagship Project Narrative

2.4.1.1 Rationale and scope

C*losing the multi-functionality gap*

Day-to-day choices and decisions in tropical landscapes reflect the grand challenges to humanity, meeting the Sustainable Development Goals (SDGs) within the constraints of planetary boundaries. Use of land for production of tradable or locally consumed goods is traded off against the imperatives of environmental integrity of water, nutrient and carbon cycles and biodiversity conservation. Issues on human rights, tenure, poverty, migration and lack of options for young people add to the complexity. Actual landscapes tend to operate substantially below their potential ('production possibility frontier'). It is this '***multi-functionality gap'*** that FTA Flagship 4 addresses[1]. The Flagship project supports negotiations of multi-functionality at landscape scale within a SDG framework. It does so by combining: 1) observations of changes in forest cover, land use and the presence of trees on farms, with 2) consequent changes in the provision of ecosystem services (provisioning, regulatory, cultural, supportive/regenerative), and 3) the search for alternatives, design of policy instruments to nudge decision-makers towards reduced externalities, scenario evaluation and multi-stakeholder platforms for agreeing on changes to close the multi-functionality gap. Exploration of the concepts and principles goes hand-in-hand with action research to achieve change in complex contexts.

Vision

Multifunctional landscapes with trees, agroforestry and forests are managed on the interface of public and private sector actors to meet the SDGs of their inhabitants and external stakeholders.

Approach

Landscapes are socio-ecological systems that influence and constrain the way actors convert, retain and/or manage forests and trees on farms and the way this in turns contributes to or reduces human well-being and resilience. It is at the landscape scale that: (i) households seek ways to improve their on-farm and off-farm livelihoods (interacting with out-of-landscape revenue); (ii) governance mechanisms aggregate up to the currently insufficient attempts at managing the 'commons' that shape future earth; and (iii) the private sector interacts with dynamic, globalizing value chains. The wide range of socio-ecological conditions represented in the global network of FTA Sentinel Landscapes, for example, provides a framework for understanding what optimizing the design and management of multifunctional landscapes may entail.

The research targets a deeper understanding of the **forest or tree cover transition** framework of historical pathways, spatial gradients and shared global drivers, and an **ecosystem services** and **multiple capitals** perspective on trade-offs between provisioning services (goods) and the regulating, cultural and supportive services that tend to be externalities of decision-making. A central tenet for this FP is that adaptive management of landscapes, negotiated in a complex socio-ecological system context, can be effectively supported by:

1. Estimation of current stocks, observations of actual change (incl. forest/tree cover, demography) and inference on drivers of change, ***[more evidence]***
2. Estimation of consequences of tree cover change and more inclusive interpretation of functions, ecosystem services and tradeoffs, ***[holistic interpretation]***
3. Innovation in search for technical and institutional (governance) solutions, ***[innovative]***
4. Comprehensive analysis of scenarios of proposed solutions in the context of external trends and expected global change, ***[prospective]*** and
5. Explicit, early involvement of stakeholders that can shape political platforms of change in polycentric governance systems aimed at SDG attainment ***[change negotiation]***.

The two **Flagship hypotheses** in this context are:

1. a) Landscapes and their ecosystems provide goods, regulatory, cultural and supportive ecosystem services essential to sustainably support the livelihoods of their inhabitants.
   b) Most tropical landscapes today have sub-optimal design and management resulting in a big gap between the potential and actual multifunctional output of the landscapes.
   c) It is possible to significantly improve the design and management of the landscapes to close the multi-functionality gap.
2. Any generic theory of desirable change needs localization, given the global diversity in landscape patterns, path dependency of historical changes within the broad spectrum of governance options, wider economic linkages, and current gender equity and youth ambitions.

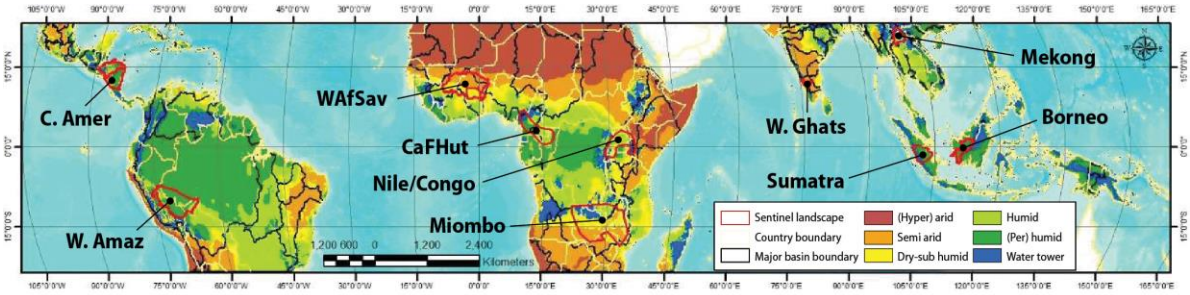
Scope and geography

Our main **research questions** and clusters of activity derive from this perspective on the body of scientific evidence on multi-functionality in practice. Our theory of change is built on a sequencing of four major research questions that can jointly lead to more informed decisions and negotiations at the landscape level, interacting with household and national or global-scale decisions, policies and discourses. These are:

1. What are the **current patterns and intensities of change** in tree cover?
2. What are the **consequences of such changes** for ecosystem function and services?
3. How does landscape diversity **contribute to human well-being and healthy diets**?
4. How can efficient and fair landscape governance emerge that influences **the generic drivers** and/or **community and household level incentives** to increase multi-functionality

To answer these questions in their local context, a network of landscapes selected to represent broad agroecological zones (Figure 1) is used for four clusters of activities: 1. Landscape observatories[2], 2. Landscape mosaics, biodiversity and ecosystem services, 3. Healthy diets from diverse landscapes and 4, Adaptive landscape institutions: “learning landscapes”.

[2] Previously termed Sentinel Landscapes by FTA.



Agroecological zone (indicative mean annual rain-fall range)	Target geography (Sentinel landscapes: most have multiple zones)	Human population density: (min)–mean–(max) km^{-2}; forest%[B]	ES issues related to dominant land uses[A]; **degradation** (loss of ecosystem services due to loss of ecosystem function)	Recovery, restoration, agro-forestation
Drylands: 17.6% of tropical area; 2.2% of tropical population (6.9 km^{-2}) 0% of SL area	No specific research landscapes, methodo-logical support for work in the Livestock and DCL CRPs where trees support drylands	No sentinel landscapes	Few high-value tree crops; overharvesting of trees for fuelwood; annual fires; overgrazing by livestock; wind erosion; irrigation agriculture islands of functioning subhumid with risk of salinization	Specific attention to migratory circuits and routes for wildlife and pastoralists
Semiarid: 16.9% of tropics; 15.2% of people (49.8 km^{-2}) 21% of SL area	**W. Africa Savanna** (Ghana/ Togo/ Burkina Faso/ Mali)	(6)–49–(1758) 0% forest (at >50% cover)	Location-specific opportunities for tree-based participation in global markets; overharvesting of com-mercial timber and within urban reach for charcoal; land clearing for crop production; annual fires; local climate effects of tree cover change.	Controlled use of remaining forests, legalization of woodfuel trade as basis for investment; recognition of mesoclimatic effects of tree cover in 'parklands' context.
Dry-Subhumid: 9.8% of area; 12.0% of people (67.68 km^{-2}) 20% of SL area	**E. African Miombo** (Zambia, Malawi, Mozambique)	(0)–23–(4727) 14% forest		
Water towers: 10.8% of area; 15.8% of people (80.8 km^{-2}) 15% of SL area	**Nile-Congo Water-towers** (Uganda /Kenya)	(0)–172–(17,025) 14%	Expansion of highland crops and vegetables; coffee, tea, cacao; overharvesting of commercial timber; highly vulnerable biodiversity (endemics); changes in local climate; modified water flows; erosion/ sedimentation; loss of soil C and nutrients	Recognition of specific hydrological functions, including attention for riparian zones as key to buffering, and ecological connectivity; incentives need to match downstream (incl. urban) interests
	S. Asia Water towers (W. Ghats in India)	(118)–240–(1360) 43%		
Humid forest: 19.7.2% of tropics; 22.0% of people (61.9 km^{-2}) 19% of SL area	**Mekong** (China, Laos, Vietnam, Thailand)	(7)–43–(301) 67%	Convertible to coffee, tea, cacao, rubber, bananas, oil palm, pasture. Overharvesting of commercial timber; connectivity loss ecological corridors; changes in local climate; soil compaction; erosion/ sedimentation; loss of soil C and nutrients	Shift from monoculture tree crops to diversified agro-forestry options; restoration of degraded pastures; spatially explicit forest restoration for biological corridor; changes in land tenure may be needed
	C. America (Nicaragua/ Honduras)	(0)–56 –(70) 63%		
(Per)Humid lowland forest zone: 25.2% of tropics; 32.9% of people (72.3 km^{-2}) 25% of SL area	**W. Amazon** (Peru/ Paraguay/ Brazil)	(0)–3–(228) 92%	Convertible to oil palm, rubber, pulp & paper plantations. Logging along rivers, and major roads; overharvesting of commercial timber; high biodiversity loss; erosion/ sedimentation; loss of soil C and nutrients; peatland issues	Opportunities for domestication and increased use of local resources may require change of rules for market access; changes in land tenure may precede ecological recovery
	CAFHUT (Came-roon/Congo/**DRC**)	(1)–33–(5622) 82%		
	Insular SE Asia (Sumatra/**Borneo**)	(0)–45–(8705) 58%, 73%		

A. Mining causes local ES loss in all zones; tree-based restoration options are differentiated by climate zone; while private-sector restoration is mandated in mining contracts, large areas of past damage require public restoration sources

B. Forest percentage, with threshold at >50% tree cover

Figure 1. Five ecological zones in relation to forest transition, with four prioritized for FTA Phase II Sentinel Landscapes

2.4.1.2 Objectives and targets

Objectives

The objectives of the Flagship project are to contribute to the knowledge base and operational modalities needed to achieve four elements of the intermediate development outcome targeted in the CGIAR Strategy and Results Framework (SRF):

- Land, water and forest degradation (incl. deforestation) minimized and reversed (35%)
- Increased access to productive assets, including natural resources (20%)
- Increased access to diverse nutrient-rich foods (20%)
- Increased resilience of agroecosystems and communities, especially those including smallholders (15%)
- Improved capacity of women & young people to participate in decision-making (10%)

Table 1. Investments by sub-IDOs

Sub-IDOs	Amount needed (million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
3.2 Increased livelihood opportunities (Sub-IDO 1.3.2).	13	21.5	0	78.5
4.5 Increased access to productive assets, including natural resources	11	21.5	0	78.5
B.1 Gender---equitable control of productive assets and resources	6	21.5	0	78.5
5.2 Increased access to diverse nutrient-rich foods	11	21.5	0	78.5
D.1 Enhanced institutional capacity of partner research organizations	10	21.5	0	78.5
8.1 Land, water & forest degradation (incl. deforestation) minimized and reversed	27	21.5	0	78.5
B.3 Improved capacity of women & young people to participate in decision-making (Sub IDO B.3)	12	21.5	0	78.5
10.1 Increased resilience of agroecosystems and communities, especially those including smallholders	14	21.5	0	78.5
7.1 Improved water quality	3	21.5	0	78.5

The specific contribution FTA Landscapes will make to these CGIAR portfolio level development outcomes and synthetic international public goods (IPG's)[1,2,3] are expected to occur at four interconnected scales:

IPG's: Global theories of place-change interaction across SDGs ("change of theory"), connectivity across global value chains

National capacity in key countries/regions: Technical and professional capacity to work in the interdisciplinary and multi-sectoral contexts needed to support multifunctional landscapes is enhanced as universities adopt and adapt modern forestry/ agroforestry/ landscape curricula ("theory of change of theory")

Subnational scale implementation: Better informed and equitable planning and governance mechanisms for landscapes, land use plans, rights and ES-incentives ("theory of change" tested; theory of place articulated as part of options in context concepts)

Local scale (Tier 3, see below): Landscape stakeholders, incl. farmers, and (private/public) beneficiaries co-invest in adaptive management ("theory of change within theory of place" translated into action)

Research efforts will be managed to achieve targeted development outcomes across scales, with cluster of activity organized around one major outcome each.

Table 2. Outcomes by windows of funding

Outcomes	Amount needed (million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
4.1 (Sub)national governance systems in at least 10 countries use contextualized theories of change to guide transitions to integral achievement of sustainable development goals through restoration, conservation and management of landscape multi-functionality, using similarity domains based on patterns and intensities of forest and tree cover change in space and time in Sentinel Landscapes understood on the basis of 'drivers' that operate at larger scales.	21	21.5	0	78.5
4.2 (Sub)national governance systems in landscapes covering 100 M ha and inhabited by 70 M people use quantified and valued functions of FT&A for biodiversity, full hydrological cycle and ecosystem services analyzed across knowledge domains and available for policy-level synthesis and planning.	32	21.5	0	78.5
4.3 Diverse diets from tree cover in mosaic landscapes recognized and enhanced as contributions to balanced diets through Increase of availability, and access to, nutrient---rich wild and cultivated food products from these landscapes (10 Sentinel Landscapes; 10 M people)	21	21.5	0	78.5
4.4 Adaptive landscape institutions empowered and supported on 6 M ha inhabited by 4 M people to manage changing landscape mosaics towards more balanced and adaptive multi-functionality and successful 'forest landscape restoration' through 'action research' and inclusive, participatory learning. This is aligned with efforts in PIM.5.2 "6 million hectares of shared landscapes under more productive and equitable management".	32	21.5	0	78.5
Total	**107**	**21.5**	**0**	**78.5**

Targeted outcome 1 (20% of resources)

(Sub)national governance systems in at least 10 countries use contextualized theories of change to guide transitions to integral achievement of SDGs through restoration, conservation and management of landscape multi-functionality, using similarity domains based on patterns and intensities of forest and tree cover change in space and time in landscape observatories understood on the basis of 'drivers' that operate at larger scales.

Targeted outcome 2 (30% of resources)

(Sub)national governance systems in landscapes covering 100 M ha and inhabited by 70 M people use quantified and valued functions of FT&A for biodiversity, full hydrological cycle and ecosystem services analyzed across knowledge domains and available for policy-level synthesis and planning

Targeted outcome 3 (20% of resources)

Diverse diets from tree cover in mosaic landscapes recognized and enhanced as contributions to balanced diets through Increase of availability, and access to, nutrient-rich wild and cultivated food products from these landscapes (10 landscapes; 10 M people)

Targeted outcome 4 (30% of resources)

Adaptive landscape institutions empowered and supported on 6 M ha inhabited by 4 M people to manage changing landscape mosaics towards more balanced and adaptive multi-functionality and successful 'forest landscape restoration' through 'action research' and inclusive, participatory learning. This is aligned with efforts in PIM.5.2 "**6 million hectares of shared landscapes under more productive and equitable management**".

2.4.1.3 Impact pathway and theory of change

Our theory of 'how change happens' is that knowledge generated on the four research questions described above can be used (as active 'theory of how we help the world to change') to support specific impact pathways according to tiers of research applicability:

Tier 1: agro-ecological zones and the recognized domains of socio-ecological system similarity (**theories of place**), overlain by national boundaries and differentiated systems of governance; impact at this level generally depends on policy change, informed by ideas and experience at tier 2, plus long term changes in human capacity supported by change in curricula

Tier 2: 'learning landscape' action research efforts that benefit local actors (incl. farmers) and contribute to international public goods by tested paradigms, concepts and generic **theories of change**

Tier 3: landscape observatory sites with intensive data collection for monitoring and unraveling the **complexity of change** as it happens without specific project interventions.

In research we zoom in from Tier 1 to Tier 3, with site selection for Tier 3 geared towards explicitly known 'representativeness' and 'salience', to facilitate the learning of lessons, by zooming out, for Tier 1 application elsewhere. The forest transition theory of FTA phase I will still form a first step to theories of place[4,5]. Water flows are a major functional connector of landscape elements, and a dominant argument for protecting and restoring parts of it[6,7] Landscape level effects on nutrition and dietary diversity provide a new entry point for policy[8].

In line with the impact pathway and theory of change, the Flagship project was designed (**Figure 2)** with four clusters of activity (CoA) that differ in research approach and focus, but interact on an enriched understanding of context ('theory of place') and system dynamics ('theory of change'). The geographic domains selected as landscape observatories or learning landscapes (beyond the sites characterized in Phase 1) are the primary focus of FP 4. Existing efforts on forest landscape restoration, enhancement of nutritional diversity, use of economic instruments in enhancing ecosystem services and integrated conservation efforts in learning landscapes are testing the relevance of the similarity domains at tier 2 level, beyond the mapped boundaries of the Sentinel Landscapes.

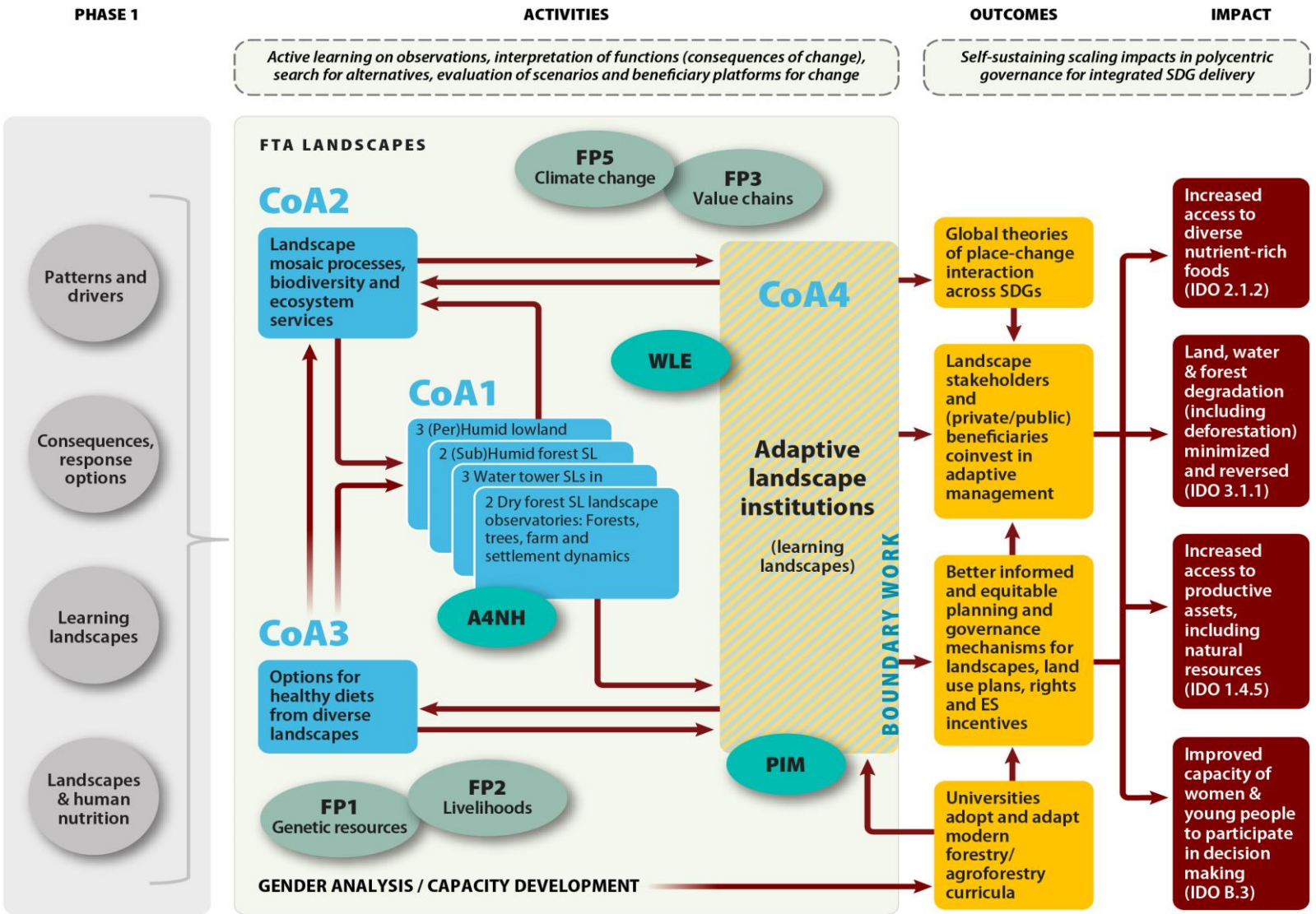


Figure 2. Schematic relationship between structure in Phase 1, CoA's in Phase II, the generic types of outcomes targeted in boundary work, and the CGIAR Intermediate Development Outcomes (IDO). These are related to; interactions with other FPs in FTA and three integrative CRPs (PIM, WLE and A4NH) are indicated

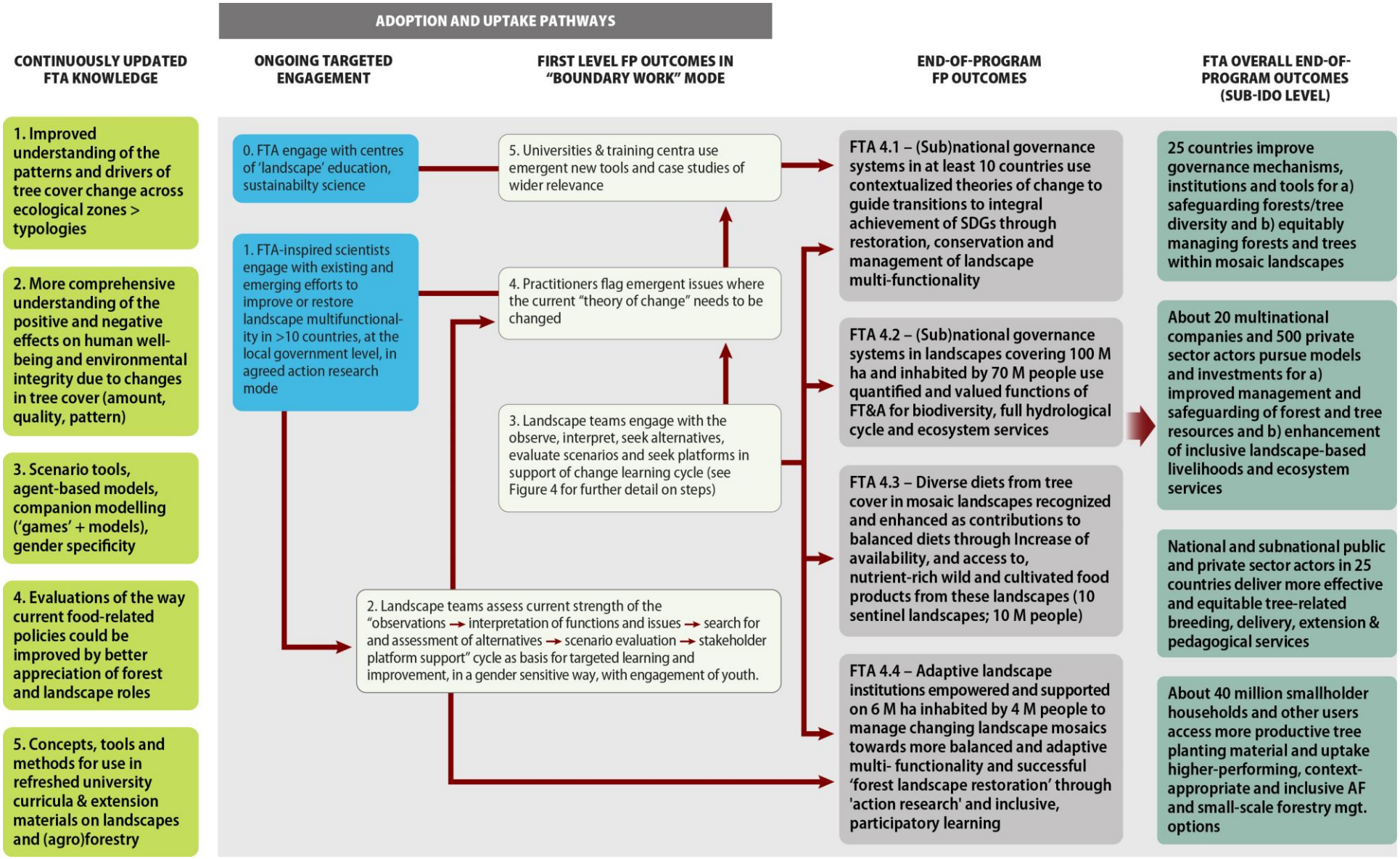


Figure 3A. Theory of change for the landscapes Flagship project.

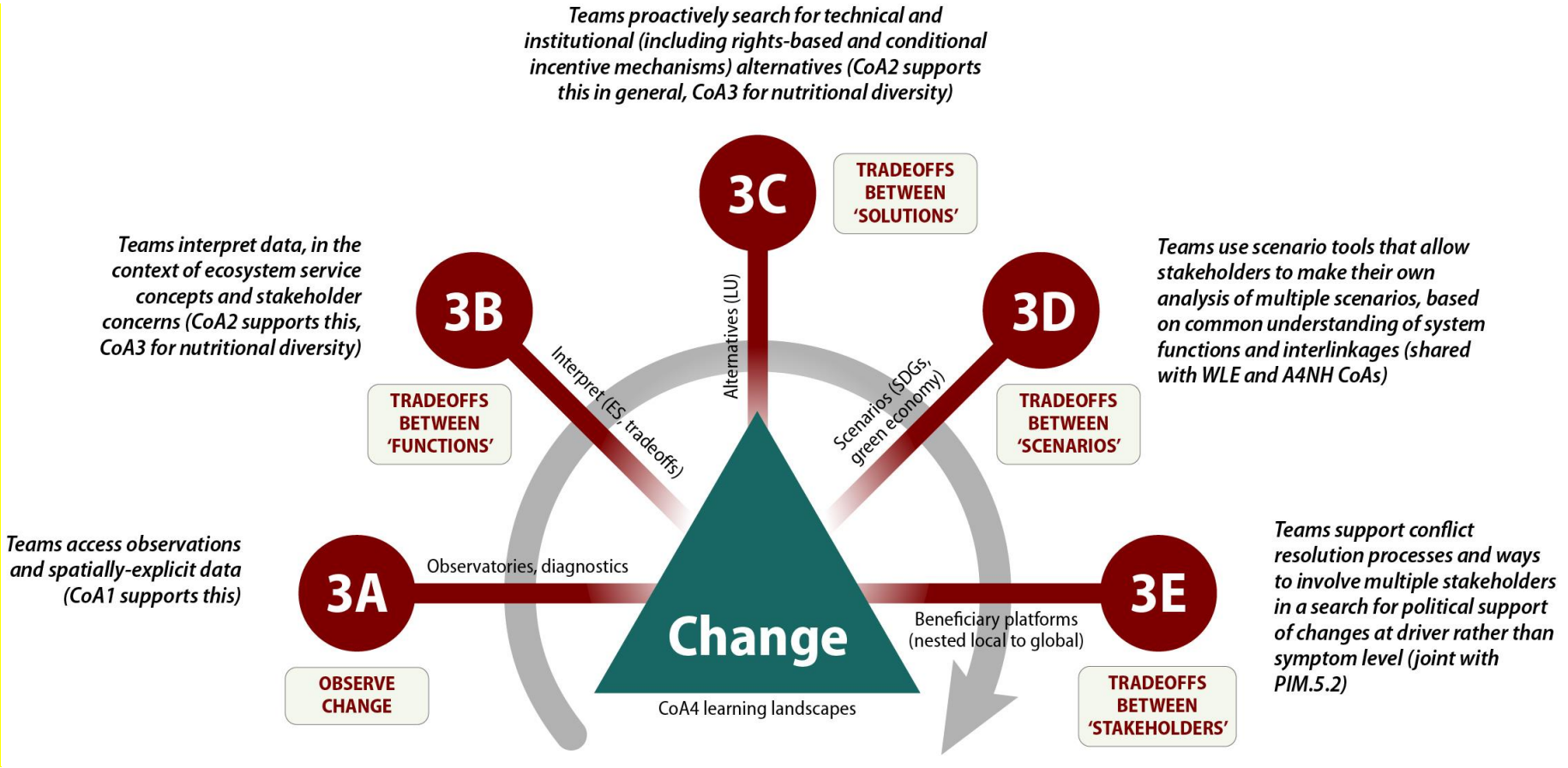


Figure 3B. The learning loop in 'learning landscapes' as part of overall theory of change.

Table 3. Example of how a landscape systems approach can lead to location-specific project ToCs

Question	Topic	Theory of change	Project articulation
Why?	Drivers of current/recent/past degradation? Leverage or nudge?	Change of rules, incentives, motivation?	Approach
Who?	Who are actors and stakeholders of what led to current (degraded?) state	Free and Prior Informed Consent?	Actors
What?	What land uses and ecosystem components support on-farm and off-farm livelihoods; what are options for change?	land use change, livelihood options, value chains?	Means, interventions
Where?	Landscape configuration, lateral flows, buffers, filter effects?	Spatial zoning?	Targets (spatially explicit)
So what?	Ecosystem service change?	Restoration potential, urgency of protection	Objectives (rationale)
Who cares?	Common but differentiated responsibility across scales	Which combination of carrots, sticks and sermons can be used?	Co-investment (rights-based, financing)

Boundary work: the 'learning landscapes' cluster of activity on adaptive landscape governance (CoA 4.4) provides the primary interface with local stakeholders (incl. government agents, private sector, local communities) to ensure that science can move from 'enlightenment' to 'decision support' and 'negotiation support' modes.

Youth considerations: employment and business opportunities in dynamic multifunctional landscapes are an explicit consideration for the integrative planning tools; engagement of young people in the process can energize the search for innovative solutions, the sense of urgency and legitimacy of what is proposed.

Gender aspects: process-level inclusive engagement across gender and social strata is key to the theory of change; explicit attention to resource access and land tenure has a strong gender dimension in terms of targeted outcomes[9,10,11].

2.4.1.4 Science quality

The interdisciplinary science of landscapes is still relatively young. Policy-driven discourse – such as 'land sparing versus sharing versus caring' or attractiveness of Payment for Ecosystem Services (PES) schemes as basis for REDD+ – are not sufficiently recognizing earlier progress. That includes the segregating versus integrating comparisons; scale-dependent conclusions on tests of the Borlaug intensification hypothesis; political and social context of instruments perceived to be primarily economic in nature; rich lessons on human decision-making of behavioral economics beyond 'rationality'. The CIFOR-led exercise to have target groups of practitioners identify their top questions, T20Q, framed two questions on greening business models, but 18 others on restoration, integration of local knowledge, environmental services, landscape approaches and rights and benefits. Generic answers on all these exist, supported by the outputs of related FTA research in Phase I (395 journal articles, 129 book chapters, 26 books per 1 March 2016). However, specific support for localizing the generic principles in project-level theories of change remains in demand. It characterizes most of the bilateral/W3 funding for FTA's landscapes agenda, ensuring that it is aligned with real needs on the ground.

FTA Landscapes science consists of three parts, balanced within funding realities:

1. Uses current methods and concepts ("Theory of change") in practical applications, often in bilaterally funded projects that align with donor priorities for location and context specific problem solving, with sufficient predictability to convince an application-oriented investor,
2. Closes in on 'paradigm shifts' ("Change of theory") where existing, dominant ideas and common assumptions don't seem to align with the observations and emerging facts ('changing the theory of change'), and
3. Tests new ideas, concepts and methods that have the potential to be game-changers, but that so far lack 'proof of principle'.

Research of Type B is a primary target for W1/W2 funding, with increased investment in the more risky Type C if more funds become available.

Table 4. Examples of research topics in the three parts of the FTA Landscapes portfolio

C. New ideas, seeking 'proof of principle', extending theory	B. Closing in on paradigm shifts	A. Utilizing current paradigms in practical applications
'Ecological rainfall infrastructure' and 'biological rainfall generation': vegetation effect on hydroclimate	Co-investment, compensation and commodification as PES paradigms	Negotiation Support process reconciling local, public/policy and science-based knowledge
Typology of landscape configurations beyond 'forest transition curve' stages	Land equivalent ratios as indicator of potentially negative yield gaps at landscape scale	Land use for multiple environmental services (LUMENS) as spatial planning tool for local governments
Agent-based models of (gendered) land use decisions interacting with rule-based governance options	Tree diversity transition curves as underpinning of proactive management	Forest landscape restoration based on contextualized understanding of driver+ actor+ pattern+ consequences
Tree functional/life-history traits[12] as basis for biodiversity and ecosystem service management	Quantified buffer functions used in climate downscaling	Tenure reform as basis for increased landscape multi-functionality
Reconciling 'five capitals' concept, investment and ES-dividends[13]	Gendered understanding of land use change preferences	Explicit recognition of forest-based scenarios for inclusive food security[14,15]
Trees on farms: single-tree ecosystems and their goods and other ecosystem services	Scattered trees on farms as source of ES, likely to be high per unit biomass	Assessment of the contribution of trees on farms to provision of ecosystem services at the landscape level

FTA operates, across these three types of science in four out of five broad agroecological zones (Figure 1), each represented by two to three landscape observatories characterized in FTA Phase I as Sentinel Landscapes. We expect the FTA effort to be allocated across the six ecological zones at approximately <5 (drylands), 15, 15, 15, 20 and 30%, respectively. Within each of the five prioritized zones, FTA Phase II will work across the range of landscape configurations that represent forest and tree cover transitions and have implications for the balance between livelihoods and ecosystem services (Figure 4).

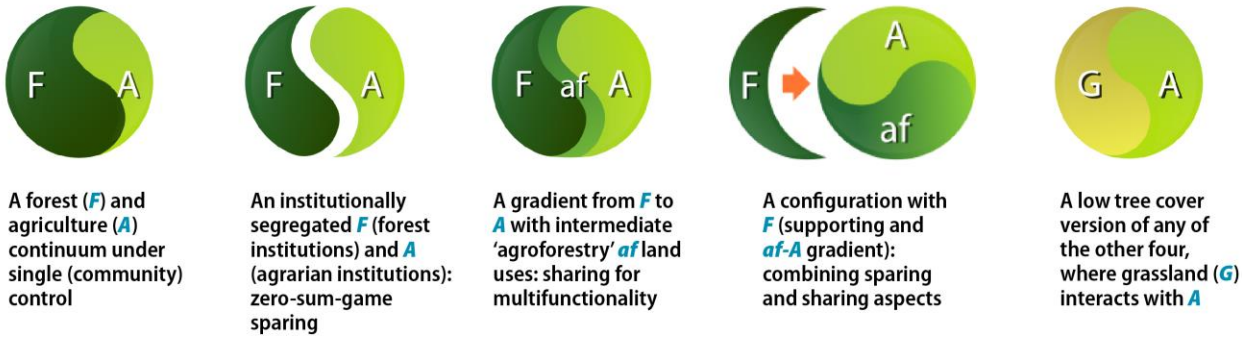


Figure 4. Five-step classification of landscape configurations derived in Phase I[16,17]

Research team niche and qualifications

The forest transition focus of Flagship 4 provides a broad vision of the integrated institutional change needed to achieve the CGIAR System Level Outcomes. The team includes: Ecologists, Economists, Geographers, Geoscientists, Social scientists, Anthropologists, (Agro)foresters, Nutritionists and Statisticians. 31 scientists with Scholar.Google h-factor of at least 10. Two of the top-ten CGIAR scientists based on total citation scores in Scholar.Google, ten of the top-hundred. Five out of 11 scientists in the core team of the Flagship, and 17 out of top 40 scientists are female.

Table 5. Key scientists involved (CVs in Annex 3.8)

Name, institution	Original discipline	H	Total cited	Rank in CGIAR	FP4 role
Meine van Noordwijk, ICRAF[#1]	Ecologist, modeler	63	18156	3	FP4 leader, WLE
Terry Sunderland, CIFOR[#2]	Ecologist	28	3518	61	FP4.1 leader, A4NH
Peter Minang, ICRAF[#3]	Social ecologist	18	1108	176	FP4.2 leader
Eduardo Somarriba, CATIE[#4]	Agroforester	30	3765	58*	FP4.3 leader
Beria Leimona, ICRAF[#5]	Env. economist	16	924	191	FP4.4 leader
Delia Catacutan, ICRAF[#6]	Social scientist	15	779	234	FP4.4,PIM liaison
Bryan Finegan, CATIE[#7]	Forest ecologist	32	5030	45*	FP4.2 focal
Laura Snook, Bioversity[#8]	Forest ecologist	16	1106	155	FP4.3 focal
Rene Boot, TBI	Ecologist	22	2056	102*	FP4.4 focal
Sonya Dewi, ICRAF[#9]	Spatial ecologist	18	1311	151	FP4.2 focal
Stepha McMullin, ICRAF	Social scientist	1	1		FP4.4 focal
Douglas Sheil, CIFOR assoc	Ecologist	49	8681	18*	FP4.2 scientist
Christine Padoch, CIFOR	Anthropologist	43	5160	35	FP4.1 scientist
Sven Wunder, CIFOR[#10]	Economist	44	13369	9	FP4.2 scientist
Manuel Guariguata, CIFOR	Forester	35	5589	30	FP4.1 scientist
Jianchu Xu, ICRAF	Ethnoecologist	33	8290	19	FP4.2 scientist
Robert Nasi, CIFOR	Forester	33	4180	44	FP4.3 scientist
Ingrid Oborn, ICRAF	Soil scientist	26	2217	91	FP4.2 scientist
Ravi Prabhu, ICRAF	Forester	23	2696	73	FP4.4 scientist
Rhett Harrison, ICRAF	Ecologist	22	2014	103	FP4.1 scientist
Barbara Vinceti, Bioversity	Forest ecologist	20	1637	122	FP4.3 scientist
Cheikh Mbow, ICRAF	Geographer	20	1889	112	FP4.2 scientist
Suyanto, ICRAF	Economist	18	938	185	FP4.2 scientist
Glen Hyman, CIAT	Geographer	17	1103	165	FP4.1 scientist
Robert Zomer, ICRAF	Geographer	17	1281	145	FP4.1 scientist
Betha Lusiana, ICRAF	Statistician	15	2460	82	FP4.2 scientist
Evert Thomas, Bioversity	Ethnobotanist	14	527		FP4.4 scientist
Grace Villamor, ZEF, ICRAF assoc	Modeler	13	423		FP4.2 scientist
Tor Vaagen, ICRAF	Geo-scientist	12	764	225	FP4.1 scientist
Rachmat Mulia, ICRAF	Statistician	11	381		FP4.2 scientist
Amy Ickowitz, CIFOR	Economist	10	939	175	FP4.3 scientist
Katja Kehlenbeck, ICRAF assoc	Agroforester	10	352		FP4.3 scientist
Ujjwal Pradhan, ICRAF	Social scientist	10	367		FP4.4 scientist

Diversity analysis
Male: 21, Female: 12

Continent of origin
Asia: 10, Africa: 2, Latin America: 2, Europe: 14, North America: 5, Pacific: 0

2.4.1.5 Lessons learned and unintended consequences

Beyond location-specific lessons learned from characterization of the Phase I Sentinel Landscapes, and guidance from FTA evaluation, five lessons in particular were used to prioritize the new Flagship project:

1. The initial forest transition hypothesis was expanded as a theory of change interacting with 'theories of place', defining domains of similarity and the degrees of freedom in deviating from 'destiny' in the way forests and human population density interact. We will use these insights in communicating landscape perspectives across FTA and the CRP portfolio of CGIAR.
2. Conceptual development progressed on how payments for environmental services (PES) can be more effective, and how commodification, compensation and co-investment concepts relate to each other and to application domains[18,19] We aim to take further steps in CoA 4.4.
3. New insights were derived on the way forests, trees and water interact at the landscape and (sub)continental scales. New activities on the full hydrological cycle in CoA 4.2 will follow this lead.
4. Guidance was derived on how a landscape approach can be implemented and a toolbox on (gender-sensitive) negotiation support was launched[1]. This will serve as an example for our theory of change on how a synthesis of locally derived lessons can inform global debate and set new standards.
5. New perspectives emerged on the roles of forests, trees and agroforestry for dietary diversity and food security. As a specific interest within the wider ecosystem services discourse, global prioritization of this issue shaped our CoA 4.3 and guided global forestry policy processes[20].

Unintended consequences of our type of engagement at landscape scale have been noticed where latent vertical and horizontal conflicts (hidden from view by existing power structures, between local communities, government and private sector, or between communities) change to open conflict stage. Challenging *status quo* on tenure and access of forest can increase perceived conflict before situations improve. In such situations the legitimacy *dimension* of science quality is as important as the *credibility* and *salience* dimensions: it is important who the messenger is and how it is brought, beyond what the message is. The shared experience in the negotiation support toolbox provides some guidance on how to avoid unintended consequences of this type to spiral out of control.

Recognition of the complexity of landscape-scale change can slow down the implementation of policies, such as REDD+, that were designed with a simplified scheme of land cover (e.g. forest vs. non-forest) as basis[21]. Mitigating this type of risk is possible where understanding of the complexity is shared in an early stage of an "issue cycle", where a different perspective on definitions and framing can avoid the false coalitions that fuzzy concepts can induce otherwise, but that don't lead to implementable policy.

The use of economic instruments to internalize ES externalities in land use decisions has led to a discussion of motivational crowding out: payments can undermine existing social cohesion and motivation for environmental management. Part of the FTA.Landscapes research has tried to ascertain the risks involved, with a perspective on longer-term sustainability, rather than metrics at the time scale of typical projects. The downsides of existing PES experiments are shared with wide audiences alongside the positive experiences, to reduce the risk of naïve upscaling with unintended consequences remaining unmanaged.

2.4.1.6 Clusters of activity (CoA)

CoA 4.1 Landscape observatories: Forests, trees, farm and settlement dynamics

Problem statement and rationale.

This CoA is designed to maximize its interactions with all other parts of the FTA CRP that require data on actual tree cover change and countries that have commitments to the Aichi targets of the CBD, Bonn Challenge and associated reporting obligations. The observatory function of monitoring actual change in 10 landscapes selected to represent 5 major agroecological zones will continue the ***'Sentinel Landscapes'*** of Phase I, and plan for a second characterization around 5 years after the initial one. It links between wider

agroecological zone concepts and the observatories, supporting analysis of representativeness and extrapolation domains of site-based studies across FTA.

Targeted outcome FTA.4.1 (see above)

Hypothesis: Forest and tree cover transition as process interacts with social, political, economic and ecological factors in ways that allow the recognition of similarity domains, supporting out- and up- scaling of theories of change where an integrated landscape approach is used.

Key research questions:

1. ***Who*** are the actors and stakeholders of the landscape, in a historical-political perspective on (claimed) rights, an economic perspective on livelihoods and value chains and a cultural-social perspective on identity and aspirations?
2. ***What*** land use systems are present ***where*** in the landscape and what are **current patterns and intensities of change** (tree cover, objectively observable aspects of forests, farms, other land uses) in space and time
3. Can observed changes be understood (***'why?'***) on the basis of drivers that operate at larger scales, demography and economic policies?

Question 1 implies differentiation by gender and age as sub-questions in the fact-finding stage.

Key deliverables

2017 Identified similarities (tier 1 & 2) connected to 10 Sentinel Landscape data sets, used as basis for planned impact studies of interventions across all FTA FP's, and linked with SDG performance planning and monitoring in 10 countries. Decision support tools for approaches (natural regeneration or planting), species (seed sources) for landscape restoration adopted within three countries with Bonn Challenge pledges.

2018 Adjustments to portfolio of Sentinel Landscapes for round-2 characterization based on explicit account of representativeness for wider domains, track record of connecting results to local development planning (local governments and external supporting agencies) and interventions balancing livelihood opportunities and reversal of land degradation and deforestation. Decision support tools for sites and objectives for restoration of forests, at the landscape and local scale, tested and adopted in three priority countries.

2019 Second round surveys of conditions and trends in at least 10 Sentinel Landscapes, tailoring surveys to the integral SDG portfolio and its internal tradeoffs, with strong roles for local partners

2020 Second round surveys of conditions and trends in Sentinel Landscapes completed, changes documented, interpreted, and linked to national SDG reporting systems.

2021 Scenario studies and participatory development planning results for at least 10 Sentinel Landscapes that make use of rounds 1 + 2 results, aligned with national goals and international commitments (incl. Aichi targets of CBD, UNCCD and UNFCCC modalities)

2022 Use of FTA research results in evaluation of SDG performance and adjustments to the goals and means of implementation. Countries in Africa, Latin America and Asia, guided by FTA-informed practices and policies, successfully establish on degraded land millions of ha of self-sustaining forest that benefit local communities.

CoA FTA.4.2 Landscape mosaics, biodiversity and ecosystem services

Problem statement and rationale.

This CoA is coordinated with the **Ecosystem Services Flagship in WLE**, the Ecosystem Services Partnership and FutureEarth groups in the academic world. It will use a variety of methods to unravel the complex relations between human well-being and ecosystem services as affected by (bidirectional) tree cover change and its effects on biodiversity, water quantity, quality and regularity of flow. What degree of 'restoration' is feasible and how can climate change adaptation be built into traditional "steady-state" restoration concepts? Location-specific studies of ecosystem service issues will be used to test and further develop classifications,

such as a recent '10 prototypes' list of tree-related watershed services in specified 'theories of place'. New efforts will be made to understand the role of terrestrial evapotranspiration and associated plant functional traits. This will especially examine the roles of trees and forests in rainfall elsewhere on the same continent based on prevailing winds, and more specific hypotheses about 'bioprecipitation' and 'biotic pump' that suggest further agency for vegetation. A combination of methods will use coupled soil-vegetation–atmosphere models, dendrochronological reconstructions of past water sources (land versus ocean derived), and reconstructions of specific 'teleconnections'.

Targeted outcome FTA.4.2 (see above)

Hypothesis: Spatial and temporal configurations of forests and trees on farms in landscape mosaics at various scales (landscape, watershed, farm, plot) matter for the way ecosystem services change with scale; understanding of the scaling rules can be used in planning land use for multiple ecosystem services.

Key research questions:

1. What are the **consequences of changes** ('so what?' and 'who cares?') in quality, quantity and spatio-temporal configuration of forest and tree cover in landscapes for ecosystem functions that underpin the provision of usable goods and other ecosystem services (with specific attention to biodiversity and the full hydrological cycle e.g. effects on terrestrial recycling of rainfall, safe drinking water, water-sustainable agricultural intensification, and regulated water flows)
2. How are perceptions and preferences of ecosystem functions differentiated by gender, ambitions of young people and intergenerational aspects?
3. How can stakeholders of the (unintended) consequences of landscape change achieve **leverage on the drivers** of change, through a combination of rights-based approaches (incl. land use planning, tenurial reform), economic instruments (generic tax/subsidy, specific performance-based contracts) and motivational factors (addressing perceived 'fairness', 'environmental justice')?
4. How can existing 'green economy' planning tools for land use for multiple ecosystem services be improved, adapted and adopted more widely?

Questions 1 and 2 imply differentiation by gender and age as sub-questions.

Key deliverables

2017 Assessment of effects of tree cover change on rainfall patterns and variability at continental scales, combining global circulation models with qualified tree cover data, quantified water balance data, dendrochronological evidence of past change and vulnerability of livelihoods

2018 Synthesis of options for achieving Aichi targets of biodiversity conservation through managed transition zones around protected areas, landscape connectivity and ecological corridors and development zoning utilizing full spectrum of FT&A land use systems

2019 Valuation studies that relate human and social capital benefits across scales to changes in forest and tree cover as indicators of ecosystem services in local context, as contributions to national and international debate (incl. IPBES)

2020 Reevaluation of co-benefit relations among global conventions (CBD, UNCCD, UNFCCC) at landscape scale, utilized in international discourse

2021 Impact study of shifts in gender-equitable control of productive FT&A assets and resources. Policy options to favor sustainable restoration of tree-based ecosystems adopted by at least 3 countries that have made pledges to meet international agreements

2022 Re-assessment of new evidence of effects of tree cover change on rainfall patterns and variability at continental scales, combining global circulation models with qualified tree cover data, quantified water balance data and dendrochronological evidence

CoA FTA.4.3 Healthy diets from diverse landscapes.

This CoA will be further developed to match the Food Systems for Healthier Diets Flagship through specific attention to the way landscape diversity can contribute to healthier food systems and diets across forests and tree based systems/agroforestry[22]. It combines analysis of landscape-level patterns, with a focus on the various components of healthy diets and the way these can be derived in complementary ways from shifting cultivation, home gardens, landscape mosaics, and forests of a range of management intensities. Its theory of change is based on the lack of visibility in the current policy arena of the way food security and diverse diets depend on trees and forests (e.g. along the five landscape configurations used for characterizing the landscape observatories; see above). Identifying the opportunities and issues recognized is a first step, but requires well-chosen and adequately quantified case studies, as well as analysis of global datasets. The CoA will take a Research in Development approach with participatory action research to explore year-round portfolio solutions and options within local economic and social contexts. This includes management and improving available diversity of tree foods particularly nutrient rich fruits, vegetables, nuts and oils, and early steps will be taken towards domestication of wild edible mushrooms, fish dependent on forest streams, edible insects, bushmeat and tree products as part of diverse diets with sustainable harvest intensities. The CoA will provide information to land planners, decision-makers, development agencies and communities on the contribution of forests and trees on farms to local food security and strengthening rural-urban food system linkages. The evidence will be used for developing interventions, implementing them and evaluating failures and success as basis of further learning (as in CoA4).

Targeted outcome FTA.4.3 (see above)

Hypothesis: Landscape mosaics with partial forest cover and agroforestry support nutritional diversity and human health beyond their current weak recognition in policies aimed at increasing food security

Key research questions:

How does landscape multi-functionality **contribute to human well being and healthy and diverse diets** through the (local) availability of and access to improved tree food sources as well as wild foods (i.e. provisioning services part of the wider ecosystem services concept)?

The question implies differentiation by gender and age as sub-questions.

Key deliverables

2017 Stock taking of statistical data sets that link dietary diversity to species-level and genetic diversity of agricultural and associated landscapes and process-level models that interpret this in terms of availability, access and behavioral patterns, setting priorities for further work by FTA and partners

2018 Analysis of priorities and options for developing capacities of value chain actors (including input suppliers, producers, processors, retailers and traders) on production, post-harvest handling, processing, marketing and consumption of nutrient-rich foods derived at landscape scale

2019 In at least 5 landscapes: Increased on-farm production of a diversity of fruits, nuts, vegetables and legumes, and increased amount of collected wild resources including wild fruits, vegetables, bush meat, mushrooms, insects and fish from forests

2020 In at least 5 countries: Increased value capture by producers/collectors of nutrient-rich food; reduced post-harvest losses of wild and cultivated nutrient-rich food; increased incomes and employment

2021 In at least 5 countries: Increased dietary diversity of low-income rural and urban consumers using a variety of nutrient-rich wild and cultivated nutrient-rich food available during economic, social and/or environmental shocks

2022 Impact study of the effectiveness of interventions by development partners aimed at supporting dietary diversity through diverse landscapes

CoA FTA.4.4 Adaptive landscape institutions

This CoA in Tier 2 landscapes interacts with **PIM 5.1 (property rights) and PIM 5.2 (NRM governance)**. It combines the development of local governance instruments (land-use plans, green economy plans), increased

understanding how PES instruments can be effectively used to shift incentives on the ground, and an action-research perspective on the way changing mosaics can be geared towards more balanced multi-functionality. It pays specific attention to gender, youth and innovations in institutional capacity to increase ownership and voice in natural resource management. Specific attention to environmental justice concepts and their application in local institutions will lead to critical reflection on current generic theories of change and the diverse roles of agency for change. The CoA will operate as a network of networks, building on the RUPES and PRESA networks in Asia and Africa, the Model Forest Network in Latin America, new initiatives on large scale forest landscape restoration, the ASB Partnership for Tropical Forest Margins, and the Poverty and Environment Network (PEN) set of data and landscape observatories. The CoA will interface with national-level forest negotiation platforms, including those managed by Tropenbos International (TBI) in 10 countries. It interacts with capacity development partners in the emerging "Landscape Academy"

Targeted outcome FTA.4.4 (see above)

Hypothesis: Contextualized generic theories of change at the landscape scale provide an "efficiently fair" middle ground in progress towards sustainable development goals

Key research questions:

How can local and external stakeholders concerned about consequences of 'business as usual' trajectories **affect the generic drivers and/or community and household level incentives** (including economic and socially constructed ones) and rights (including tenure) to nudge land-use decisions into a more desirable direction (including land-use plans for enhanced multi-functionality, economic incentives)? How can ecosystem services be restored most effectively within landscapes in terms of both defining the desired changes (restoration to forest or agroforest, use of ecosystem services-friendly agroforestry practices) and types of intervention (regulation, incentives, markets for ecosystem services)? Key sub-questions are the ways in which gender and intergenerational empowerment can be achieved.

Key deliverables

2017 Exchange of lessons learned across the various learning landscapes associated with FTA, including a further review of existing typologies of 'payment for watershed services' settings and as basis for new action research efforts.

2018 Reflection on the multi-scale character of the 'common but differentiated responsibility' phrase that so far is primarily used at international negotiation tables but that may increase space for local adaptive landscape management.

2019 Compilation of lessons learned at landscape scale across the learning landscape networks for reporting on Aichi targets to CBD.

2020 Impact study of the further development and use of the LUMENS tool for participatory planning of land uses providing multiple environmental services. Cost-effective, multi-scale and participatory protocols for monitoring viability of restored forests developed and adopted by key countries and other stakeholders.

2021 Documented investment action of development support partners on the basis of the shared learning that links issues to places and action perspectives

2022 Next-level stock taking of how the 'payment for environmental services' debate has progressed conceptually (combining behavioral economics, applied ecology and institutional political ecology) and in evolving practice.

2.4.1.7 Partnerships

The primary partners for Flagship 5 are ICRAF, CIFOR, CATIE, Bioversity and TBI, with active participation expected from CIAT and CIRAD. Under an existing MoU, the FTA Centers are supporting the Convention on Biological Diversity (CBD) and its national parties in their implementation of the Aichi targets. The political commitment in the Bonn challenge for forest landscape restoration has led to government initiatives, such as the 20x20 initiative for Latin America of which FTA partners were among the founders.

Four strategic external partnerships are:

- Ecosystem Services Partnership (ESP), an umbrella for the academic community interested in valuation at global and local scales, implementation of payment schemes and scenario modeling at landscape and global scales. Together with WLE, FTA connects ESP to developing countries.
- The Landscapes for People, Food and Nature (FPFN) network of key development partners. FTA provides conceptual and empirical support to the evolving community of practice. Jointly with LPFN, Cornell University and CDI (Wageningen), FTA partners are among the founders of the emerging "Landscape Academy".
- The Ibero-American Model Forest Network. Model Forests are social, inclusive and participatory processes that seek the sustainable development of a territory and thus contribute to global targets related to poverty, climate change, desertification and sustainable development. 29 model forests in 14 Latin American countries cover more than 31 million hectares. Three of these countries are CGIAR tier 1 (Brazil, Perú and Guatemala) and three are tier 2 (Bolivia, Colombia and Honduras).
- The national networks of Tropenbos International (TBI), operating at the government–society interface in 10 tropical forest countries that are also mostly FTA priorities, provides national interfaces for FTA research.

Further partnerships will be developed strategically to increase the likelihood that a relevant enabling environment will emerge, with organizations that include IIASA, SEI, WRI, IUCN, WWF, TNC and the Ibero-American Model Forest Network.

2.4.1.8 Climate change

Climate change has increased the awareness of landscapes as a relevant scale at which feedback loops operate. Forests and trees can dampen the variability in climatic parameters such as maximum temperatures, wind speed and humidity and as such contribute to 'buffering' of the climate as experienced by crops, livestock and people. Loss of tree cover will increase exposure to macroclimatic variability and a reduction or reversal of deforestation can be a relevant part of human adaptation strategies, as is studied in more detail in FP5. FP4 adds a deeper understanding of buffering of hydrological cycles, with recent interest in effects on rainfall as a potential 'game changer'. Analysis of flow persistence and flood risks, as influenced by the condition ('health') of upper watersheds, helps in teasing apart the interactions of land use change and climate change on blue water availability (as basis of WLE discussions on water-focused policy issues), exposure to 'hazards' (floods, landslides), and negative effects of lateral flows (erosion/deposition cycles). Multifunctional landscapes also contribute to human resilience in the face of climatic shocks via dietary diversity, with options to retain and restore diversity in integrated development pathways that form alternatives to the simplification that has often accompanied intensification for specific commodities.

FP 4 supports the use of land use and economic planning instruments that reconcile climate change adaptation, locally appropriate mitigation actions and development ambitions – with LUMENS as current work in progress. These tools help to understand the opportunities to reconcile climate change policies (SDG 13) with the imperatives of the other SDGs.

2.4.1.9 Gender

We expect to contribute to all three gender foci related to the sub-IDOs formulated in the SRF:

B.1: Gender-equitable control of productive assets and resources: In CoA 4.1 the legends used for describing and analyzing land use need to be gender inclusive; in CoA 4.4 increased security of tenure for women is potentially important for the maintenance of ecosystem services in sensitive landscapes, while empirical evidence for this assertion is scarce.

B.2: Technologies that reduce women's labor and energy expenditure developed and disseminated: in CoA 4.2 the specific methods that are used to manage the ecosystem service consequences of land use will be evaluated in a gender sensitive way; in CoA 4.3 mothers with young children are an especially important target group of nutritional education with potential impacts on children under five years of age; CoA 4.4 will assess the effectiveness of existing informal gender-specific networks on landscape management.

B.3: Improved capacity of women and young people to participate in decision-making: in CoA 4.2 the effects of landscape level land-use change on ecosystem services will be evaluated with an emphasis on explicitly understanding the consequences for women and young people. Visioning exercises with young people will be used to explore the way landscapes and livelihoods are expected to change and the desirability of changes. These will be documented and incorporated into wider discussion; in CoA 4.4 participatory land-use planning methods that support the negotiation of effective multi-functionality will ensure full representation of all social strata (including women and young people).

2.4.1.10 Capacity development

Landscape management has evolved from singular disciplines (such as planners, architects, foresters, civil engineers, development economists) designing and managing according to disciplinary principles into a broader transdisciplinary interaction, understanding and co-management. However, universities still deliver and agencies still employ disciplinary experts. Reflexive practitioners do not come out of universities automatically, rather through exchange of practice, coded, tacit and local knowledge. FTA.LAN supports efforts to innovate in and refresh university curricula, providing opportunities for direct engagement in learning landscapes. It recently joined an initiative for a "Landscape Academy" in which the knowledge, skills and attitudes are defined that can inform curricula, existing materials are made more accessible and new modules are developed and tested. Synergy with similar other efforts is sought[23].

Capacity development elements of this Flagship are focused on four sub-IDOs:

D.1: Enhanced institutional capacity of partner research organizations: in all four CoAs national partners are actively engaged in projects, within the specific modalities required for bilateral projects, and guided by institutional agreements with host countries.

D.2: Enhanced individual capacity in partner research organizations through training and exchange: in all four CoAs there are opportunities for graduate student involvement, with a preference for staff of partner organizations and universities in regional networks associated with FTA (CapDev Element 4), and under existing arrangements with international universities (including Bonn, Cornell, Davis, Goettingen, Harvard, Uppsala and Wageningen).

D.3 and D.4: Increased capacity for innovation in partner R&D organizations: the inter- and transdisciplinary nature of ecosystem service and landscape concepts is a specific challenge for most partner research organizations, because they are mostly organized under a forestry, agricultural, environmental or socioeconomic framework. CoA 4.4 addresses adaptive landscape institutions and provides an opportunity to support innovation at local levels.

2.4.1.11 Intellectual assets and open access management

The following CGIAR IA Principles are guiding IA management in FP 4:

- Research results and development activities are regarded as international public goods for the maximum possible access;
- Partnerships are critical to ensuring access to the best knowledge and innovation to achieve maximum impact;
- Sound management of IA and Intellectual Property Rights (IPR) with integrity, fairness, equity, responsibility and accountability.

FP 4 research involves the interface of local, public/policy and science-based ecological knowledge systems, and is aware of the sensitivities regarding protection of intellectual property rights of traditional knowledge and its recognition in the CBD as a potential source of future revenue on ethnobotanical (or related) knowledge of biological resources with potential wider use. In exploring local knowledge systems FP 4 tends to focus on more generic, explanatory knowledge, and associated preferences and concerns about land use systems and landscape configurations. In current negotiation support practice, a balance is sought between protecting vulnerable informants of sensitive information and the benefits that can be obtained by more inclusive and open-access knowledge systems. We respect the concept of "Free and Prior Informed Consent" that has emerged in ecocertification and REDD+ debates, and help to further operationalize these ideas.

Subject to fund availability, FP 4 outputs will be made available under the least restrictive licensing to describe the legal rights to information products and encourage their use and adaptation. It will be published in a format that can be downloaded, indexed and searched by commonly used web applications. The outputs will

be disseminated through open access repositories to ensure it is archived and shared systematically with other Centers and made accessible as International Public Goods. See also Sections 1.0.12 and 1.0.13 of the Full FTA Proposal, including a detailed strategy for IA management in Annex 3.10 and OA/OD implementation in Annex 3.9.

2.4.1.12 FP management

Flagship 4 is led by Meine van Noordwijk, Chief Science Adviser to the World Agroforestry Centre (ICRAF), who, together with the leaders of the four CoAs and the focal points (identified in Table 5) will form a core group that discusses progress, responds to new opportunities and adjusts the annual work plans.

The four clusters of activity (CoA) are organized to add focus and depth to the overall integrative effort:

CoA 4.1 – an 'observatory' function of monitoring actual change in 10 landscape observatories (also called Sentinel Landscapes) selected to represent four agroecological zones, providing a platform for cooperation between all Flagships; the CoA will be led by an ICRAF scientist (Dr. Peter Minang) and has active participation by all FTA.4 partners, and active interfaces with all FP's.

CoA 4.2 – unraveling of the complex relations between human well-being and ecosystem services as affected by tree cover change (degradation and deforestation, restoration) and its effects on biodiversity, water quantity, quality and regularity of flow, coordinated with WLE. The CoA is led by a CATIE scientist (Dr. Eduardo Somariba) with active participation by scientists from all partners.

CoA 4.3 – new and specific attention to the way that diverse and healthy diets relate to landscape multifunctionality across the forest transition curve, coordinated with A4NH (Healthy Food Systems); the CoA is led by a CIFOR scientist (Dr. Terry Sunderland), with active participation from ICRAF and evolving interest in CATIE.

CoA 4.4 – a local governance and action research perspective on the way changing mosaics in learning landscapes can be geared towards more balanced, integrated and adaptive multi-functionality, coordinated with PIM 5.2; the CoA is led by an ICRAF scientist (Dr. Beria Leimona), with leadership in the contributing networks by CATIE, CIFOR and TBI.

2.4.2 Flagship Budget Narrative

2.4.2.1 General Information

CRP Name	Forest, trees and agroforestry Agri-food systems Program (FTA)
CRP Lead Center	CIFOR
Flagship Name	Flagship 4. Landscape dynamics, productivity and resilience
Center location of Flagship Leader	ICRAF

2.4.2.2 Summary

Total Flagship budget summary by sources of funding (USD)

Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	16,016,753	16,454,463	16,905,228	17,378,531	17,875,499	18,403,066	103,033,542
Other Sources							0
	17,863,553	18,393,603	18,941,325	19,516,432	20,120,295	20,760,102	115,595,310

Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Assumed Secured)	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3							0
Bilateral	12,521,000	5,872,500	2,936,250	1,468,125			22,797,875
Other Sources							0
	14,367,800	7,811,640	4,972,347	3,606,026	2,244,796	2,357,036	35,359,645

Funding Gap	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Required from SO)	0	0	0	0	0	0	0
W3 (Required from FC Members)	0	0	0	0	0	0	0
Bilateral (Fundraising)	-3,495,754	-10,581,963	-13,968,978	-15,910,406	-17,875,500	-18,403,067	-80,235,668
Other Sources (Fundraising)	0	0	0	0	0	0	0
	-3,495,753	-10,581,963	-13,968,978	-15,910,406	-17,875,499	-18,403,066	-80,235,665

Total Flagship budget by Natural Classifications (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
Personnel	9,072,000	9,525,600	10,001,880	10,501,974	11,027,072	11,578,426	61,706,953
Travel	1,566,500	1,571,375	1,571,375	1,571,375	1,571,375	1,571,375	9,423,375
Capital Equipment	675,000	675,000	675,000	675,000	675,000	675,000	4,050,000
Other Supplies and Services	2,839,400	2,839,400	2,839,400	2,839,400	2,839,400	2,839,400	17,036,400
CGIAR collaborations	0	0	0	0	0	0	0
Non CGIAR Collaborations	1,380,625	1,383,062	1,383,062	1,383,062	1,383,062	1,388,062	8,300,937
Indirect Cost	2,330,028	2,399,165	2,470,607	2,545,621	2,624,386	2,707,839	15,077,649
	17,863,553	18,393,602	18,941,324	19,516,432	20,120,295	20,760,102	115,595,308

Total Flagship budget by participating partners (signed PPAs) (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
CIFOR	6,292,972	6,447,072	6,608,877	6,778,772	6,957,163	7,150,222	40,235,080
ICRAF	7,718,828	7,965,906	8,225,337	8,497,740	8,783,764	9,084,087	50,275,664
Bioversity	427,483	440,996	455,184	470,081	485,724	502,148	2,781,619
CATIE	342,556	361,718	373,008	384,862	397,310	410,379	2,269,835
CIRAD	127,103	129,403	131,818	134,354	137,017	139,812	799,510
INBAR	1,751,047	1,806,650	1,865,032	1,926,334	1,990,701	2,058,286	11,398,052
TROPENBOS	1,203,561	1,241,856	1,282,066	1,324,286	1,368,617	1,415,165	7,835,552
	17,863,550	18,393,601	18,941,322	19,516,429	20,120,294	20,760,099	115,595,295

Explanations of these costs in relation to the planned 2022 outcomes:

For the explanation of these costs in relation to the planned 2020 outcomes, please refer to the FP narrative and more especially the PIM tables B and C

NOTE: Support Platform: Given the absence of a specific location to upload the costs/budgets of the various cross-cutting components (CCT) of the Support Platform (Gender, Youth, Capacity Development, MELIA, Communication/Outreach, Site Integration, Partnerships, OA/OD) we have allocated these amounts across the 5 Flagships within the supply and services class (but they will be managed in practice by the relevant CCT component leads. The amounts added per FP for the SP (year 2017) are USD 1,271,000 of which USD 346,000 W1/W2

Use of W1/W2: W1/W2 are used strategically to leverage bilateral funding likely as basket funds, in such a way that different sources of bilateral contribute to the same major goals, this in order to build a program that is consistent and that can deliver its expected objectives across the different six countries in which we are planning to do our work. W1/W2 funds are also used for global comparative analyses on major issues (e.g. food production-environment nexus at the landscape scale), to strengthen science quality, implement open access and to foster the probability of outcomes thanks to targeted communication and outreach. As explained in the Section 2.4.1.4, the application of ToCs (focused on development outcomes) oriented part of the FP is expected to be primarily funded by bilateral sources (within the geographical priorities of investors), while W1/W2 funds will be used for the "change of theory" and "innovative" research lines (assuming co-funding requirements by bilateral funders can be met in other ways). A reduction in W1/W2 fund availability will primarily affect the innovative research lines.

2.4.2.3 Additional explanations for certain accounting categories

Benefits: This is the same for all FP's and follows existing human resource policies of the Centers participating in FTA. In general the following benefits are covered by the Centers: Pension, Health, AD&D Insurances and allowances for housing, education and transport. These have been rolled into the salary. It is difficult to standardize the benefits as they vary by Center (based on individual Center polices), but also vary by type of staff i.e. Internationally recruited and National Staff.

Other supplies and services: The FTA.LAN type of research is relatively light in costs beyond staff time, travel (to a large number of sentinel and learning landscapes), and basic costs of offices, computers and publications. The relative cost structure is based on long term average for this type of work at CIFOR and ICRAF.

2.4.2.5 Budgeted costs for certain key activities

	Estimate annual average cost (USD)	**Please describe main key activities for the applicable categories below, as described in the guidance for full proposal**
Gender	2,670,000	see FP and CRP narratives
Youth (only for those who have relevant set of activities in this area)	534,000	see FP and CRP narratives
Capacity development	1,600,000	see FP and CRP narratives

	Estimate annual average cost (USD)	Please describe main key activities for the applicable categories below, as described in the guidance for full proposal
Impact assessment	0	Costs are indicated at the CRP level budget narrative as this is centralized within the Monitoring Evaluation Learning and Impact Assessment cross-cutting theme
Intellectual asset management	0	Costs are indicated at the CRP level budget narrative as this is mainly something managed at Centers' levels
Open access and data management	534,000	Overall costs are indicated at the CRP level budget narrative as this is mainly something managed at Centers' levels; the amount indicated here is linked to the Sentinel Landscapes and other network data
Communication	1,780,000	see FP and CRP narratives

The above selected key activities are described in the proposal text and the PIM tables. They do not include the Support Platform (that is included in the CRP budget narrative)

2.4.3 Flagship Uplift Budget

Outcome Description	Amount Needed	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other (%)
Outcome 4U1. Countries (at least ten) following international guidance on inclusion of green accounting in nationally adjusted GDP estimates are using FTA-generated data on intermediate-intensity land uses in the forest-agriculture spectrum.	18,700,974	25	0	75	0
Outcome 4U2. A full second round characterization of the Sentinel Landscapes five years after initial data collection is used by government agencies in 10 countries to adjust sustainable development trajectories and report to international fora.	16,891,650	30	0	70	0
Outcome 4U3. Hydroclimatic consequences of changes in vegetation (degradation, restoration), including teleconnection effects on rainfall, start to inform international debates on ecosystem services and climate change in CBD, UNCCD and UNFCCC, based in part on FTA research in Africa and Asia, complementing currwent studies in the Amazon basin.	16,498,938	37	0	63	0

2.5 Flagship 5. Climate change mitigation and adaptation opportunities in forests, trees and agroforestry

2.5.1 Flagship Project Narrative

2.5.1.1 Rationale and scope

Flagship Program 5 (FP5) is a unique, globally renowned and impactful international partnership implementing a research-for-development program on the use of forest, tree and agroforestry (FT&A) resources for climate change mitigation and adaptation focused on developing countries. Complementary to the *CGIAR Research Program on Climate Change and Food Security* (CCAFS) in many ways (as explained in Annex 3.17), FP5 is the only CGIAR program addressing FT&A resources. These resources have become crucially important in the context of the Paris Climate Agreement. The Paris Agreement has put heightened emphasis on the land sector as it is the only sector with a significant potential sink size, which is key to achieve the ambitious Paris objectives of keeping global warming below 2.0/1.5 °C. Furthermore, FT&A resources are central to adaptation efforts and provide a key means of achieving bioenergy targets in the context of low-emission development strategies. FP5 has a strong, tested ToC and demonstrated policy impact that potentially can reach a large number of people, thus underpinning future significant achievements in the land sector for mitigation. FP5 is integrated in FTA through direct links to FPs 2, 3 and 4, an indirect strong link to FP1 and significant contributions to FTA's gender and capacity development agenda.

The importance of forests in climate change mitigation and adaptation has strongly been recognized in the Paris Climate Agreement. It endorses Reducing Emissions from Deforestation and forest Degradation (REDD+), allows for alternative (nonmarket) policy approaches such as joint mitigation and adaptation and emphasizes the importance of non-carbon benefits and equity for sustainable development. Countries should develop capacities and grow national ambitions through their Intended Nationally Determined Contributions (INDCs) (to eventually become Nationally Determined Contributions [NDCs])[1] towards reaching the 2.0/1.5°C goal. Likewise, the United Nations (UN) Sustainable Development Goals (SDGs) emphasize climate, forests and bioenergy (see Section 2.5.1.2). The Green Climate Fund has begun its work but much needs to be done before large, results-based funds will flow with transparency and accountability. But the Paris Agreement is also less clear on important areas such as the key role of sustainable energy in reducing emissions, or that of agriculture as a major deforestation driver; both of these areas require more knowledge support.

In this ambiguous political context, decision-makers at all levels need information and guidance for policy and action. They need to know how to achieve climate mitigation and adaptation through the implementation of NDCs and how to increase ambition. They will need to mainstream climate policies across the sectors and levels of government. They will need to inform the UNFCCC Facilitative Dialogue in 2018 and the 5-yearly Global Stock Takes starting in 2023. Aiming for these goals, they will increasingly look for tested, trusted and reliable information and for cost-efficient (policy) performance assessment methods and procedures that allow them to assess the state, dynamics and drivers of change of land resources, livelihoods, social protections and equity indicators. FTA research can effectively fill the gap and engage meaningfully with boundary partners working at all levels towards these goals.

Thus, the Paris Agreement (and the gaps therein) sets the stage for climate change research in FTA. We have designed Flagship Program 5 (FP5) to address four research questions:

- How can we achieve effective land-based **mitigation** of climate change?
- How can people and forests effectively **adapt** to climate change?
- How can we sustainably produce **bioenergy** in developing countries?
- How can we reliably assess the **performance** of policy and practice addressing these goals?

Deforestation and forest degradation (mainly agricultural expansion) produce 70% of tropical land-use

emissions and account for 10–11% of net global greenhouse gas (GHG) emissions[2]. But forests also absorb 4–6 gigatonnes (Gt) of carbon annually[3], part of it from fossil fuel emissions; the Paris Agreement's *mitigation goal* (see Section 2.5.1.4) includes 'sinks' and needs 'negative emissions' (removals), where afforestation/reforestation will be crucial[4]. If countries continue on their fossil-fuel economy pathways, land-use emission reductions and forest restoration will not be enough to reach the 1.5–2.0°C target. Sustainable bioenergy production will be central for low-emission development.

FT&A ecosystem services are vital for the Paris *adaptation goal* (see Section 2.5.1.4). They support the livelihoods of approx. 1 billion directly forest-dependent people worldwide and provide goods and services (timber, energy, tourism, etc.) to billions more. Ecosystem-based adaptation can increase the climate resilience of forest-dependent people, smallholder agroforestry farmers and the world as a whole[5]. Measures will be more durable if they also reduce harmful inequalities based on gender, ethnicity and economy.

FP5 research will operate under the following **hypothesis:**

Effective, cost-efficient and equitable (3E+ criteria)[6] policies and practices make use of FT&A resources and combine climate change mitigation and adaptation with economic development. They are enabled by major shifts in enabling governance, economic and policy incentives, values, discursive practices, power relations and technologies; they depend on multi-purpose, climate-resilient landscapes and their performance can be assessed, measured and documented.

2.5.1.2 Objectives and targets

FP5 research tests this hypothesis and provides, under the 3E+ criteria, evidence on policies and measures that address: (i) mitigation of land-based emissions (i.e. emissions reduction and increased GHG sinks through landscape management with a focus on avoided deforestation and forest degradation, ecosystem restoration and conservation of FT&A resources combined with livelihood and development objectives); (ii) adaptation (of people and forests) to climate change through ecosystem-based actions that reduce risk and increase resilience; and (iii) low-emission development pathways including sustainable bioenergy supply to support development. Climate mitigation and adaptation, sustainable energy production and economic development activities must be integrated in policy and action to provide coherent, sustainable outcomes for people and the environment at local, national and global levels. This supports a fourth point: (iv) the success or failure of these policy interventions needs to be vigorously assessed to inform future policy options.

Outcomes. The expected outcomes of FP5 are integrated, equality- (gender-, youth-) sensitive climate change mitigation, adaptation and development strategies that follow the 3E+ criteria. We work towards four end-of-program outcomes, one for each of the clusters of activity (CoA; see Section 2.5.1.6). The outcomes are:

1. Efficient, effective and equitable national and international climate mitigation policies and funding, aligned with development objectives (3E+ goals);
2. Risk-assessed ecosystem-based adaptation (EbA) policy and practice including joint mitigation and adaptation approaches;
3. Integrated food and bioenergy production policy and practice;
4. Widely implemented performance assessment of mitigation and adaptation policy and practice.

These outcomes contribute to the Paris goals, the UN Sustainable Development Goals (SDGs) and CGIAR research outcomes (sub-IDOs[7]). The supported SDGs are:

- Urgent action to combat climate change and its impacts (SDG = 13) (this includes achievement of the adaptation and mitigation goals agreed in Paris and the implementation of NDCs by countries);
- Access to affordable, reliable, sustainable and modern energy for all (SDG 7)
- Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss (SDG 15); and

- Sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (SDG 8).

In the CGIAR context, FP5 work supports five key sub-IDOs:

- 10.3/A.1: Reduced net GHG emissions from agriculture, forests and other forms of land use;
- A.4: Enhanced adaptive capacity to climate risks;
- 3.2: Increased livelihood opportunities;
- B.1: Gender-equitable control of productive assets and resources; and
- D.2: Enhanced individual capacity in partner research organizations.

Targets. FP5 efforts address 3E+ *mitigation policies* that should contribute to reducing deforestation by 10–30% in six countries with 55% of global tropical forest cover (Brazil, Cameroon, Democratic Republic of the Congo [DRC], Indonesia, Peru and Vietnam). Users of the knowledge generated in the program would achieve this through better policy formulation and more efficient climate action. Through this, 0.5–1.6 million ha of forests could be saved annually, resulting in annual avoided emissions of approximately 0.2–0.6 Gt CO_2 (5–15% of the total annual land-use emissions of 3.3 Gt CO_2) positively affecting at least 0.5 million forest-dependent people directly and 1.5 million people indirectly (i.e. those depending on remote forest products and services). We expect our *adaptation* research to support 1 million rural poor people and our *bioenergy* research to support 0.5 million directly bioenergy dependent people and 0.7 million indirectly dependent people. The corresponding annual FTA expenses amount to only 3% of the cost of emissions reduction strategies[8].

FP5 supports gender outcomes by considering important gender aspects as these relate to decision-making power and asset and resource control (cf. Section 2.5.1.9). Capacity development (Section 2.5.1.10) in developing countries is central to our ToC (Section 2.5.1.3) – it represents an important long-term impact of FTA that is often overlooked when the expectation horizon for research programs or projects (such as the CRP program) is drawn too close.

Tables 1 and 2 show the anticipated allocations of funds to the outcomes and to the CGIAR sub-IDOs, both as percentages and in US dollars. In the wake of the Paris Agreement, we assume that bilateral climate funding will increase, but our current plans are using conservative estimates for bilateral funding. The bulk of funding will be from bilateral funding. Window 1 and 2 funding will cover 21% of the overall FP budget and will be used for three purposes: (i) to partially cover staff time of CoA coordinators (see Section 2.5.1.13) working on flagship integration, coordination, fundraising and reporting; (ii) to cover expenses of FP5 integration and partner engagement (e.g. in-country meetings and workshops); and (iii) to cover expenses to undertake framing research (e.g. how to raise ambitions under the Agreement), initiate strategic approaches (e.g. novel approaches to tenure and rights holding) and scoping research. Given that the Paris Agreement has just been concluded, the pathways to and pitfalls in its implementation are not yet fully evident; in this 6-year program we are likely to see many policy swings and may need to refine our targets and the pathways towards them, under the changing circumstances.

Table 1. Outcomes by windows of funding.

Outcomes	Amount needed (million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
5.1 Efficient, effective and equitable climate national and international mitigation policies and funding, aligned with development objectives (3E+ goals)	40	21	0	79
5.2 Risk-assessed ecosystem-based adaptation (EbA) policy and practice in place including joint mitigation and adaptation approaches	19	21	0	79
5.3 Integrated food and bioenergy production policy and practice realized	9	21	0	79
5.4 Performance assessment of mitigation and adaptation policy and practice widely implemented	9	21	0	79
Total	**77 million**	21%	0%	79%

Table 2. Investments by sub-IDOs.

Sub-IDOs	Amount needed (million USD)	W1/W2 (%)	W3 (%)	Bilateral (%)
10.3/A1: Reduced net GHG emissions from agriculture, forests and other forms of land use	34	21.2	0	78.8
10.2: Enhanced adaptive capacity to climate risks	21	21.2	0	78.8
3.2: Increased livelihood opportunities	9	21.2	0	78.8
B.1: Gender equitable control of productive assets and resources	5	21.2	0	78.8
D.2: Enhanced individual capacity in partner research organizations	8	21.2	0	78.8

2.5.1.3 Impact pathway and theory of change

Our policy-learning framework applies to developing countries and the international arena that frames national implementation (e.g. UNFCCC, IPCC). Actors make (policy) decisions based on the information (and technologies) they have access to and the interests and ideas that structure their understanding of the (policy) problem and how to solve it (Figure 1). Change is enabled or hindered by institutions at multiple levels of governance – they often show structural biases disfavoring marginalized groups or preserving inequalities (see Section 2.5.1.9). Shifts in incentives, discourses and power relations are needed to transform current unsustainable practices into sustainable ones. Identifying how these shifts can be initiated in national policy arenas, multi-stakeholder and international fora is key to understanding how lasting transformational change can be achieved. The right choice of actors is essential (see Section 2.5.1.7).

In this context and given the need to interpret and bridge globally defined climate change policies and targets with effective, efficient and equitable local actions, our ToC requires leveraging political economy and governance dynamics at national and subnational levels.

The new knowledge generated in FP5 helps to: (i) identify options for more equitable and effective incentive structures; (ii) ensure well-informed decisions based on evidence; and (iii) contribute to rebalancing power by working in partnership with and providing evidence to potential agents of change in developing countries ('information is the new currency'). To achieve this, FP5 works along a clear impact pathway in our successfully evaluated[5] 'co-production of science' model (Figure 2):

1. **Early engagement** and trust-building with various types of collaborating partners from all levels and sectors (see Section 2.5.1.7) in developing countries (identifying and understanding needs), e.g. through multi-stakeholder consultations
2. **Joint definition** of relevant research questions (responding to needs);
3. **Co-development** of robust and salient, credible and legitimate research (output);
4. **Delivery**, directly or through the collaborating partners, **of knowledge and tools** to knowledge-using partners, i.e. national and global policy-makers and practitioners within the parameters needed to achieve the required transformational change (e.g. expected policy change) that represents the end-of-program outcomes in national and global policy and practice towards the intended goals (sub-IDOs, SDGs) (these changes happen within the 'boundary partners').

We envisage a stepwise or spiraling feedback process (Figure 3). First, boundary partners, research partners, policy-makers (at national and international levels, e.g. negotiators) and practitioners (mostly operating at subnational level) are contacted and consulted for a joint definition of relevant research questions ('targeted engagement' in Figure 2). Early participation will facilitate the internalization of the 3E+ principles of more efficient, effective and equitable climate policies and practices that are aligned with development and equity considerations. Once the knowledge becomes available, they then can start to use it in their day-to-day practice and apply it to climate change policy-making and practice. This is a complex process grounded in trust and mediated by debate, interaction and feedback. In this process we make use of national champions and national research partners that become emboldened through the interaction to operate in the national arena, but we will also works directly and early on with policy-makers at the various levels of administration. As an end point, we expect the generated knowledge to become (more) reflected in policy and practice at subnational, national and international levels. The process encompasses a 'spiraling' engagement with increasing levels of intensity, building on feedback loops, continuous engagement and iterative adaptation.

We operate in a development environment in parallel to many other actors of change and we work closely with many of them. We are acutely aware of the attribution problem, but we also have evidence[6] that our knowledge has been taken up at various levels of policy and practice.

The FP5 theory of change is, furthermore, supported by proactive, visible and significant communications, outreach and capacity development (see Section 1.0.14). It is accompanied by continuous policy analysis to identify current and anticipate emerging policy trends. The politics of developing countries are highly dynamic: anticipating trends helps to prioritize our research agenda and stay relevant to our partners. Some degree of flexibility is needed in order to respond to these rapid changes.

In summary, rather than trying to be 'predictive and prescriptive'[9], we see our role as 'honest brokers' of knowledge, committed to transdisciplinary biophysical, social and economic research with sound problem analysis that provides evidence-based policy options to target users – options that are based on an identification of what their needs are.

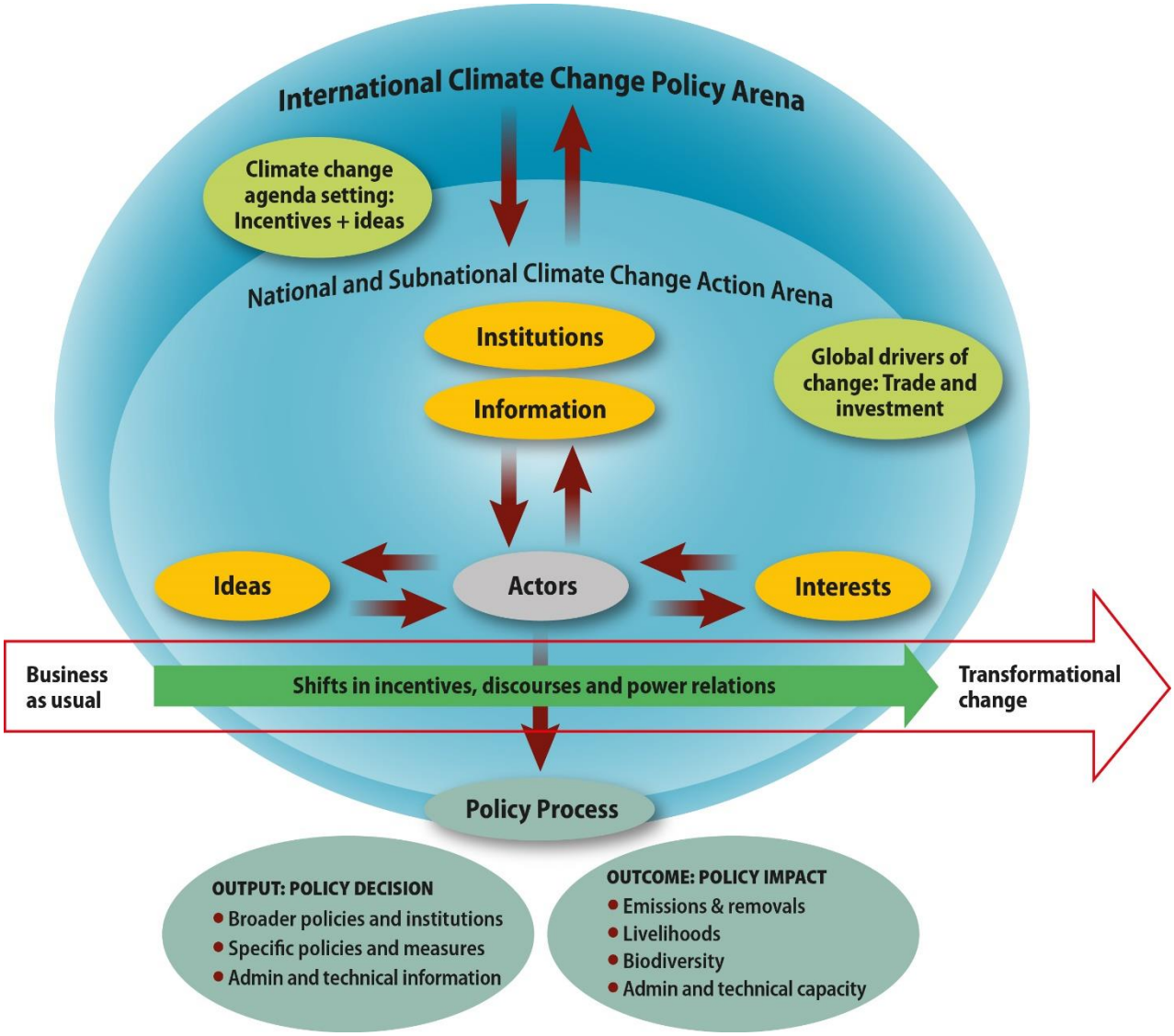


Figure 1. FP5's theory of climate change policy transformation.

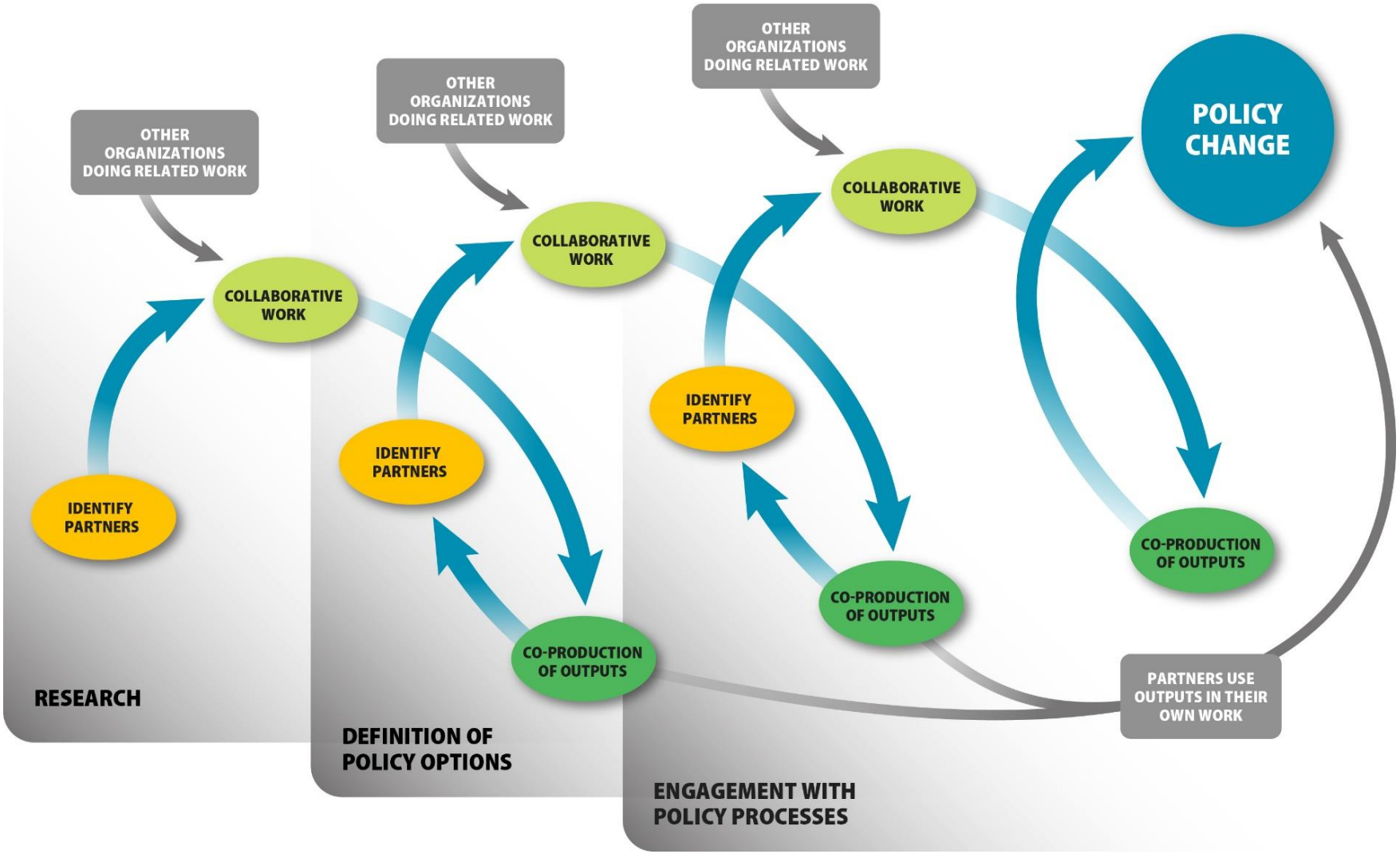


Figure 2. Linking research activities to end-of-program outcomes, policy change and sub-IDOs in FP5 through multiple partner engagement in our co-production of science model (for details on CoAs see Section 2.5.1.6; for details on which sub-IDOs are addressed see Figure 4).

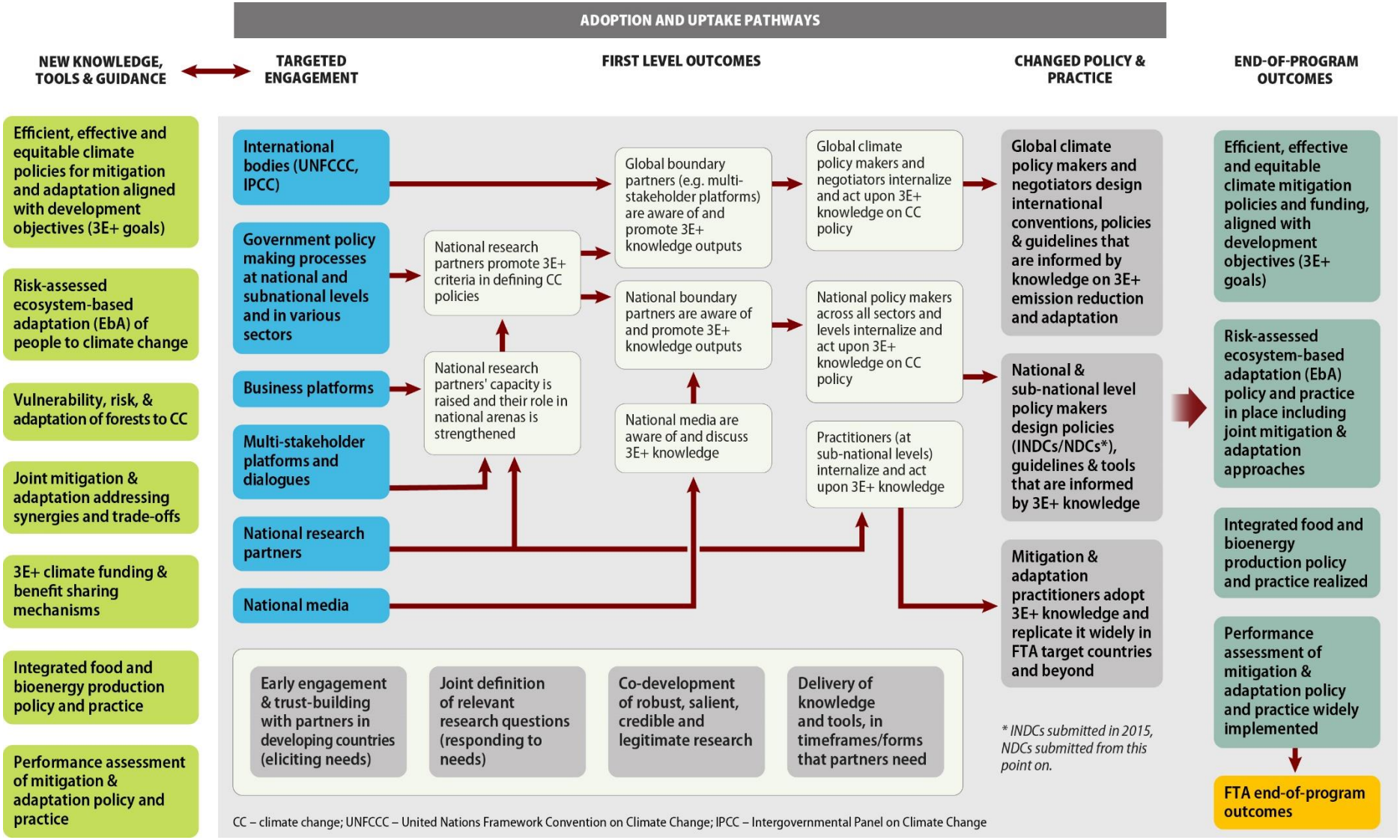


Figure 3. FP5 theory of change.

2.5.1.4 Science quality

Quality of science in FP5 is defined by (a) the identification of major gaps in theory, analysis and policy practice (innovation); (b) the research that we propose to fill these gaps (soundness of research and of the team); and (c) our competitive advantage to address these gaps (see also Sections 2.5.1.3 and 2.5.1.5). We relate this discussion to the topics addressed in the four CoAs (see Section 2.5.1.6).

Mitigation: A current debate declaring REDD+ "dead" seems premature, as REDD+ is now part of the Paris Agreement; the Green Climate Fund (GCF) is developing its results-based payment strategy and early anecdotal evidence indicates that developing countries are gearing up for REDD+. Instead, this seems the right time to address the identified operational challenges by testing REDD+ in practice. Our successful Global Comparative Study on REDD+ in FTA phase 1 is seen as pioneering and has had demonstrated impact[10]. It has created a substantial body of work on the elements of REDD+ (national strategies, baselines and emission factors, monitoring, reporting & verification [MRV] systems and safeguard information, multi-level and multi-sectoral governance challenges, equity, benefit-sharing and livelihood effects) – documented in over 350 publications (www.CIFOR.org/GCS). The key to this impact was our innovative approach coupling comparative, standardized research with enough flexibility to address new issues coming up in the fast-changing policy environments, together with our effective partner engagement approach based on our 4i approach (Figure 1) explained in Section 2.5.1.3. The Paris Agreement now also explicitly stipulates sustainable forest management and joint mitigation–adaptation approaches as additional mitigation options. After Paris, the GCF and many country partners are looking to research for answers and the FP5 partnership is strategically placed at the heart of the debate.

Adaptation: The Paris Agreement establishes adaptation (i.e. enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change) as a global goal of subnational, national and international dimensions that needs to contribute to sustainable development and support the 2.0/1.5°C goal effectively. Paris also prioritizes safeguarding food security and ending hunger and addressing the vulnerabilities of food production to climate change. Countries and the Green Climate Fund are now beginning to implement Joint Mitigation–Adaptation projects and further policy developments are expected from the UNFCCC. FTA has a long history of successful work on agriculture as a deforestation driver, on synergies between mitigation and adaptation and on climate finance/benefit-sharing; these were all innovative themes at the time we started them and we are recognized as discussion leaders in these areas which, to achieve the 3E+ criteria, need much more support from research. We have developed the understanding of policy environments enabling transformational change by leveraging a political economy approach (see Section 2.5.1.3) and will continue to do so. Multidisciplinary in nature, embedded in the broader context of FTA and building on well-defined ties to the *CGIAR Research Program on Climate Change, Agriculture and Food Security* (CCAFS) and other CRPs (see Figure 4), FP5 is well placed to develop system-oriented innovative landscape approaches to integrated climate and development policy.

Bioenergy: The Paris Agreement emphasizes, "the enhanced deployment of renewable energy"…"in particular in Africa" and fossil fuel consumption is central to the current global climate crisis. Bioenergy is expected to play a large, yet uncharted role in carbon removal, improving the balance between carbon sources and sinks. FTA has been working on biofuels, particularly fuelwood and charcoal production in Africa and is now ramping up its engagement by setting aside work in a specific CoA and developing an innovative, integrative policy approach supporting policy and practice of bioenergy development in developing countries, in collaboration with partners in research and capacity development.

Performance assessment: Once the stumbling blocks for policy change are removed, we believe that 3E+ policy development can include a more interactive approach to policy-making where decision-makers act upon feedback on policies. This is not the reality in many countries and requires a paradigm shift. Performance assessment based on evidence is at the heart of this shift. We need to develop rigorous performance assessment methods for climate policy and practice that can: (i) be done efficiently; and (ii) be used for effective policy-making. We are leaders in MRV of forest and carbon for REDD+, having supported the development of reference levels for many countries and we have developed a sophisticated approach to

performance assessment in our comparative 'difference-in-difference' approach (BACI: before-after/control-intervention) used in our global comparative study on REDD+. This will be continued in Phase 2 – we are working to reduce the efforts, emphasizing efficiency of data collection. It too holds great promise for broader implementation beyond climate policies, but expanding into that area will only be possible under an 'uplift' budget scenario.

In development research, the quality of science is also determined by its applicability to real-world development problems. We leverage this through our capacity to partner with advanced research institutes and think tanks for high-level analysis and advanced technologies (see Section 2.5.1.7) and through our close partnerships with research partners and policy-makers in developing countries (see Section 2.5.1.3). Our comparative advantage lies in the strong links to partners in environment, development and climate policy arenas in developing countries, giving us a head start over other actors in identifying the most pressing problems and effectively addressing them through these partnerships. FP5 pays significant attention to capacity development, offering postdoctoral positions and PhD and MSc studentships, in addition to conducting regular seminars and knowledge-sharing events with partners. This has been and is an important part of the impact pathway.

We strongly rely (but do not rest) on the achievements of FTA FP5 in phase 1, exemplified in approx. 900 scientific and policy publications to date (February 2016). Our achievements were positively assessed in the CGIAR-required FTA assessment[11] as well as the assessment of our global comparative REDD+ study[12]. Science quality in development is also defined by the accessibility and comprehensibility of science. We make great efforts to translate our work – making science accessible through short and readable policy briefs (many policy-makers request this!) in the native languages of our target countries.

Our approach to research and impact is based on accumulated experience and lessons from previous engagement and achievements, including many large-scale comparative projects. This includes a decade of well-regarded research on deforestation drivers, sustainable land management and policy analysis. This experience, combined with legitimacy as an independent global research partner, operating through country offices and long-established partnerships worldwide, puts us in a unique position to achieve the results outlined in this proposal. FP5's comparative advantage is derived from:

- the quality of staff from many nationalities and cultures with expertise in a wide range of disciplines
- the skills and networks of diverse delivery partners both in developing countries and globally
- our brand – the FP5 team is associated with credible, high-quality analysis, independent thinking, a reputation for tackling difficult and controversial issues and an ability to convene diverse actors
- a global mandate and local relevance – we are empowered to address global issues with the legitimacy to engage in international, national and local fora
- a distinct perspective: our interdisciplinary, global perspective is informed by the views of multiple stakeholders, emphasizing our commitment to understanding issues from the viewpoint of resource poor people and forest users.

Staff with lead positions (cf. Section 2.5.1.12) in FP5 are listed in Table 3, with an overview of their Google citation indices and rank in CGIAR Google Scholar. CoA leaders and scientists have been carefully selected based on criteria such as scientific expertise, partnerships they bring into the team and center representation.

Table 3. List of names, roles and H-index, number of citations and FTE (full-time equivalent).

Name, institution	Original discipline	H	No of citations	Rank in CGIAR	FP5 role	FTE
Christopher Martius, CIFOR	Ecology, climate change, land use	28	3027	71	FP5 lead and CoA FP5.2 lead	0.6
Bruno Locatelli, CIFOR	Forest climate change adaptation	23	1551	n.a.	CoA FP5.2 lead	0.04
Navin Sharma, ICRAF	Bioenergy	7	168	n.a.	CoA FP5.3 lead	0.3
Maria Brockhaus, CIFOR	Forest governance, REDD+, policy analysis	25	2245	111	CoA FP5.4 lead	0.5
Peter Minang, ICRAF	Agroforestry, REDD+, forestry, landscape approaches	18	1102	n.a.	CoA FP5.1 co-lead	0.3
Houria Djoudi, CIFOR	Climate change adaptation, gender	6	230	433	CoA FP5.2 co-lead	0.5
Lalisa Duguma, ICRAF	Climate change, sustainable landscapes, forest governance	9	271	400	CoA FP5.2 scientist	
Himlal Baral, CIFOR	Forestry, ecosystem services, landscape ecology, bioenergy	7	144	n.a.	CoA FP5.3 co-lead	0.5
Glenn Hyman, CIAT	Geography, tropical agriculture	17	1150	158	CoA FP5.4 co-lead	0.4
Arild Angelsen, UNMB	Economics, REDD+	47	13,970	n.a.	CoA FP5.1 partner	
Markku Kanninen, CIFOR	Tropical silviculture	32	4806	n.a.	CoA FP5.2 partner	
Eduardo Somarriba, CATIE	Agroforestry, trees on farms	30	3732	n.a.	CoA FP5.3 partner	
Martin Herold, Wageningen University	Remote sensing	42	8053	n.a.	CoA FP5.4 partner	

2.5.1.5 Lessons learned and unintended consequences

FP5 in Phase 2 has learned from the 2014 external FTA evaluation, the revised CGIAR portfolio, the ISPC's and other comments on the pre-proposal and global policy changes (including the Paris Climate Agreement), in several ways:

- We learned from years of successful REDD+ research:[13] e.g. we built a forest transition approach into the framework for setting reference GHG emission levels; our work on participatory MRV refocused from monitoring efficiency to empowering stakeholders. We see new multi-stakeholder policy processes emerging and we will study them. We are expanding work on adaptation and risk reduction (CoA 5.2) and introducing new research on forest degradation and restoration, climate finance (CoA 5.1), bioenergy (CoA 5.3) and performance assessment (CoA 5.4). We adapt to the Paris Agreement with a broader scope for REDD+ implementation and support to country-level implementation (NDCs). We are intensifying our work with CCAFS (see Section 2.5.1.8). Finally, our REDD+ experience enables much accelerated policy learning in other emission reduction approaches.
- Increasing focus on drivers of forest gains and losses to make interventions more effective: Research has shown that most large-scale deforestation is not driven by the value of the trees and forest resources harvested but by demand for land conversion to other uses (e.g. agriculture, livestock, timber, mining,

infrastructure, settlements and a rising developed-country demand for bio-products[11]). Land demand in developing countries grows with population growth and higher per-capita consumption of natural resources. We will address the underlying drivers of forest loss and will propagate work on the forest carbon sink capacity for mitigation that still needs to be better quantified and understood.

- Assessing performance as key to evidence-based policy-making that works: Our REDD+ research prepares us to assess the impact of mitigation and adaptation policy on non-carbon benefits that got greater focus in Paris (see Section 2.5.1.4).
- Constantly refining our theory of change, most recently in response to an internal evaluation of CIFOR's climate change program: Outcome mapping is now routine in new projects. Phase I demonstrated the catalytic potential of combining research, capacity development and partner engagement to bridge the science–policy divide (see Section 2.5.1.3). We will follow this approach in all CoAs.

We are well aware of **unintended consequences** and address them through our multidisciplinary work:

- Focusing too narrowly on mitigation could mean underemphasizing development and other, non-carbon objectives. This is addressed under the topic of safeguards, long a centerpiece of our climate policy research and by new, integrative research at the landscape level.
- Also, global emphasis on mitigation has often undercut adaptation as a topic in international debate. This has been somewhat repaired in the Paris Agreement in relation to REDD+,[14] the interaction between the long-term mitigation and adaptation goals[15] and the recognition that adaptation can contribute to mitigation outcomes[16]. We have focused on synergistic mitigation and adaptation approaches (FTA phase 1) contributing through our work to raising awareness of this topic and will continue this work. We are also addressing joint mitigation and adaptation by linking closely to CCAFS (see Section 2.5.1.8).

We are confident that the landscape-oriented systems approach that recognizes the multiple objectives of functional landscapes and that pervades FTA as a whole is safeguarding us against working on too narrow and non-adaptive premises for climate change policies and practices.

2.5.1.6 Clusters of activity (CoA)

Following on the research questions from Section 2.5.1.1, FP5 combines research, capacity development, technology transfer and policy engagement, to explore the following **hypotheses**:

1. Carbon-effective, cost-efficient and equitable emission reduction (mitigation) strategies and policies (Paris goals) can be attained involving FT&A resources and combined with development objectives (SDGs) through broad, integrative, cross-sectoral approaches using a political economy lens.
2. Strategies, policies, institutions and practices can be developed to preserve and manage FT&A resources for efficient and effective adaptation of people and landscapes to global environmental change and support joint mitigation–adaptation.
3. Renewable bioenergy from FT&A can effectively and efficiently support energy sufficiency and equity and generate rural income in developing country sustainable landscapes.
4. Methods to reliably and independently monitor and assess performance of mitigation and adaptation policy and practice can be developed, linking these to cost and benefit sharing.

Research is carried out in four clusters of activities integrated with research in other FPs and CRPs (Figure 4): FP5 links with FP2 on adaptation, with FP3 on private-sector approaches to mitigation and with FP4 on landscapes. We will work with CCAFS (see Section 2.5.1.8), the *CGIAR Research Program on Policies, Institutions and Markets* (PIM) on policy development and with the *CGIAR Research Program on Water, Land and Ecosystems* (WLE) on landscapes (Figure 4).

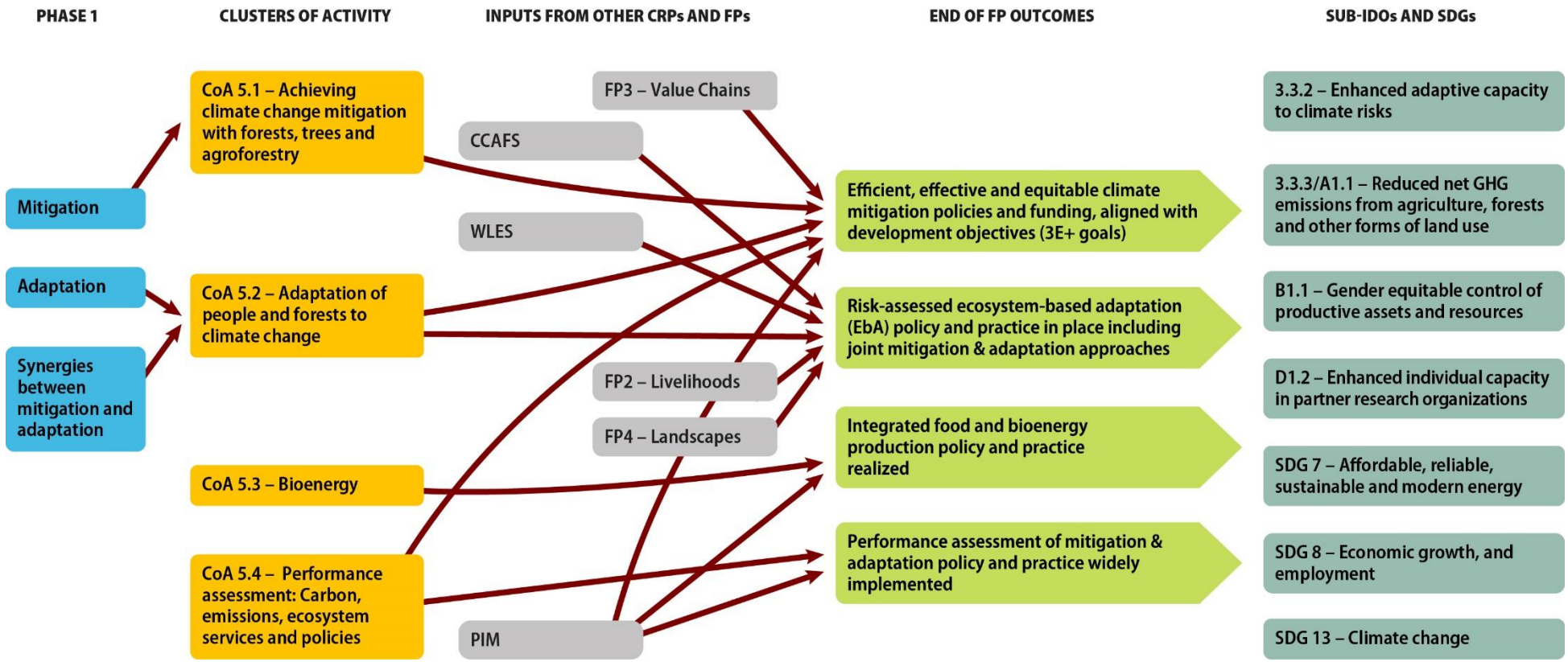


Figure 4. Clusters of activity in FP5 and links to other FPs and CRPs.

Geographic orientation. FP5 co-locates research with FTA FPs 3 and 4 and CCAFs to enhance the impact on climate change of CGIAR as a whole, at three levels: (1) joint regional approaches in all agroecological zones identified in FP4; (2) National-level research in countries with strong national climate strategies ((e.g. REDD+, Secured Landscapes, NDCs, LEDS) or large forest areas (e.g. Brazil, Indonesia, Peru, Vietnam, Cameroon, DRC) adding case studies where impact is promising (e.g. Myanmar); and (3) subnational-level work (e.g. in sentinel landscapes where work of various FPs converges towards joint landscape objectives [e.g. West Kalimantan, Peru, East Africa, Central America]) and collaborates with CCAFS on climate-smart villages. FP5 countries are shown in Figure 5.

Figure 5. FP5 research countries.

CoA 5.1 Achieving climate change mitigation with forests, trees and agroforestry

The Paris Agreement goals require immediate, coordinated efforts of all GHG-emitting sectors. CoA 5.1 will provide analysis and guidance on GHG emission reduction options for tropical landscapes using FT&A, integrated within economic and social development. National emission reduction and adaptation objectives come together in the NDCs and can be realized by various policy measures – REDD+, NAMAs, SFM or JMA[17]. These approaches share many elements: they account for GHG emissions and removals; some form of measuring, monitoring, reporting and verifying MMRV (see CoA 5.4) is required to establish baseline and reference points; funding can be domestic, international or mixed, public or private. All countries face the challenge of aligning climate and development objectives and integrating FT&A resources, emission reduction and sustainable bio-production in comprehensive, national, long-term LED strategies. We anticipate a growing demand for capacity development and analysis in support of LED implementation, realistic targets and a means of reaching them. CoA 5.1 builds on 8 years of comparative research on mitigation policy and practice (see Section 2.5.1.4) to accelerate policy learning on governance, benefit-sharing, MRV and finance. CoA 5.1 seeks to advance knowledge through country-specific, as well as global, comparative analysis of emission reduction options, incentives, policies, governance and partnership mechanisms for achieving mitigation through FT&A at global, national and landscape scales (linking to FP4). Guidance will be provided on policy design and architecture and there will be a focus on the political economy of enabling policies. Foresight studies on FT&A-based mitigation and adaptation with respect to SDGs and Paris Agreement targets will be undertaken.

CoA 5.1 addresses sub-IDOs 10.3/A.1, reduced net GHG emissions from agriculture, forests and other forms of land use; and 8.1, land water and forest degradation (including deforestation) minimized and reversed; and 9.1, more productive and equitable management of natural resources.

Key research activities (research questions):

- 5.1.1. **Comparative analysis of best, 3E+ options for policies and practices for emission reduction** in support of country-level development and implementation of NDCs (including REDD+[18], NAMAs, SFM, and JMA) and international climate change policy-making, using FT&A resources; and including analysis of ways to reduce complexity and 3E+ goals in LEDS (e.g. governance of multi-level and multi-sectoral integration of local, national and regional climate change, restoration and development agendas)
- 5.1.2. Research on policy and practice of **forest restoration** and on enhancing the forest carbon sink capacity (supporting the Bonn Challenge), e.g. in collaboration with the 20×20 initiative
- 5.1.3. Research on the complex challenge of **forest fire** policies, with particular reference to Indonesia
- 5.1.4. Research on the effectiveness and efficiency of **results-based climate finance** and incentive mechanisms, including through the Green Climate Fund, in affecting policy and behavioral change towards mitigation and adaptation outcomes
- 5.1.5. Studies of the **enabling policy architecture and public–private partnership mechanisms** that can enhance performance of corporate zero deforestation commitments and other mitigation initiatives, addressing standards and certification (with FP3)
- 5.1.6. Support for **evidence-based decision-making** in NDC planning and implementation (e.g. in support of the *Facilitative Dialogue* set in the Paris Agreement) and develop **policy learning from country-level to the international policy arena.**

Methods: a variety of biophysical and social methods, using our databases for long-term comparative research.

CoA 5.2 Adaptation of people and forests to climate change

Land-based economic activities in developing countries will continue to be vulnerable to climate change, which emphasizes the need for adaptation. Maintaining and managing FT&A resources can help people adapt to climate variability: e.g. adequate tree management in agriculture enhances food security, forests regulate the microclimate locally (e.g. in cities) and water regionally in watersheds, and mangroves buffer the impacts of extreme climate events in coastal areas. CoA 5.2 addresses two issues: (i) how can FT&A adapt to climate change; and (ii) how can FT&A help people and heterogeneous societies adapt to climate change. We will use empirical research supporting policy integration, practice and assessment at local, national and international levels, combining climate risk reduction with increased resilience (with FP2). In addition, in CoA 5.2 we seek to advance knowledge on nature-based solutions to climate change by analyzing the synergies between and incentives for mitigation and adaptation approaches, as recognized in the Paris Agreement.

CoA 5.2 targets sub-IDO 10.1, increased resilience of agroecosystems and communities especially those including smallholders; and bears on 10.2, enhance adaptive capacity to climate change risks; and 9.3, on enrichment of plant and animal biodiversity for multiple goods and services.

Key research activities (research questions):

- 5.2.1. Continued work on understanding the **synergies/trade-offs between mitigation and adaptation** in support of the Paris Agreement (link to CCAFS)
- 5.2.2. Assessment of potential impacts of climate change on biodiversity, ecological functions and ecosystem services to **assess risks and vulnerability of both people and forests**, systematize experiences where FT&A has strengthened local responses to climate change, equitably reducing risk and increasing resilience and to contributing analysis to the 'loss and damage' debate
- 5.2.3. Identifying options to reduce climate-related risks, analyzing trade-offs, exploring adaptation economics, using and demonstrating ecosystem-based adaptation (***EbA)***, developing adaptive capacity of social groups and exploring the interface to climate-smart agriculture (CSA)

- 5.2.4. Comparison of policy mechanisms that **strengthen local capacity to respond with *EbA*** to expected climate change and variability (e.g. land-use planning, multi-stakeholder dialogues, encounters of knowledge), and their integration into national development and adaptation plans (NAP, NAPAs) across scales
- 5.2.5. Development and testing of approaches to **measure and monitor effectiveness and efficiency of *EbA* actions** in reducing vulnerability and increasing resilience to inform national and international policies and priority setting. Setting apart unsuccessful, business-as-usual tree- and land-based interventions from successful *EbA* requires a tool set integrating vulnerability assessments of socioeconomic and ecological systems to increase resilience.
- 5.2.6. Experimentation with and development of **flexible, data-driven approaches** that emphasize flexibility and heterogeneity as risk reduction strategies and feedback-based policy responses.

Methods: risk and vulnerability assessments; meta-analysis and systematic reviews of case studies at household/landscape level (case studies are the preferred approach because adaptation is strongly place-based, depending on local practices and preferences, climate, crops and tree species); desk studies analyzing national policies and programs and the performance of existing adaptation projects; biophysical studies at landscape level on the management of ecosystem services to reduce climate-related risks.

CoA 5.3 Bioenergy

Bioenergy is key to improve the sustainability of the energy sector[19] and achieve the Paris goals[20]. Many governments have renewable energy targets and the Paris goal of balancing sources and sinks requires a thorough understanding of the role bioenergy can play. However, globally, the level of government subsidies to fossil fuels remains high[21]. Also, in many regions, biofuels are unsustainable, contribute to climate change and human health problems (e.g. open cooking fires; charcoal production), and are considered 'backwater technologies' by national actors.

In CoA 5.3 we analyze climate the benefits and disadvantages of bioenergy policies under current and plausible future scenarios. Renewable energy efficiency targets can be included in NDCs by developing countries, making for an interesting investment arena. We address bioenergy as part of a coherent approach across FTA that considers energy poverty, climate change and food and nutritional security through diverse production systems involving forest landscapes, with links to FP2 Livelihoods (smallholder production), FP34 Value Chains, and FP4 Landscapes (agroforestry production). We will integrate bioenergy in landscape mosaics by evaluating various production typologies (such as extractive system, integrated food and energy systems, abattoir waste from agriculture and forests and cellulosic material) and identify the conditions for these production systems to support livelihoods and examine the impacts of such systems on GHG emissions.

CoA 5.3 supports sub-IDOs 10.3/A.1, Reduced net GHG emissions from agriculture, forests and other forms of land use; and 3.2, Increased livelihood opportunities.

Key research activities (research questions):

- 5.3.1. Analysis of the **current status of bioenergy types**, including the relative benefits, disadvantages and the extent of their use in different regions
- 5.3.2. Analysis of **international and national drivers of bioenergy development** to understand how markets and standards (e.g. EU Renewable Energy Directive) affect land allocation for bioenergy production
- 5.3.3. Assessments of **potential of bioenergy production on degraded land** using spatially explicit data about the area, type and extent of degradation, tree species' suitability, growth and yield at national and subnational level in Indonesia

- 5.3.4. Analysis of the **impact of bioenergy on social and environmental outcomes** (e.g. health, poverty, migration, gender, biodiversity) to support equitable, sustainable energy generation
- 5.3.5. Studies of **demand and supply, costs, social and environmental impacts, carbon footprints and synergies/trade-offs with food production and variation** by region, feedstock types and scale of bioenergy production
- 5.3.6. **Scenario development:** Analysis of **how bioenergy extraction links to landscape configuration**, as people's practices of wood extraction depend on a landscape, but also shape it; assessment of how future energy developments may affect the role of biofuels, retaining flexibility to include new developments (e.g. lignocellulosic fuels) and investigate how they may benefit stakeholders.

CoA 5.3 will use bio-economic modeling, field-scale comparative analysis (e.g. life-cycle analysis) and political economy studies.

CoA 5.4 Performance assessment: Carbon, emissions, ecosystem services and policies

Performance assessment builds on the traditional MRV approach but includes policy performance assessment as the basis for evidence-based policy and practice. This is broader than the traditional MRV and it is known as MMRV (monitoring, measuring, reporting and verification). MMRV of practices and policies is needed to achieve intended emission and risk reduction effectively, in line with the Paris Agreement. REDD+ needs safeguarded information systems; NDCs need more transparency, clarification, time frames, implementation pathways, scope and coverage; and countries need to develop the technical MMRV details in a broad range of topics and sectors for LEDS[22]. Private-sector pledges also require performance assessments (linked to FP3). Data-driven approaches will improve confidence and enable effective and transparent policy implementation. In addition, independent monitoring data and systems based on existing or new data sets and initiatives at global (e.g. Global Forest Watch, ESA's biomass satellite, EC-Copernicus), national or subnational (e.g. jurisdictional, landscape, community-based) level can provide more transparency for performance-based MMRV but will require assessment and testing. Independent monitoring, in terms of carbon and non-carbon outcomes, can provide tailored approaches for specific users, e.g. civil society members can be empowered by new information and data to follow up with governments and private sector actors and their commitments.

Building on our expertise in performance assessment (see Section 2.5.1.4), this CoA can be expanded into broader performance assessment, e.g. for the SDGs, which also support other flagships.

CoA 5.4 supports all sub-IDOs directly addressed in FP5 through improved performance assessment and capacity development.

Key research activities (research questions):

- 5.4.1. **Determine reference levels:** Research that supports the setting of country targets, baselines/reference levels/points of departure regarding FT&A resources, carbon stocks and other ecosystem services for REDD+, NAMAs, INDCs and LEDS; develop criteria and tools to measure and contribute to private-sector assessment
- 5.4.2. Basic research to **understand carbon source/sink dynamics** to improve regional and global models (link to SP1) and feed into IPCC processes aiming to implement the Paris Agreement
- 5.4.3. Measuring **non-carbon benefits** (biodiversity, governance and livelihood outcomes, social equality, and informing the implementation of safeguarded information systems). Use of innovative methods, such as qualitative comparative analysis and quasi-experimental methods to identify causal change
- 5.4.4. **Impact assessment of REDD+** policy and practice, building on 8 years of comparative research and longitudinal data sets

- 5.4.5. **Identify and develop approaches to cost-efficient, transparent, reliable MMRV,** including independent monitoring approaches. We specifically aim for more integrated landscape monitoring approaches (e.g. including climate modeling) to assess multifunctional performance (linked to 5.4.3.) building on existing methods and approaches, so that countries find support in their multiple monitoring needs under Paris (INDCs), SDGs and the like. Linking MMRV for forest- and agriculture-related mitigation should create important synergies for mitigation planning and implementation
- 5.4.6. Coupled **bio-economic modeling** to understand emergent properties, complexity and conditions of landscape systems. Develop decision-making tools; e.g. landscape management for LEDS: models of future scenarios and climate/carbon outcomes under different land-use policies; spatial economic analyses to assess the cost and equity implications of policy mix options

Methods in CoA 5.4: biophysical assessments, social science, political economy, policy analyses.

2.5.1.7 Partnerships

Our outcome statement is that **climate change policy-makers and practitioner communities have access to and use of the information, analysis and tools needed to design and implement policies for mitigation, adaptation and bioenergy, create enabling conditions to assess the degree to which REDD+ has delivered effective, cost-efficient and equitable carbon and non-carbon benefits**. To achieve this goal, we build on tested and trusted relationships with key R&D/delivery government and non-government partners in a number of countries, following the principles outlined in FTA's overall partnership strategy (see Annex 3.2). We select our partners based on their competitive advantage for FP5 work using the following criteria: (i) they are addressing climate and development policy and practice; in which they play a key role or have the potential for such a role and (ii) they are highly engaged. We work either directly with the target agencies or with intermediate partners for which we identified the mandates, the capacity, the networks, or the potential, to effectively reach key national decision-makers and practitioners. We work with local, national and international partners to support all implementation levels. In the coming years, national implementation (e.g. INDCs) and subnational action will be key; we will temporarily increase the focus on these levels. But national and subnational experiences need to flow back to the international level to influence the development of the new Paris global framework, amongst others and we will actively support this policy learning process. These partnerships are essential for our ToC, as they ensure local ownership of research and results. We have evidence[23] that they were key to success of FTA's climate change mitigation and adaptation work over the past 4 years.

Experience in Phase 1 shows that partners are key in co-developing science (outputs) and that they use the knowledge generated in FP5 for their decision-making (outcomes) (Table 4). Regarding **outputs**, developing country research partners are central for capacity development and research in our co-production of the science model. World-renowned advanced research centers provide cutting-edge science and training to young academics from developing countries; they bring expertise and analytical capacity (including labs) into the practice-oriented research of the flagship program and they link us to international processes (i.e. Intergovernmental Panel on Climate Change [IPCC], Global Forest Observations Initiative [GFOI], Global Observation of Forestry and Land Cover Dynamics [GOFC-GOLD]). Networks such as Sustainable Wetlands Adaptation and Mitigation Program [SWAMP][24] (with over 200 partners in 20 countries working on tropical wetlands) or Global Forest Watch[25] (on forest resource monitoring) are important multipliers of our research output. Civil society organizations, including movements representing indigenous peoples and forest communities, link us to local contexts and the rights and equity debate.

Regarding **outcomes**, we work with national policy actors dealing with climate change mitigation and adaptation, e.g. line ministries and subnational agencies. NGOs and agricultural and development research and delivery partners (IUCN, CARE, GIZ; e.g. FORCLIME project, Indonesia); pilot project proponents and private-sector actors use our knowledge for implementation on the ground. We are currently expanding our partnerships with multi-stakeholder round tables and networks (e.g. Governor's Forests and Climate

Task Force) assessing their potential for broader multiplication and they have expressed interest in using this knowledge to inform their work. We provide knowledge and tools to donors and multilateral and agencies for technology transfer. We provide information and training to the media in developing countries. At the global level, we work with UNFCCC bodies to support their policy learning, knowledge management, transfer and implementation.

Table 4. Selected partners in FP5 and their roles.

Advanced research centers used for capacity development and underpinning FTA with world-class science	School of Economics and Business, Norwegian Univ. of Life Sciences (NMBU), NO; Dep. of Forestry & Environmental Resources, North Carolina State University, USA; Columbia Univ., New York, USA; Geoinformation Science & Remote Sensing, Wageningen Univ., NL; VITRI – Dep. of Forest Sciences – Univ. of Helsinki, FI; Center for Development Research (ZEF), Univ. of Bonn, DE; IIASA; Laxenburg, Austria; International Network for Bamboo and Rattan (INBAR), Beijing, China and external offices
Developing country research partners → local research, capacity building and out-scaling and multiplication	Bogor Agric. Univ. (IPB), Indonesia; Iwokrama Int. Ctr. for Rainforest Conservation & Dev. (IIC), Guyana; Wondo Genet College of Forestry & Nat. Res., Hawassa Univ., Ethiopia; Conseil p. la Défense Environnementale par la Légalité et la Traçabilité (CODELT), DRC; Indonesian Ctr. for Env. Law (ICEL); Libelula Comunicacion Ambiente y Desarrollo Sac (Libelula); Nat. Forest Inst., Myanmar; Vietn Acad. of Forest Sciences; Vietn. Forestry Univ.
National policy actors (line ministries) → national policy implementation	Ministry of Environment and Forestry, Indonesia; Bappenas (Planning), Indonesia; Vietnam Forest Protection and Development Fund; Ministry of Environment, Forest Service (Peru)
Civil society organizations → national/subn. research, dissemination, & implementation	Earth Observation Institute; Rights and Resources Initiative; Instituto de Mudanças Clímaticas (IMC); Instituto de Pesquisa Ambiental da Amazônia (IPAM) [Amazonian Environmental Res. Inst.]; Society of Indonesian Environmental Journalists (SIEJ); The Nature Conservancy (TNC)
Private sector → outcomes	DANONE Livelihoods Fund; Indonesian Estate Crop Fund for Palm Oil
Multi-stakeholder roundtables & networks → research outcomes	Roundtable for Sustainable Palm Oil (RSPO); Governor's Forests and Climate Task Force UN Sustainable Energy for All initiative; Global Initiative on Clean Cookstoves; REDD+ Roundtable, Peru; Global Forest Watch
Donors & agencies → technology transfer	Green Climate Fund; World Bank Indonesia; UNFCCC Climate Technology Centre and Network – CTCN, Copenhagen; UN-REDD; KfW (German Development Bank)
International policy actors → policy learning	UNFCCC COP; UNFCCC SBSTA; UNFCCC Paris Workgroup; Adaptation Board, IPCC

2.5.1.8 Climate change

FP5 provides knowledge on how to use FT&A resources for the mitigation of and adaptation of forests and people to climate change. This is an essential part of a landscapes approach that integrates the multiple functions of a productive and sustainable landscape, particularly with regard to regulating (climate change) and provisioning (food production) ecosystem services. FP5 focuses on deforestation and forest degradation that account for approximately 70% of tropical land-based emissions. CCAFS focuses on the remaining 30% of emissions from agriculture (from enteric fermentation, manure management, paddy rice and cropland soils). Work in both programs is complementary (see overall FTA description). CCAFS emphasizes CSA, enhanced food security and improved nutrition under climate change. FT&A focuses on integrated bioproduction and environmental services provision through FT&A resource management at the landscape scale, working on policies and practices that link climate mitigation and adaptation to development. FTA-FP5 is expanding work on sustainable supply chains. FTA adds work on bioenergy (CoA 5.3) to support adaptation, mitigation and rural income generation, addressing the trade-off in land demand for food and energy production by emphasizing the use of degraded lands for the latter. FTA's focus on performance assessment is unique. It will provide hard data of how climate aspirations translate into achievements and aspires to be of use to the CGIAR as a whole (CoA 5.4). Both programs work on LED(S): CCAFS as a broad strategy to encompass its mitigation work in Flagship 3 and FTA as a specific area of work related to the role of FT&A resources in LEDS (CoA 5.1). Together, FTA and CCAFS provide a coherent approach to climate change across the CGIAR.

2.5.1.9 Gender

Equity is one of our 3E+ objectives. In FP5, we study inequalities related to gender, indigenous people and local communities (IPLC), and the structural causes of gender-disaggregated impacts of climate change in different social, political and cultural contexts; and of mitigation (e.g. REDD+), adaptation and biofuel development on households; adaptation options; and access to resources and distribution of benefits. We will, jointly with the FTA Gender Integration team, identify gender-specific research questions (following the FTA gender strategy), to address the gender implications of these and other activities (e.g. corporate zero-deforestation pledges, bioenergy development). We will assess gender-differentiated roles in land-use planning for adaptation, how climate change and coping strategies impact and change gender relations, and the gendered impacts of adaptation policies, projects and interventions. FP5 aims to identify mechanisms to enhance the participation of marginalized groups in the formulation of adaptation and mitigation policies and interventions, through our work on safeguards, benefit-sharing, Free, Informed and Prior Consent (FIPC), and negotiated approaches to resource management. We will address the gender and IPLC aspects of producing, transporting and using wood energy.

Gender considerations will be integrated into target and priority settings, identifying boundary partners, dissemination of knowledge products, performance evaluation and our own staffing. For example, while our FP5 leadership composition is still male-biased (something FP5 will work to change), our REDD+ research team has a F:M relation of 2:1 (in terms of number of staff and person-month allocation). We will use the Gender Equality in Research Scale (GEIRS) for monitoring. FP5 will contribute to the sub-IDO (B1) Gender-equitable control of productive assets and resources.

We will apply in our overall design of FP5 research the concept of inter-sectionality and use methods, which will be gender, race and age sensitive and take power relations into account as well. For example, we will analyze in focus group discussions differentiated perceptions, impacts and (preferred) responses to diverse drivers of change of women, men and youth, as outlined for example in Djoudi et al. (2012[26]); Brockhaus et al. (2013[27]). This will allow us to provide much more nuanced policy recommendations for the needs and ambitions of different societal groups and classes. In addition, we will work with youth groups, e.g. forestry students concerned with climate change that came up with innovative solutions at the Global Landscape Forum.

2.5.1.10 Capacity development

We will develop capacity by: (i) working with national partners on mitigation and adaptation; employing the co-production of science model that enables country partners to develop research capacity 'on the job'; (ii) investing considerable resources into academic training of our future developing country leaders; and (iii) producing quality training materials (e.g. online tools). The long-term impact of our research program in capacity development in developing countries is one of the major outcomes of CGIAR research – developing national ownership and problem-solving capacity by empowering national institutions and individuals addressing development and climate change problems. Our capacity development efforts predominantly address ***D.1.2 Enhanced individual capacity in partner research organizations***, but indirectly contribute to developing the capacities of research/delivery institutions where those individuals work, in poor, vulnerable countries. This is reflected in 10% of our budget going to capacity development explicitly (see Table 2). We expect direct involvement in 30–40 new PhD studies and 20–30 MSc and BSc studies in the course of this phase.

2.5.1.11 Intellectual asset and open access management

Intellectual assets (IA) produced under FTA are in compliance with the CGIAR Principles on the Management of Intellectual Assets (CGIAR IA Principles) and CIFOR IA management policy for effective dissemination of research outputs and maximizing global impact. The following CGIAR IA principles shall be adopted as guidance on IA management of FTA:

- FTA research results and development activities are regarded as international public goods for maximum possible access
- Partnerships are critical to ensuring access to the best knowledge and innovation to achieve maximum impact
- Sound management of IA and intellectual property rights (IPR) with integrity, fairness, equity, responsibility and accountability
- All IAs produced under FTA are managed in ways that maximize global accessibility.

In line with the CGIAR Open Access and Data Management policy and CIFOR OA policy, FTA outputs will be made available under the least restrictive licensing to describe the legal rights to information products and encourage their use and adaptation. It will be published in a format that can be downloaded, indexed and searched by commonly used web applications. The outputs will be disseminated through open access repositories to ensure it is archived and shared systematically with other centers and made accessible as international public goods.

A section on FTA IA management and open access implementation is available in Sections 1.0.12 and 1.0.13 of the full FTA Proposal, including a detailed strategy for IA management in Annex 3.10 and OA/OD implementation in Annex 3.9.

2.5.1.12 FP management

FP5 will rely on a collaborative management model in which the three lead partners will distribute responsibilities and manage the flagship program collaboratively, building on the last 6 years of a successful partnership (Table 5). The overall coordination of FP5 will be led by Christopher Martius, a Principal Scientist at CIFOR and each CoA will have a small management team (the rows) consisting of the institutions and the named people in the table. Teams will meet annually and consult frequently by email and VoIP. The coordinating team (column 2) will meet biannually if possible and consult frequently by email and VoIP. This

arrangement will be revised every 2 years – or earlier in specific cases, e.g. if one of the leaders should leave the team.

Table 5. FP5 leadership and CoA management groups

Cluster of activity	Lead/coordinating	CGIAR partner	Non-CGIAR major partner
CoA 5.1	CIFOR: Christopher Martius	ICRAF: Peter Minang CIAT: (20x20 Initiative): Louis Verchot	Norwegian University of Life Sciences (NMUB): Arild Angelsen
CoA 5.2	Cirad (EbA): Bruno Locatelli	CIFOR (vulnerability): Houria Djoudi ICRAF: Lalisa Duguma	Helsinki University (adaptation policies): Markku Kanninen CATIE (smallholders, capacity development): Eduardo Somarriba
CoA 5.3	ICRAF (bioenergy for smallholders): Navin Sharma	CIFOR (bioenergy policies): Himlal Baral	Will be determined later
CoA 5.4	CIFOR (policies): Maria Brockhaus	CIAT (Terra-i): Glenn Hyman	Wageningen University (remote sensing): Martin Herold

2.5.2 Flagship Budget Narrative

2.5.2.1 General Information

CRP Name	Forest, trees and agroforestry Agri-food systems Program (FTA)
CRP Lead Center	CIFOR
Flagship Name	Forests and climate change: mitigation and adaptation opportunities
Center location of Flagship Leader	CIFOR

2.5.2.2 Summary

Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2	1,846,800	1,939,140	2,036,097	2,137,901	2,244,796	2,357,036	12,561,772
W3		0	0	0	0	0	0
Bilateral	11,021,309	11,499,269	11,989,324	12,539,296	13,102,601	13,679,904	73,831,706
Other Sources		0	0	0	0	0	0
	12,868,109	13,438,409	14,025,421	14,677,197	15,347,397	16,036,940	86,393,473

Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Assumed Secured)	1,846,800	1,939,140	2,036,097	2,137,902	2,244,797	2,357,037	12,561,773
W3							0
Bilateral	9,216,000						9,216,000
Other Sources	0						0
	11,062,800	1,939,140	2,036,097	2,137,902	2,244,797	2,357,037	21,777,773

Funding Gap	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
W1+W2 (Required from SO)	0	0	0	0	0	0	0
W3 (Required from FC Members)	0	0	0	0	0	0	0
Bilateral (Fundraising)	-1,805,310	-11,499,270	-11,989,325	-12,539,297	-13,102,601	-13,679,904	-64,615,707
Other Sources (Fundraising)	0	0	0	0	0	0	0
	-1,805,310	-11,499,270	-11,989,325	-12,539,297	-13,102,601	-13,679,904	-64,615,707

Total Flagship budget by Natural Classifications (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
Personnel	4,025,204	4,226,464	4,437,788	4,659,677	4,892,661	5,137,294	27,379,091
Travel	798,400	838,320	878,240	926,144	974,048	1,021,952	5,437,104
Capital Equipment	114,060	119,763	125,466	132,309	139,153	145,996	776,748
Other Supplies and Services	4,464,996	4,624,675	4,784,355	4,975,971	5,167,587	5,359,202	29,376,788
CGIAR collaborations	0	0	0	0	0	0	0
Non CGIAR Collaborations	1,787,000	1,876,350	1,970,169	2,068,679	2,172,114	2,280,720	12,155,032
Indirect Cost	1,678,449	1,752,836	1,829,402	1,914,417	2,001,834	2,091,774	11,268,714
	12,868,109	13,438,408	14,025,420	14,677,197	15,347,397	16,036,938	86,393,469

Total Flagship budget by participating partners (signed PPAs) (USD)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
CIFOR	9,755,328	10,169,989	10,596,736	11,070,762	11,558,114	12,059,455	65,210,384
ICRAF	1,655,536	1,738,312	1,823,537	1,918,096	2,015,354	2,115,446	11,266,283
CIAT	835,903	877,698	920,752	968,452	1,017,540	1,068,084	5,688,431
Cirad	167,865	176,258	184,933	194,458	204,293	214,451	1,142,260
CATIE	164,182	172,391	180,826	190,237	199,898	209,819	1,117,355
Tropenbos	289,294	303,759	318,636	335,190	352,199	369,683	1,968,763
	12,868,108	13,438,407	14,025,420	14,677,195	15,347,395	16,036,938	86,393,463

For the explanation of these costs in relation to the planned 2020 outcomes, please refer to the FP narrative and more especially the PIM tables B and C.

Use of W1/W2: W1/W2 are used strategically to leverage bilateral funding likely as basket funds, in such a way that different sources of bilateral contribute to the same major goals, this in order to build a program that is consistent and that can deliver its expected objectives across the different six countries in which we are planning to do our work. W1/W2 funds are also used for global comparative analyses on major issues (e.g. REDD+, bioenergy), to strengthen science quality, implement open access and to foster the probability of outcomes thanks to targeted communication and outreach.

NOTE: Supporting Platform: Given the absence of a specific location to upload the costs/budgets of the various cross-cutting components (CCT) of the Supporting Platform (Gender, Youth, Capacity Development, MELIA, Communication/Outreach, Site Integration, Partnerships, OA/OD) we have allocated these amounts across the 5 Flagships within the supply and services class (but they will be managed in practice by the relevant CCT component leads. The amounts added per FP for the SP (year 2017) are USD 1,271,000 of which USD 346,000 W1/W2.

2.5.2.3 Additional explanations for certain accounting categories

Benefits: This is the same for all FP's and follows existing human resource policies of the centers participating in FTA. In general the following benefits are covered by the Centers: Pension, Health, AD&D Insurances and allowances for housing, education and transport. These have been rolled into the salary. It is difficult to standardize the benefits as they vary by Center (based on individual center polices), but also vary by type of staff i.e. Internationally recruited and National Staff.

Other supplies and services: Under Supplies and Services we include costs related to consultants, research support, communications (publications and multimedia knowledge sharing) and outreach (bilateral meetings, workshops and events). This budget line is important for FP5 to get short term support on specific analysis (consultants) and to get our knowledge out in the policy debates.

2.5.2.4 Other Sources of Funding for this Project

Efforts to raise bilateral funding will continue throughout the implementation period. The four research areas this Flagship is focusing on (mitigation, adaptation, bioenergy and performance assessment) are gaining interest in the donor community so opportunities for securing additional bilateral funding are there. W1/W2 will be used strategically to leverage bilateral funding likely as basket funds, in a way that different sources of bilateral contribute to the same major project goals, this in order to build a program that is consistent and that can deliver its expected objectives across the different six countries in which we are planning to do our work.

2.5.2.5 Budgeted Costs for certain Key Activities

	Estimate annual average cost (USD)	**Please describe main key activities for the applicable categories below, as described in the guidance for full proposal**
Gender	979,000	see FP and CRP narratives
Youth (only for those who have relevant set of activities in this area)	0	Youth as a new topic for this FP will be initiated via the Youth cross-cutting theme of the supporting platform
Capacity development	1,390,000	see FP and CRP narratives

	Estimate annual average cost (USD)	Please describe main key activities for the applicable categories below, as described in the guidance for full proposal
Impact assessment	0	Costs are indicated at the CRP level budget narrative as this is centralized within the Monitoring Evaluation Learning and Impact Assessment cross-cutting theme
Intellectual asset management	0	Costs are indicated at the CRP level budget narrative as this is mainly something managed at Centers' levels
Open access and data management	0	Costs are indicated at the CRP level budget narrative as this is mainly something managed at Centers' levels
Communication	1,293,000	see FP and CRP narratives

The above selected key activities are described in the proposal text and the PIM tables. They do not include the Support Platform (that is included in the CRP budget narrative)

2.5.3 Flagship Uplift Budget

Outcome Description	Amount Needed	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other(%)
Outcome 5U1. A broader data set available from more case studies for an analysis of policy and practice in REDD+ pilot/early mover projects is available and being used by boundary partners for more informed decision-making on REDD+.	7,800,000	30	0	70	0
Outcome 5U2. Performance assessment approaches and tools from climate change policy assessment (e.g. forests and carbon in landscapes, livelihoods) adopted for decision-making in broader contexts (e.g. SDGs), and harmonized across the SDG/Paris Agreement policy and practice.	9,000,000	30	0	70	0
Outcome 5U3. The carbon and livelihoods benefits of restoration in South Asia are assessed and include established including forests and bamboo resources, and this information is used by boundary partners for 3E+ restoration in that region.	5,400,000	30	0	70	0

Outcome Description	Amount Needed	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other(%)
Outcome 5U4. Policy-makers in sentinel landscapes have access to specific climate change mitigation and adaptation policy analysis for their regional contexts and are using it for 3E+ decisions.	4,500,000	30	0	70	0